urban stream crossing

Local impacts of road crossings on Puget Lowland creeks

Introduction

One of the most pervasive components of urban development is the road network. In modern society, roads are necessary to cater to the principal mode of transportation—the car. As such, they are pervasive and likely to be with us for a long time, and so mitigating their physical and biological impacts is critical for reducing the net influence of urbanization on aquatic systems.

Removal of vegetation, compaction of soils, and the installation of drainage networks associated with roads combine to transport water more “efficiently” to streams during storms. Such alterations also affect other components of the hydrologic cycle. While surface runoff experiences net increases during and immediately after storms, groundwater recharge, evapotranspiration, and throughflow typically suffer net reductions. This pattern commonly results in a flashy and extreme response to storms; repetition of these patterns over multiple-year periods induces persistent physical and biological consequences to streams. Although not all of these changes have simple causes, a wide range of data suggests that roads are among the most significant and damaging elements of the modern urban environment. Work at the Center, therefore, is exploring the major sources of road-induced damage to streams and is pursuing some of the most promising approaches for mitigation.

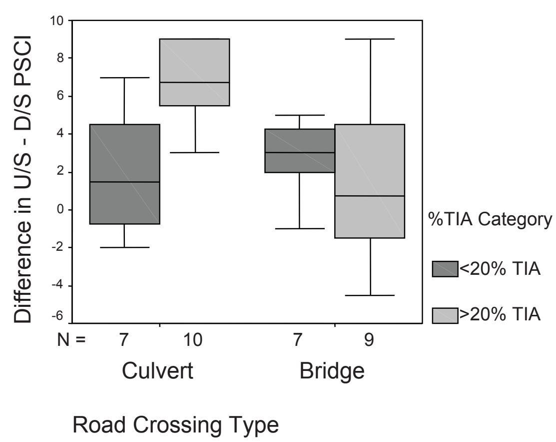
Arch culvert in the Soos Creek watershed.

The effects of road crossings

Objectives of recent work has been to:
1) develop methods for measuring local road-crossing impacts to physical creek conditions;
2) determine specific physical processes and conditions altered by road crossings;
3) determine what road-crossing characteristics contribute to downstream alterations; and
4) assess the significance of local road-crossing impacts relative to basin-wide urbanization impacts.

The work has investigated the relationships between stream-channel condition and road crossings in a variety of urban and suburban watersheds, primarily by direct observation and measurement of instream conditions.

Geomorphic results implicate all road crossings; that is, for almost every road crossing, geomorphic condition was found to locally degrade in the downstream direction, as measured by such parameters as bank erosion, presence or absence of pools and large woody debris, and degree of substrate cementation. These local road-crossing impacts were experienced across the entire gradient of urbanization; however, these changes were statistically different between the urban (>20% total impervious area, or TIA, in the contributing watershed) and suburban (<20% TIA) channels investigated here. Both sets of channels show degradation downstream of road crossings, but the urban creeks experience larger upstream-downstream changes in geomorphic condition than their less developed suburban counterparts. Therefore, to avoid impacts to natural fluvial systems, the number of road-creek crossings simply should be held to a minimum. Unfortunately, this becomes increasingly important in those watersheds where road networks



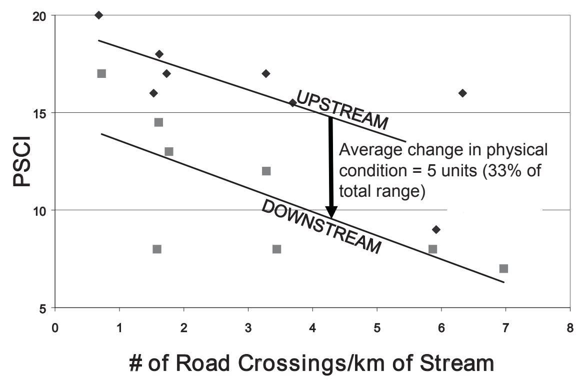
All road crossings degrade downstream physical stream-channel quality (as measued by a multi-metric index, the PSCI), but changes are particularly significant for culvert crossings in urban watersheds (i.e., those with a TIA >20%). Box spans 25-75% of values, median is dark line within the box, and whiskers span 5-95% of values.

are likely to be the densest. In these urban areas, ensuring efficient transportation networks commonly competes successfully with the need to avoid physical alterations of creeks. It is therefore important to understand which road crossing designs might best be able to minimize their downstream impacts.

Culverts generally have larger impacts to overall geomorphic condition than their less confining counterparts—bridges. Bridges are generally associated with downstream channel geometry (i.e., larger width-to-depth ratios) that correlates to higher instream channel complexity and greater quality of overall physical condition.

Channel confinement and riparian buffers

To the same extent that the confinement related to the road-crossing design (i.e. bridges vs. culverts) should be minimized, so the confinement imposed by bank armoring should be avoided. Longer artificial banks associated with roads (whether by the road crossing itself or with rip-rapped banks downstream) produce longer downstream reaches that display physical degradation. The key factor here is the loss of a naturally meandering creek, which requires both erodible banks and the physical space needed to make lateral channel adjustments. A lack of space is often a vital issue for urban reaches abutted by private property, and so creek banks along residences are often lined with concrete and rip-rap to protect private property.



Physical stream quality declines with increasing density of road crossings; additional degradation is imposed by the presence of the crossing itself. R2 (shown as R-squared) values = 0.52 (upstream) and 0.53 (downstream).

Results of this work also suggest that protecting and restoring riparian buffers along creeks can help mitigate the local effects of road crossings. Suburban creeks with better riparian buffers are more resilient to the local impacts of a culvert than urban creeks. Measures of the riparian zone width and integrity show significant correlation with instream conditions, specifically large woody debris abundance, channel complexity, and reach sinuosity. Therefore, wide and intact riparian corridors can successfully support complex geomorphic structure even in some of the most urbanized basins.

Summary

This study affirms the negative influence of road crossings on the geomorphic condition of lowland streams, and it emphasizes the value of road network designs that minimize the number and density of stream-channel crossings. Less hydraulically confined crossing designs produce less geomorphic impacts than more confined crossings; the presence or absence of a natural substrate within the crossing itself, however, does not appear to be a determining factor. Both watershed and adjacent riparian conditions are important determinants of the net effect of the road crossing on the stream channel, with greater resiliency and less degradation found in those downstream reaches having intact riparian corridors in low-urban watersheds, in comparison to those reaches with devegetated corridors or in highly urban watersheds.

For more information see Avolio, C. M., 2003, The Local Impacts of Road Crossings on Puget Lowland Creeks: MSCE thesis, CEE Department, University of Washington. Available online at: http://depts.washington.edu/cwws/Theses/avoliothesis.pdf

Christina Avolio

The Water Center

University of Washington ◆ Box 352100 ◆ Seattle, Washington 98195-2100

206.543.6920 ◆ cwws@u.washington.edu ◆ http://depts.washington.edu/cwws