Article 148

Technical Note #46 from Watershed Protection Techniques. 1(4): 182-183

The Longevity of Instream Habitat Structures

Instream structures play a key role in urban stream restoration, as they recreate the pools, riffles, over head cover and channel complexity that had been destroyed by increased stormwater flows. The same forces that degrade urban stream habitat—high flows, debris jams, and sedimentation—also work to lessen the effectiveness of artificial stream habitat structures. Therefore, a key question for urban stream managers is how long artificial habitat structures will persist before they too are damaged by urban stormwater flows. The question has enormous significance: is stream restoration a one-time intervention to reverse prior damage, or is it a constant struggle to try to maintain structure in streams that are dominated by erosive stormwater flows? If these structures fail, how often must they be replaced or repaired?

Urban stream restoration is such a new endeavor that we simply do not have enough of a track record to satisfactorily answer these questions. However, some insights into their longevity can be gleaned from an extensive study of the persistence of instream habitat structures in the Pacific Northwest conducted by Frissel and Nawa (1992). The researchers surveyed 161 fish habitat structures in 15 Oregon and Washington stream systems six months after a five- to 10-year flood event. The structures were one to five years old and were evaluated to determine how well they were functioning after the flood. The findings suggest that the expected longevity of structures is not as great as was once thought. In the 15 streams studied, more than half the structures had failed before the expected lifetime of 20 years. What's more, some of these "habitat improvement" structures had unintended and even negative effects on the stream morphology. For example, some had changed the course of the low-flow channel, or created barriers to fish migration rather than pools for breeding.

Are the observations from this large-scale study of undeveloped watersheds transferable to smaller, urbanized streams? It is important to remember that large and small streams differ in their vulnerability to physical forces (e.g., flood peak and sediment load) that damage structures.

The Causes of Structure Damage Are Multiple and Interacting

Of the eight Oregon streams studied, wider streams did tend to experience greater peak flows and greater damage and failure rates of structures than narrower streams (Table 1). The relationship between channel width and failure rate appears to be linear. Channel width appears to be one stream characteristic correlated with failure rates in the Oregon streams studied. No other single stream characteristic was a useful predictor of future failure; indeed, failure rates were quite high and variable in most streams studied (Table 2).

Although stream variables other than channel width (e.g. valley type, drainage area, channel slope) were generally a poor predictor of longevity of instream habitat structures, structure type was correlated with failure rates. Some types of instream habitat structures appeared to be more susceptible to failure or impairment. The majority of cabled debris jams and boulder clusters remained functional after floods, whereas the majority of log-weirs failed or were impaired (Table 2). The durability of the materials themselves is not a great factor in structure performance; structures may still be in one piece but washed away whole or buried under sediments. Placement is a factor, in the sense that a structure may be well-placed to begin with but becomes ineffectual or deleterious if the stream channel shifts.

Table 1: Active Channel Width and Structure Failure Rates (Frissel and Nawa, 1992)

Stream name and no. of structures (n)	Width of active channel (ft)	Flood peak (cfs)	Damage rate (%)	Failure rate (%)
Outcrop (5)	18.0	247.2	40	40
Crooked Bridge (6)	19.7	423.7	100	100
Silver (6)	29.2	600.3	50	17
Foster (15)	31.5	1,059.3	27	7
Bear (19)	35.8	988.7	79	32
Boulder (5)	39.4	ND	60	40
Shasta Costa (18)	60.0	1,589.0	83	55
Euchre (19)	98.4	3,248.5	100	95

Table 2: Performance of Eight Types of Instream Habitat Structures After a 5-10 Year Flood (Frissel and Nawa, 1992)

Structure type	No. of structures	% working	% impaired	% failed
Cabled debris jam	19	75	10	15
Individual boulders	9	56	8	36
Boulder clusters	15	40	55	5
Multi-log structure	17	41	25	34
Transverse log weir	30	40	30	30
Diagonal log deflector	23	30	58	12
Lateral log weir	30	33	9	58
Downstream V log weir	12	0	52	48

"working" = remained functional; "impaired" = buried under sediment or damaged such that it was no longer functions as intended; "failed" = washed away or no longer in the channel

"Habitat-improvement" Structures May Have Unintended and Adverse Effects on Stream Morphology

Instream structures can have a negative impact on stream habitat quality in some cases. These impacts include habitat destruction during installation or deterioration of the structures; unforeseen changes in stream geometry that render a structure ineffective or deleterious; and unanticipated effects of the structure on the hydrology of a stream (e.g., boulders that were expected to scour out pools instead cause the creation of a midchannel gravel bar).

Some of the most common negative impacts of stream structures in Frisell and Nawa's study are:

- Accelerated bank erosion near log weirs
- Damage to riparian vegetation from heavy equipment during construction
- Overuse of streambank trees for construction material
- Streambank anchor-trees torn out along with the anchored devices during floods
- Gravel bars become larger and embedded with sand, resulting in loss of pool microhabitats
- Bed load triggered when structure fails, endangering nearby juvenile fish

Can Observations Be Applied to Stream Restoration?

Direct comparisons cannot be made between these large rivers of the Northwest (drainage area ranging from one to 200 sq. miles) and the typical small urban or suburban stream. Some key differences in size, discharge volume, and land use should be noted. First, the streams evaluated by Frissel and Nawa are much wider (average 40 feet) than typical urban headwater streams and consequently experience greater channel movement and changes in the streambed and banks. Second, the structures in this study are exposed to large, erosive floods (the February 1986 flood averaged 1,000 cfs in these mountain streams). Third, the streams studied by Frissel and Nawa were impacted by major logging disturbances (e.g., road-collapse and landslides from clear-cut slopes) that contributed to the sediment load.

While there are some sharp differences between small urban streams and the larger mountain systems studied here, urban streams are also subjected to high peak flows and the same basic principle could apply: the simpler the structure, the more likely it is to continue functioning after a large flood. On the other hand, the more elaborate structures, such as V-shaped weirs, make bigger changes to the stream hydrology and will be heavily impacted by floods. Stream habitat designers learn several lessons from this study:

1. The selection and placement of habitat structures should be fundamentally based on computed peak flows and velocities for the 10-year storm
2. Uncomplicated, low-profile structures will probably be the least impacted by the force of a flood
3. Structures perpendicular to streamflow (e.g., transverse log weirs) are fully exposed to undercutting and should be well anchored into the streambank.

—JMC

Reference

Frissell, C. A., and R. K. Nawa 1992. "Incidence and Causes of Physical Failure of Artificial Habitat Structures in Streams of Western Oregon and Washington." *N. Am. J. Fish. Manage.* 12(1): 182-197.

Interacting Stream Characteristics That Bring About Physical Impacts on Instream Structures

Stream Characteristics		Physical Impacts	Structure Performance
Width of active channel	Flood peak	Hydrological force	Structure buried, broken or displaced
Channel slope	Land use	Channel movement	
Bank stability	Natural disturbance	Sediment deposition	
Regional precipitation	Valley type		