EVALUATION OF THE LONG-TERM IMPACTS OF URBANIZATION ON THE PHYSICAL CHARACTERISTICS OF PIEDMONT HEADWATER STREAMS

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Abstract. A field study has been initiated to measure and evaluate long-term changes in channel cross-sections, bank and channel scouring, streambed composition, longitudinal reach profiles, plan-form dimensions, land cover to document the long-term response of a Piedmont headwater stream to urbanization. This case study will evaluate the rate and interrelationship of those changes over time and in comparison to a comparable relatively undisturbed control stream and a stream draining a nearly fully developed urban watershed.

INTRODUCTION

The upper portion of the Proctor Creek watershed in northwest Cobb County has and will continue to experience rapid development. In 1995 the 3.1 km^2 portion of the watershed above Baker Road was, as reported by the Atlanta Regional Commission (ARC, 1997), 18.6% impervious, with approximately 19.5% of the basin in urban land uses and 12.1 % in limited access highway right-of-way. No substantial indications of physical stress such as bank scouring, bed aggradation or degradation, bank scouring or undercutting were observed during field measurements in 1996. The water quality then was rated as "best," with water quality index values comparable to the control site in an ARC (1997) study to develop stream assessment guidelines. The above study also reported a mean habitat rating of 123 out of a possible 200 (which denotes the best possible biological habitat) for the site. However, diminished numbers of macroinvertebrate taxa, in comparison to the control site, may indicate increasing stress. Cobb County has been making biological observations and collecting quarterly water column samples (including oxygen demand, solids, nutrients, turbidity, and selected metals) at this site since 1994.

As development continues and the impervious portion of the watershed increases, well-described hydrologic changes result in increases in peak discharges and the frequency of bankfull flows that cause changes in downstream channels. Channel enlargement resulting from channel incision and quasi-equilibrium expansion (Booth, 1990) is a common response described in many studies (including Hammer, 1973 and Robinson, 1976), but other attributes of the channel such as stream bed material composition, width-depth ratio, habitat characterization, stream bed aggradation, bankfull cross-sections, longitudinal changes such as water surface slope, and plan-form dimensions such as sinuosity and pool or riffle spacing may change as well, albeit at different rates. Substantial changes in stream channel characteristics will lag years behind development sufficient to disrupt stream equilibrium (Wolman, 1967; Leopold, 1973; and Hammer, 1973). However, little research is available to quantify the long-term response of stream channels to urbanization.

The early and continuing measurement of the physical characteristics of Proctor Creek before and during the substantial effects of rapid urbanization, in comparison to a control basin and a developed urban watershed, will provide valuable information on the long-term impacts of urbanization on stream channels.

STUDY SITES

In addition to Proctor Creek, a tributary to Whooping Creek in Carroll County will serve as an undisturbed control stream and an unnamed tributary to the North Fork of Peachtree Creek in DeKalb County (labeled Northwoods Branch) will serve as the developed urban control stream. The sample reach for the approximately 3.2 km^2 Northwoods Branch watershed is located below Aztec Road in Doraville. As in the Proctor Creek watershed, soil types are dominated by the Appling-Cecil-Madison associations, though there is slightly less difference in relief (150 as compared to 190 feet) in the Northwoods watershed. The watershed, which began to develop in the early 1960's, is now almost completely developed with retail and office uses and a limited access highway on the ridge lines and single and multi-family residential areas in the remainder of the watershed. The 2.8 km^2 watershed of the tributary to Whooping Creek is

also dominated by soils in the Appling-Cecil-Madison associations and has a difference in relief of 180 feet.

Sampling reaches of at least ten times stream width with at least two meander-wave lengths were selected. At least four cross-sections consisting of two bends and a riffle and a pool in a run segment of the sample reach were selected at each site. Metal pins were installed on each side of a cross-section and related to reference points so that they could be replaced, if necessary.

SITE MEASUREMENTS

The suite of parameters being evaluated has been expanding since the initial habitat assessment and measurement of channel cross-sections at Proctor Creek in 1996. Baseline measurement of the physical characteristics (including pebble counts) of each site and cross-section, mapping and photo-documentation, and land cover characteristics will be followed by long-term quarterly and annual measurements that will be evaluated and reported in approximately five years.

Watershed Measurements

Following initial estimates of percent impervious area from 1995 ARC land cover data and a historical review of major development in the watersheds, the number and type of building permits issued will be compiled annually. Annual and monthly rainfall amounts at the closest weather station will be compiled.

Baseline and Annual Reach Measurements

After initial measurement, the following measurements will be conducted annually (with applicable methods referenced in parenthesis) for each reach:

1. Channel mapping
2. Documentary photography
3. Survey of channel bed material composition (Rosgen, 1996)
4. Stream habitat assessment(GEPD, 1997)
5. Flag estimates of bankfull flow stage and estimate bankfull flow (Rosgen, 1996 and Henson, et al., undated)
6. Longitudinal profiles including water surface slope (Rosgen, 1996)
7. Plan-form dimensions including sinuosity, pool and riffle spacing, meander length and belt width (Rosgen, 1996).

Baseline, Annual, and Quarterly Channel Cross-section Measurements

At least four channel cross-sections have been permanently located in every stream reach. Scour chains embedded in the stream bed to show aggradation or degradation and bank pins to measure the amount of bank recession have been installed and referenced to channel cross-sections (C.C. Harrelson, et al., 1994).

After initial measurement, the following measurements will be conducted annually (with applicable methods referenced in parenthesis) for each cross-section:

1. Channel cross-sections and area (Figure 1 on the following page illustrates three years of change in channel cross-section #1 at Proctor Creek)
2. Bankfull cross-sections, area, mean and maximum depth, width to depth ratio, flood prone stage and width, and entrenchment ratio
3. Sream bed aggredation or degradation
4. The amount and rate of bank enlargement at selected locations.

Quarterly water column samples will be collected at Proctor Creek. Quarterly visual observations and measurements of bank or stream bed changes will be made at Proctor Creek and Northwoods Branch.

EVALUATION AND ANALYSIS

Field observations and measurements will be evaluated to develop a temporal profile of changes in the physical characteristics of the Proctor Creek reach. The control stream will provide an indication of "natural" changes during the study period while Northwoods Branch will provide a gauge of corresponding long-term changes in the channel of a developed urban watershed. The evaluation would address comparable changes and rates of change for bankfull indicators, channel and bankfull dimensions and measures, habitat assessment scores, pebble counts, bank and channel scouring or recession, and entrenchment ratios in the Proctor Creek reach and in comparison to the control and developed reach. The relationship between the increase in percent impervious area and the time of the expected onset of rapid channel expansion and increase in the entrenchment ratio (a measure of the degree of stream entrencment) will be evaluated, as well as changes in Rosgen's (1996) stream classification. An interim evaluation will be conducted and reported in approximately five years.

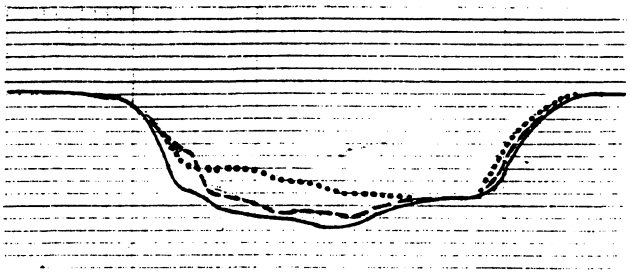

Figure 1. Cross-section 1 of Proctor Creek in 1996 (dotted line), 1997 (dashed line), and 1998 (solid line)

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