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RESEARCH SUMMARY

LONG-TERM BED DEGRADATION IN MARYLAND STREAMS (PHASE 2): BLUE RIDGE AND WESTERN PIEDMONT PROVINCES

Problem

Estimation of potential long-term down-cutting of the stream bed is necessary for evaluation and design of bridges for scour and culverts for fish passage. Existing guidelines for assessing this potential long-term bed degradation (LTBD) in Maryland streams require expertise that may not be available and/or field studies that, depending on the project budgets, may be cost prohibitive, especially for replacement of county structures. The morphological techniques recommended by these guidelines also lack verification data and may lead to overly conservative estimates, unnecessarily large foundation depths, and consequently, significantly higher costs.

Objective

The purpose of this study was to improve predictions of LTBD in non-urbanized Maryland streams through the measurement and analysis of stream bed and waterway structure survey data and plans. A primary objective was the development of equations for estimating potential LTBD in streams in Frederick, Carroll, and Montgomery counties.

Description

The study examined LTBD in the Blue Ridge and Piedmont physiographic provinces in three Maryland counties: Frederick, Carroll, and Montgomery. A total of 30 sites—23 bridges, 2 culverts, 2 utility crossings, 2 embankment walls, and 1 concrete ford—were selected for inclusion in the final sample. Drainage areas of these sites ranged from 1.7-25.9 mi^2.

At each sampling site, LTBD was measured with a pocket rod and a hand level. These rapid measurements were conducted where a step, a series of steps, a steep section, or a riprap-protected streambed was at the outlet of a culvert or a bridge with a paved or riprap-protected invert or downstream apron. LTBD was considered to be the vertical drop from an approximated pre-degradation channel bed elevation to the existing low-flow water surface.

Channel dimensions, bed material gradation, and the locations and characteristics of downstream grade controls were also recorded in the field. Those field measurements and some remote measurements were used to evaluate six factors that may influence a site's risk of LTBD: (1) the valley slope, (2) the effective floodplain width, (3) discharge, (4) downstream channel entrenchment, (5) bed material size, and (6) downstream grade controls.

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Results

The possibility of developing regional relations between watershed area and LTBD was evaluated for each physiographic province, but analysis of the data was inconclusive. Therefore, the development of regional relations was not pursued. Instead, equations based on risk factors were developed. Three relations between LTBD and five of the risk factors were examined: LTBD and valley slope; LTBD and an index combining Factors 1-4; and LTBD and an index combining Factors 1-5.

A comparison of the resulting equations revealed that valley slope was as good a predictor of the susceptibility of a site to LTBD as the two indices that required additional data and considered more parameters. The relation between valley slope and LTBD was recommended to estimate LTBD for Maryland Blue Ridge and Piedmont streams with the same range of valley slopes, drainage areas, and impervious area as the study streams. The relation will not apply, however, to structures located in deep deposits of sediment created by backwater from dams or other structures or to structures located in streams with evidence of active channel degradation.

The development of rate relationships for LTBD was also considered, but the number of available structure plans was insufficient to develop a rate relation. Future research on LTBD in Maryland should include the development of a method to include the effectiveness of downstream bed controls in limiting degradation, and the development of a rate relation should be explored further.

The relation between valley slope and LTBD can be used as a general guide for the prediction of long-term bed degradation. The relation and the database of LTBD field measurements will serve as a basis for SHA decisions related both to design and planning projects involving foundations for waterway crossings, depth of utility crossings, culvert replacements requiring fish passage, and mitigation projects involving stream restoration and/or stream stability. In foundation designs, the relation and database will establish a baseline for evaluating reasonable values of degradation. In the planning phase, the relation and database could support quick decisions on the type and size of the structures needed for stream crossings in small watersheds. The relation would also be of great help to all counties that lack resources to perform detailed stream morphology studies on their waterway crossing projects.

Report Information

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