STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

July 1994

Stream

Stream Channel Reference Sites: An Illustrated Guide to Field Technique

The Rocky Mountain Station, in association with the Stream Systems Technology Center (STREAM), has just released a guide for establishing permanent reference sites for gathering data about Streams and rivers. General Technical Report RM-245, *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, describes field techniques for measuring the *physical characteristics* of stream channels. These techniques can be used to establish the baseline existing physical condition of stream channels.

Permanent, benchmarked reference sites established using this procedure may serve a multitude of purpose including:

- monitoring trends in fluvial and geomorphic condition
- quantifying environmental impacts
- assessing stream response to management
- providing facts for water allocation
- supporting resource inventories
- tracking cumulative effects
- allowing comparisons based on stream type, and
- contributing to regional, national, and international databases.

The manual defines a minimum set of physical data needed to accurately characterize stream channels and shows the technically correct way to make those measurements. It identifies a set of basic procedures what will yield quality data with commonly available equipment and at relatively low cost.

The minimum procedure consists of the following:

1. Select a site
2. Map the site and location
3. Measure the channel cross-section
4. Survey a longitudinal profile of the channel
5. Measure streamflow
6. Measure bed material, and
7. Permanently file the information.

Users are encouraged to add to the minimum basic set of measurements to fit their specific data analysis needs. For example, a detailed study of channel response might survey multiple cross-sections across pools, riffles and meanders in lieu of the single cross-section which is the minimum discussed in the guide.

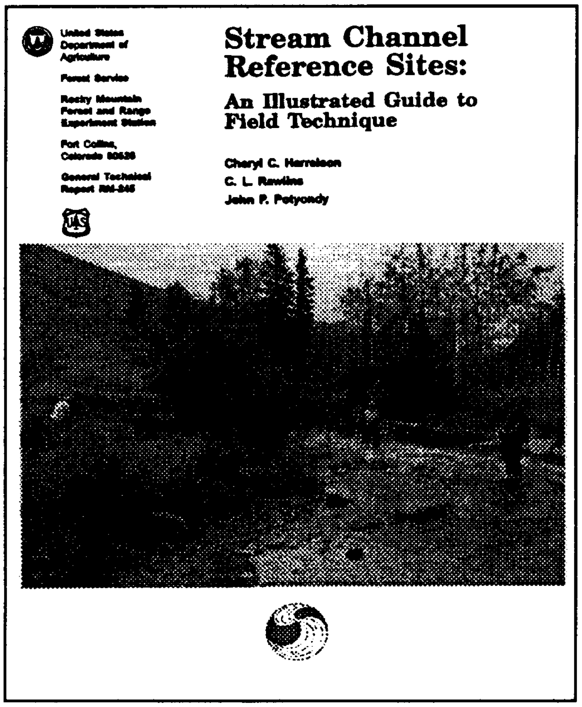
STREAM NOTES is produced quarterly by the Stream Systems Technology Center, Fort Collins, Colorado.

The PRIMARY AIM is to exchange technical ideas and transfer technology among scientists working with wildland stream systems.

CONTRIBUTIONS are voluntary and will be accepted at any time. They should be typewritten, single-spaced, limited to two pages in length. Graphics and tables are encouraged.

Phone: (303) 498-1731
FAX: (303) 498-2306
DG: STREAM:S28A

IN THIS ISSUE



The guide includes a review of basic surveying with special emphasis on establishing permanent benchmarks for long-term data collection. The guide contains practical information on site selection, use of stream classification, field mapping, and note-taking. The approach is practical and specific, targeting entry-level hydrologists, biologists, and anyone responsible for collecting stream data.

The authors consulted hydrologists in the Forest Service, U.S. Geological Survey, and private practice. Valuable help in the field and advice on technical matters was provided by Dr. William Emmett of the U.S. Geological Survey in Denver. Many of the techniques described in this guide were originally developed by Dr. Luna Leopold. and his colleagues.

Field personnel will find the section on floodplain and bankfull indicators especially useful given the current emphasis on bankfull discharge in fluvial studies. The guide suggests that the level of the active floodplain is the best indicator of bankfull stage and recommends using this as the primary bankfull indicator. Where floodplains are absent or poorly developed, rely on indicators as surrogates of bankfull stage. These may include the lower limit of streamside vegetation, the top of bars, topographic breaks, changes in bank material, and stain lines. The importance of specific indicators varies with stream type and needs to be verified locally.

The guide includes recommended techniques for measuring discharge, channel cross-sections, water surface slope, identifying bankfull stage, and doing pebble counts. The importance of good field note-taking and mapping techniques is stressed throughout the guide.

Since permanent reference sites track change over time, long-term filing and data storage are important. The guide suggests use of the Vigil Network as a means of making your data serve a broader purpose. The Vigil Network was proposed by Luna Leopold in 1962 and adopted by UNESCO in 1965. By submitting data to the Vigil Network, you make the data part of a worldwide database that future generations may find extremely valuable.

The authors draw heavily on inspiration from Luna Leopold and hope that this guide will inspire hydrologists to begin to implement the kinds of monitoring envisioned by him for National Forest streams.

Copies of ***Stream Channel Reference Sites: An Illustrated Guide to Field Technique***, 1994. USDA Forest Service General Technical Report RM-245 by **Cheryl Harrelson**, **Chip Rawlins**, and **John Potyondy** can be obtained from STREAM upon request. Send requests via the Data General to STREAM:S28A if possible. Alternatively, FAX requests to STREAM at (303) 498-2306, or phone Penny Williams at (303) 498-1731.

Stream Bank Erosion and Flushing Flows

by Michael P. O'Neill & Michael R. Kuhns

Sediment is delivered from hillslopes to stream channels through a variety of mass movement, wash, and other fluvial processes. However, the single largest source of sediment to most alluvial channels is derived from stream bank erosion (Odgaard 1987). Management strategies designed to achieve the most effective flushing flows must also consider effects of these flows on bank erosion. This paper summarizes two general classes of bank erosion mechanisms and identifies bank sediment characteristics commonly associated with these mechanisms. Flow conditions necessary for fine sediment removal are then evaluated in the context of erosion mechanisms. Finally, bank erosion mechanisms and flushing flows are reviewed in an ecosystem management context.

Bank Erosion Mechanisms

Bank erosion processes can be classified into two basic groups, those dominated by gravitational or mechanical failures and those where tractive force dominates. The circumstances under which these processes occur are determined by bank material characteristics and local soil moisture conditions. Table 1 summarizes the seven bank erosion mechanisms and presents typical sediment and moisture conditions associated with each of these processes. A graphical representation of each of the failure mechanisms appears in Figures 1 and 2.

Gravitational and Mechanical Erosion:
In the case of gravitational failure mechanisms, material strength is key. In these mechanisms, soil moisture often dominates the erosion process tthrough increases in material stress at the bank face and decreases in material strength (pore pressure). Seasonal wetting and drying can severely diminish material strength and irrigation may play a significant role in accelerating bank erosion by gravitational failures. Detailed descriptions of these mechanisms appear in Carson and Kirkby (1972), Thorne and Tovey (1981), Springer et al. (1985), and Simon (1989).

Gravitational failures are most common during the receding limb of the hydrograph. Hence, they result in the delivery of fine-grained sediment to the stream as flow is diminishing. This sediment therefore may remain in the stream throughout the summer low-flow period.

Tractive Erosion:
By contrast, tractive erosion is dominated by fluid forces. Erosion results from change in the balance between fluid shear stress and material strength. In order for tractive erosion to be effective, cohesive forces must be small in comparison with fluid shear stress. If material strength is considered to be constant (i.e., a saturated stream

Editor's Note:
<u>A Question of Basic Definitions</u>:
Readers should note that flushing flows and channel maintenance flows are different and the two terms should not be used interchangeably. *Flushing flows* pertain exclusively to reservoir regulated rivers while channel maintenance flows apply to regulated or natural river systems. Flushing flows are designed to flush fine-grained sediment from gravels in potential spawning areas with the sole purpose of improving fisheries habitat. *Channel maintenance flows* provide for the orderly conveyance or uninterrupted transport of water and imposed sediment supply produced by the watershed through the stream channel network, such that over time, channel dimensions and patterns are self-maintained. This reduces the magnitude of flood hazards, protects riparian bank vegetation, and prevents adverse channel adjustments. In many instances, channel maintenance flow regimes will maintain fish habitat. The concern over bank erosion and the effect it has on channels applies equally to channel maintenance and flushing flows.

Mechanism	Classification	Typical Flow Conditions	Sediment Characteristics	Bank Moisture	Description
Wedge Failure	Gravitational	Low	Fine-Grained Cohesive	Varies	Tension cracks formed behind bank. Culmann wedge analysis.
Popout Failure	Gravitational	Low	Fine-Grained Cohesive	Saturated	Small blocks forced out at base of channel bank due to excessive pore pressure and overburden.
Preferential Flow-Induced Failure	Hydrologic/ Gravitational	Low	Interbedded Fine /Coarse	Saturated	Selective removal of coarse material due to preferential flow. Removal of support during rapid drop in stage.
Cantilever Failure	Gravitational	Low	Composite Fine / Coarse	Varies	Tension cracks form near base of cantilever. Linked to undercutting
Undercutting	Tractive	High	Generally Non-Cohesive	N/A	Shear stress applied to the lower bank. In general, rate increases with discharge.
Bed Degradation	Tractive	High	Relatively Erodible Bed	N/A	Shear stress applied to the channel bed. Banks fail due to gravitational mechanisms.
Basal Cleanout	Tractive	Varies	N/A	N/A	Banks made unstable by removal of material at base. Residual strength of material determines requisite flow.

Table 1.

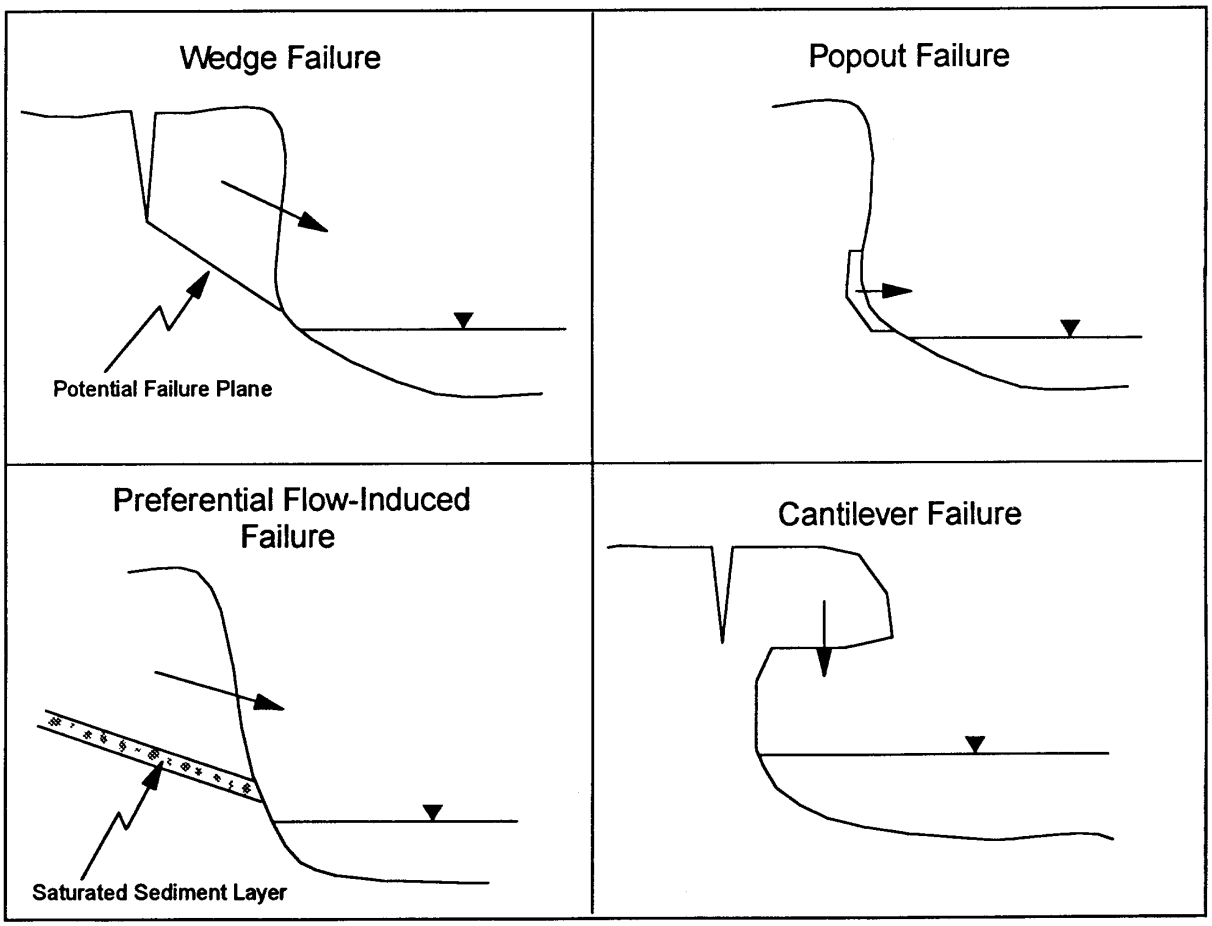


Figure 1. Gravitational Failure Mechanisms.

bank), it is obvious that erosion will occur as the critical shear stress is reached through increasing discharge. Accordingly, tractive erosion is most common at higher flow levels with the notable exception of basal cleanout occurring at potentially lower flow levels as well. Examples of these mechanisms are described in Carson and Kirkby (1972), Odgaard (1989), and Alonso and Combs (1990).

Flushing Flows

Flushing flows are normally designed to be adequate to flush fine-grained sediments from gravels in potential spawning areas. Flows must yield sufficient stress on the stream bed to re-work gravel deposits, a condition normally achieved at or near the bankfull flow. However, the majority of bank failure events (gravitational) occur on the receding limb of the hydrograph. Therefore, much of the fine-grained sediment is delivered to the channel after gravel deposits have been re-worked. In order to keep these gravels clean, this newly delivered sediment must be deposited in alternative locations. Such locations include deep pools, point bars, and other low-velocity, non-spawning environments.

Ecosystem Management Implications

Though flushing flows in stream channels are necessary to remove fine-grained sediment from spawning areas, these same flows may eliminate fine-grained sediment beds necessary for recruitment of riparian vegetation. Effective management strategies for stream and riparian ecosystems must strike a balance between the following three conditions:

1. Maintain adequate flows to flush fine-grained sediment from potential spawning areas and other in-stream habitat environments,

2. Maintain adequate flows to erode stream banks at a natural rate thereby producing fresh sediment deposits for riparian recruitment, and

3. Develop and maintain suitable sites for deposition of fine-grained sediments for future riparian recruitment.

These conditions can be difficult to balance, especially at large spatial and temporal scales. Such a balance is needed, however, for effective watershed management.

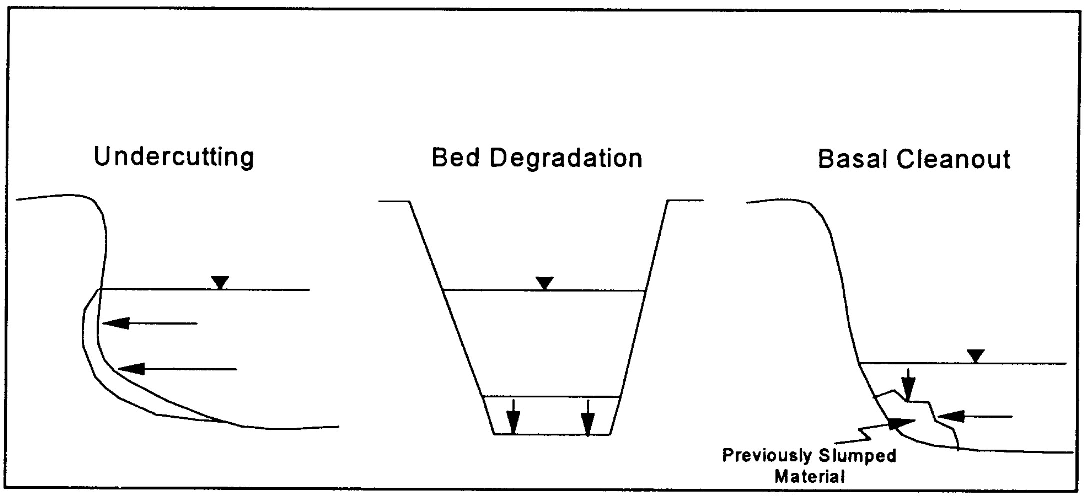


Figure 2. Tractive Erosion Mechanisms.

References

Alonso, C.V. and Combs, S.T., 1990. Streambank erosion due to bed degradation - A model concept, Transactions of the ASAE, v. 33, p. 1239-1248.

Carson, M.A. and Kirkby, M.J., 1972. Hillslope Form and Processes, Cambridge University Press, London, 475 pp.

Odgaard, A.J., 1987. Streambank erosion along two rivers in Iowa, Water Resources Research, v. 23, p. 1225-1236.

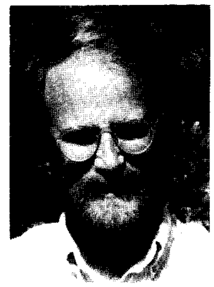
Odgaard, A.J., 1989. River meander model. II: Applications, Journal of Hydraulic Engineering, v. 115, 1451-1464.

Simon, A., 1989. A model of channel response in disturbed alluvial channels, Earth Surface Processes and Landforms, v. 14, p. 11-26.

Springer, F.M.Jr., Ullrich, C.R., and Hagerty, D.J., 1985. Streambank stability, Journal of Geotechnical Engineering, v. 111, p. 624-640.

Thorne, C.R. and Tovey, N.K., 1981. Stability of composite river banks, Earth Surface Processes and Landforms, v. 6, p. 469-484.

Michael P. O'Neill

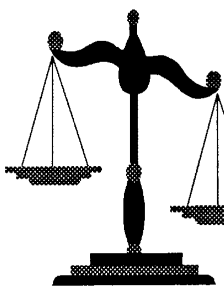


Michael R. Kuhns

Michael P. O'Neill is an Assistant Professor and Watershed Extension Specialist in the Department of Geography and Earth Resources at Utah State University. He specializes in interactions between stream geomorphology and riparian corridor dynamics.

Michael R. Kuhns is an Assistant Professor and Forestry Extension Specialist in the Department of Forest Resources at Utah State University. He specializes in urban, rural and wildland/urban interface forestry.

SUPREME COURT RULES
Water Quantity Related to Water Quality



On May 31, 1994, the Supreme Court issued a ruling by a 7 to 2 vote that the Washington State Department of Ecology has the authority under the Federal Clean Water Act to impose instream flow standards to protect designated beneficial uses.

In this case, the designated beneficial uses were to support salmon and steelhead fisheries. The Court found that it was unreasonable to separate water quantity from water quality when reduced flows would jeopardize the beneficial use.

This has important implications to instream flows because most of the National Forest streams have cold water fisheries as a designated beneficial use. The opposing public utility argued that only the Federal Energy Regulatory Commission had authority to set flow standards.

The case is No. 92-1911 PUD No. 1 of Jefferson County v. Department of Ecology, Washington State. The majority opinion was written by Justice O'Connor. O'Connor wrote, "In many cases, water quantity is closely related to water quality; a sufficient lowering to the water quantity in a body of water could destroy all of its designated uses, be it for drinking water, recreation, navigation or, as here, as a fishery". If a dispute exists when the FERC license is issued the final decision will be FERC's.

Ask DOCTOR Hydro

Dear Doc Hydro: When doing a Wolman pebble count, we often encounter a fine layer of silt coating larger substrate (a boulder, for example). If you wave your hand through the water a few inches from the bottom, this silt becomes suspended. If you do not disturb the water, the first thing your finger touches is silt. What is the protocol for this situation? Do I tally this as silt or do I ignore it?

It depends on your objectives. Pebble counts are typically done for one of three purposes:

- to characterize bed composition,
- to characterize bed roughness; or
- to characterize the size distribution of material available for sediment transport.

The pebble counting procedure is intended to sample coarse riverbed material. In most cases, you should ignore silt on the basis that it is suspended sediment and not bedload and would not figure into either a roughness parameter or entrainment threshold for bed material. On the other hand, if you are specifically trying to actually characterize the proportion of the bed covered with silt, for example where you may have pockets of accumulated silt, include it.

Dear Doc Hydro: What is the origin of the use of the letter Q for discharge?

No one seems to know exactly, but we referred to the book, *History of Hydrology* by Asit K. Biswas (1970), in the hopes of gleaning some insight into this intriguing question.

The established unit of measurement of flowing water during Roman times was one *quinaria*. One quinaria is the area of a pipe 1¼ *digits* in diameter. A digit is an ancient Greek unit of length equal to 1.85 centimeters. One *quinaria* is roughly equal to about 5,000 to 6,000 U.S. gallons per 24 hours.

The Romans believed that the discharge of a natural stream or discharge through a pipe was equal to its cross-sectional area ($Q = A$), irrespective of its velocity. The present day concept that discharge is equal to cross-sectional area times velocity ($Q = A \times V$) was first enunciated around 65 A.D. by Hero of Alexandria. Unfortunately, it was largely ignored. As incredible as it may seem, it took more than 15 centuries to realize that velocity played on important role in discharge when the Italian Benedetto Castelli independently reached this conclusion in 1628.

The 17th century is generally regarded as the beginning of quantitative hydrology. During this period, nearly all scientists of distinction belonged to the Royal Society of London or the Académie Royale des Sciences of Paris. Three men of the period, the French naturalist Pierre Perrault, the French physicist Edmé Mariotte, and the English astronomer Edmond Halley, made outstanding contributions to the development of the science of quantitative hydrology. These investigators were the first to undertake experimental investigations to establish some of the fundamental principles of the science. Mariotte's book *Trait du Mouvement des Eaux et des Autres Corps Fluides* (A treatise of the motion of water, and other fluids) and Perrault book *De L'origine des Fontaines* (Origin of fountains) were widely circulated in scientific circles of the 17th century.

Doc Hydro speculates the letter Q was probably first used and publishd by one of these French scientists as the symbol for quantity or amount of water (*Quantité des eaux* in French). This seems logical since equations probably began to be used widely as the era of quantitative hydrology began. The symbol Q most likely persisted since it translated well into the English quantity of water which is more descriptive than the technical terms discharge, runoff, or flow which might have used the symbols D, R, or F, respectively.

If you have some factual information about this or another explanation, please let us know.

Editorial Policy

To make this newsletter a success, we need **voluntary contributions** of relevant articles or items of general interest. YOU can help by taking the time to share innovative approaches to problem solving that you may have developed.

Please submit typed, single-spaced contributions limited to two pages. Include graphics and photos that help explain ideas.

We reserve editorial judgments regarding appropriate relevance, style, and content to meet our objectives of improving scientific knowledge. Send all contributions to: Stream Systems Technology Center, Attention: STREAM NOTES Editor.

New Publication on Rivers

Luna Leopold's new book, *A View of the River*, was just published by Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138. The book sells for $39.95.

"Leopold is one of the most creative scholars in the field of river morphology in the last fifty years. *A View of the River* is the synthesis of a lifetime's work by Leopold and his colleagues. There is nothing like it."

- M.Gordon Wolman, The Johns Hopkins University

We will publish a review of the book in a Special Summer Edition of STREAM NOTES.

BULK RATE
POSTAGE & FEES PAID
USDA-FS
Permit No. G-40

STREAM NOTES

STREAM SYSTEMS TECHNOLOGY CENTER
USDA Forest Service
Rocky Mountain Station
240 West Prospect
Fort Collins, CO 80525

IN THIS ISSUE