STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

April 1996

Gravelometers: Gravel Templates for Pebble Counting in Gravel-Bed Streams

Particle size frequency distributions are usually obtained by sieving bulk samples of sediment. In the case of surface samples, this is often impractical because particles can be fairly large. Consequently, various particle size axes or dimensions are measured to determine the equivalent sieve size.

The Wolman pebble count is commonly used to sample the surface particle size distribution of gravel-bed rivers. Typically, 100 individual particles are selected from the streambed and the intermediate axis of each particle is measured.

The standard practice is to measure the maximum dimensions of three mutually perpendicular axes, with the largest dimension being the a-axis, the intermediate the b-axis, and the smallest the c-axis. Since most streambed particles approximate ellipsoids, the b-dimension is an acceptable predictor of nominal diameter. The nominal diameter is defined as the diameter of a sphere with the same volume and thus corresponds to sieve size. This in turn makes it possible to determine particle size frequency distribution from the b-axis alone.

Using the b-axis to approximate sieve size equivalents can introduce systematic bias. Sieving has the tendency to produce slightly smaller particle size measurements than b-axis values. This results because certain particles (especially disc-shaped ones) will pass through a sieves square opening *diagonally* and be tallied in the smaller sieve size class even though the b-axis of the particle is actually slightly larger than the sieve size. Theoretically, bias as large as 1.4 is possible for very flat particles.

To overcome this problem, many investigators use a gravel template, sometimes referred to as a gravelometer or pebblemeter, to classify particles into size classes. Effectively, the gravelometer produces the same results as sieving while minimizing operator error which can arise from measuring the intermediate axis using a ruler. The gravelometer consists of a template with square holes of common sieve sizes (usually 8 to 128 mm)

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.*

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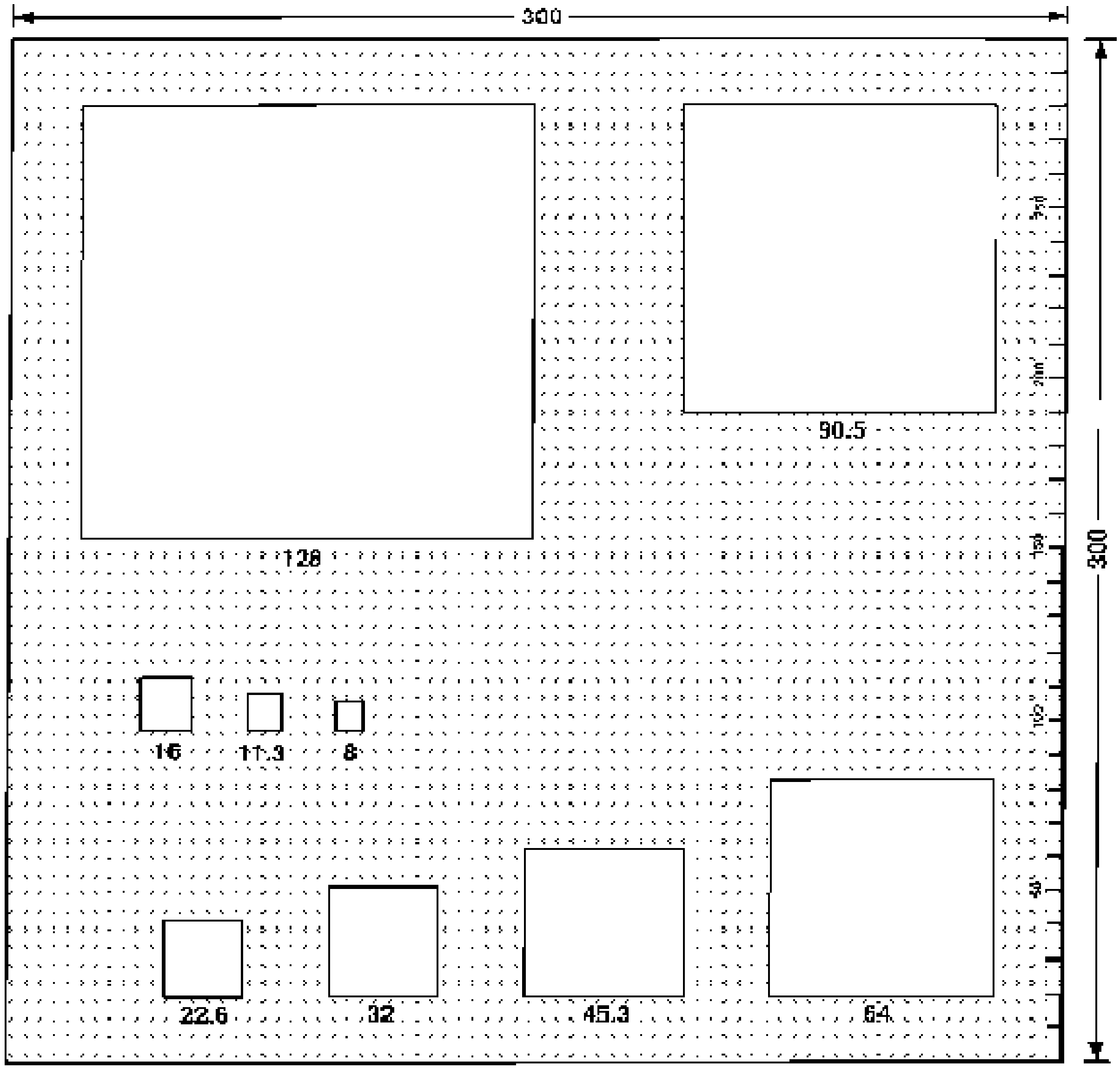

Figure 1. Gravel Template (Gravelometer). Dimensions are in millimeters. Constructed from 4.76 mm aluminum plate.

From: Yuzyk, T.R., 1986. Bed material sampling in gravel-bed streams. Environment Canada, Water Resources Branch, Sediment Survey Section, IWD-HQ-WRB-SS-86-8.

that is used as a hand sieving device to sort particles in the field. Various configurations have been tried. An example of one design is shown in Figure 1, the design used by our testers. Note that the gravelometer has 1/2 phi unit classes, similar to sieve sizes. An alternative template design is shown in Figure 2.

Who Uses Gravel Templates

When doing pebble counts, Forest Service research hydrologist, **Tom Lisle,** in Arcata, California, says, “We always use pebblemeters and I can see no disadvantages. It avoids bias for irregular particles, replicates sieving so you can blend and compare sieved and counted data, and it’s faster than a ruler.”

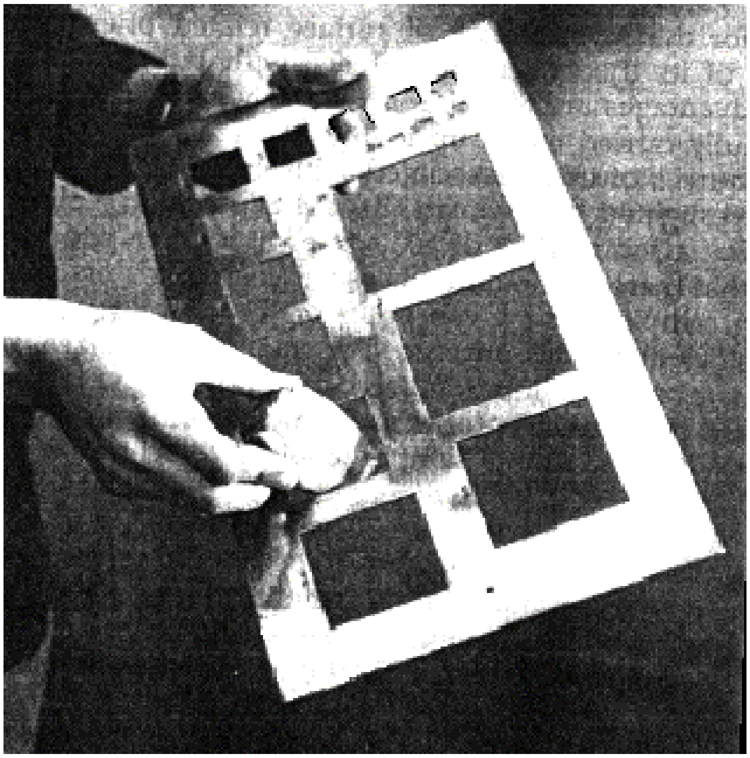

Figure 2. An alternative gravel template design.
From: Hey, R.D. and C.R. Thorne, 1983. Accuracy of surface samples from gravel bed material. Journal of Hydraulic Engineering, Vol. 109, No. 6, p. 844.

Tom's hydrologic technician, **Sue Hilton**, who actually picks up most of the rocks, agrees and says she wouldn't do it any other way. Sue points out, "The advantages are the obvious ones, you don't have to try to figure out which axis is which or project the end of your ruler to the widest part of the rock or read the tiny marks on the ruler. This eliminates a lot of possible sources of error and it makes the whole process much easier."

How Gravelometer Data Compares with Ruler Measured Data

U.S. Forest Service research geomorphologist, **Sandra Ryan**, stationed in Laramie, Wyoming, compared gravelometer pebble counts with data obtained using a ruler. Sampling along an established grid, Sandra measured the same 100 particles on several reaches of St. Louis Creek on the Fraser Experimental Forest with a gravelometer and a ruler during 1995. Typical results for a cobble-bed riffle reach are displayed in Figure 3.

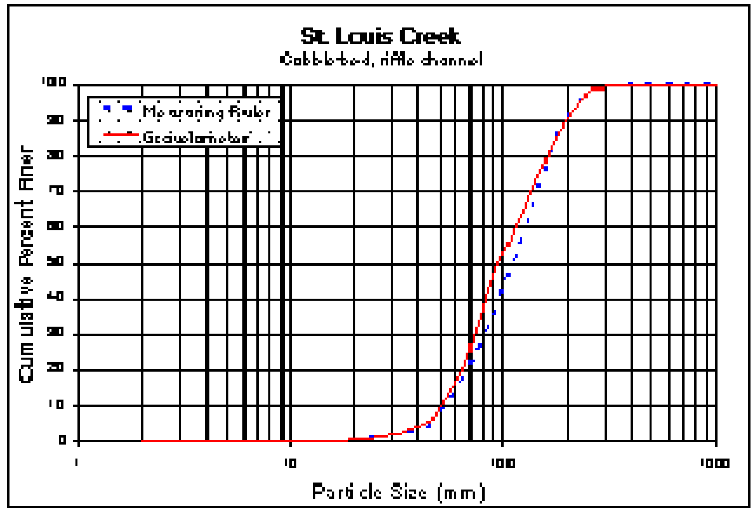

Figure 3. Comparative pebble counts.

There was little difference in the tails of the particle size distributions, however, in the middle of the distribution, d_{50} values differed by approximately 10 mm, with the gravelometer systematically producing smaller values than those measured with the ruler primarily because many particles fit diagonally through the squares. Sandra made the general observation that the number of particles tallied (e.g., 400 particles versus 100 particles) is probably more important than the manner of measuring the particles especially if one wishes to define the ends of the distribution. Since particles are tallied by size class, some detail about sizes is lost with the gravelometer. In this experiment where particles were tallied both individually and by size class, there was virtually no difference in percentiles between the two approaches.

Several field hydrologists (**Greg Bevenger**, Shoshone National Forest; **Gary Decker**, Bitterroot National Forest; **Gary Kappesser**, George Washington & Jefferson National Forests) field tested a gravelometer for us this summer in the course of their field work. The gravelometers were generally less well received by field personnel who tended to note that they were cumbersome to carry and use compared to researchers who seem to think that accuracy outweighs these minor inconveniences.

Observations & Improvements

The following is a compilation of comments and suggestions from the field testers, their field crews, and the researchers previously mentioned.

- My impression is that the gravelometer is good for consistency and training.
- It's easy to use and accurate.
- In one sense the gravelometer is easier to use than a ruler because no thought is involved. Just shove the rock through the smallest hole!
- The gravelometer provides accurate measurements, no matter who is using it.
- The observer doesn't have to make any judgment calls about how to measure a rock.
- The gravelometer is a little difficult and awkward to carry into remote sites and it is cumbersome to use.
- The gravelometer is best used for training and monitoring purposes, but not reconnaissance level work.
- For reaches with large particles, you need both the gravelometer and a ruler to measure the larger particles. Switching between the ruler and the gravelometer becomes a mid-stream juggling act. When rocks are firmly embedded, it is more difficult to measure them in place than with a ruler.
- When working in cold weather, ice forms in individual squares and decreases the size of the opening.
- Expand the size range of the template. Add a 4 mm and a 180 mm square.
- Make it out of a lighter material and paint or make the surface rough to eliminate blinding reflections from its surface.
- Add a hinge so it can be folded in half.
- Round off the corners and drill a hole near one corner so a cord can be tied to it.

How to Obtain a Gravelometer

Constructing a gravelometer is no easy matter but it can be done with a band saw, a file, and a few hours of labor. You can have one manufactured commercially, but expect to pay over $150 for a single unit. We believe significant cost reductions are possible if the gravelometer is produced in quantities. The Federal Interagency Sedimentation Committee currently produces a variety of sediment samplers and related measuring equipment. If there is sufficient interest, they may agree to add the gravelometer to their product list.

STREAM would like to make gravelometers more readily available for field use. To do so, we need <u>*your*</u> *support to gage the extent of interest and the potential market. If you might be interested in purchasing a gravelometer, please send a Data General message, FAX, or E-mail to the STREAM TEAM along with your name, address, and the number of units you may wish to purchase. Doing so is simply an expression of interest and does not imply or make any purchase commitments.*

If there is sufficient interest, the Stream Systems Technology Center will bring this matter to the attention of the Federal Interagency Sedimentation Committee in the hopes of having them produce a gravelometer at reasonable prices.

Stream Activities

Upcoming Events from Larry Schmidt,
STREAM Program Manager

This new column affords me the opportunity to periodically discuss some of the activities STREAM is pursuing.

The Stream Systems Technology Center operates under a team concept and adds people through details, contracts, and agreements to help our three-person permanent staff achieve results. STREAM is involved in many activities a few if which I would like to share with you.

We are working in partnership with **Jeff Kershner** of the Fish Habitat Relationship (FHR) Program to establish an Aquatic Restoration Center, and in another effort, to provide teams of experts to assist forests in responding to instream flow aspects of FERC hydropower relicensing. We are also working in partnership with **Nick Schmal**, R-2 FHR, **Russ Rader**, Rocky Mountain Station, and **Dr. Poff** of Trout Unlimited to develop an individually-based model for salmonids to enhance the existing IFIM instream flow approach.

To further assist forests with pending hydropower relicensing, **Dr. Ned Andrews**, U.S. Geological Survey, and **Dr. Tom Brown**, Rocky Mountain Research Station, are reviewing existing approaches to analyze the effects of hydropower facilities on aquatic and riparian resources. The study strives to provide an improved analytical framework for assessing the potential to enhance or restore the physical structure and function of affected streams below hydropower facilities. The goal is to sharpen the process and thereby reduce costs that do not contribute to an improved situation.

To give Forest Service leaders the foundation in law, philosophy and insight needed to strategically guide water activities on the National Forest, we are developing, in cooperation with management, a course, "Water Resources Management for Line Officers."

Later this year, WinXSPRO, A Windows-based version of XSPRO, a computer program for analyzing stream channel hydraulics at a cross-section will be available. Beta testing is almost complete and training sessions are being developed for technical specialists in several Forest Service Regions.

STREAM has a number of ongoing partnerships where we are testing and developing cost effective instrumentation for stream measurements, including a low cost water level recorder, velocity-head rod for measuring velocity, bedload measurement bridges, and laser mapping computer programs and technology.

In partnership with Colorado State University, we studied the feasibility of developing a set of self-regulating diversion structure for splitting and delivering a pre-determined proportion of the instream flow to an outtake channel. The proposed structure retains the channel maintenance flow in the natural channel while all flows exceeding the instream flow requirement are delivered to the offtake channel.

These are but some of the efforts underway. I look forward to sharing others with you in future issues.

Ask DOCTOR Hydro

Dear Doc Hydro: Would you please recommend some procedures or reference materials for measuring the rate of flow from small seeps and springs in wilderness areas. We need to determine the quantity of water that comes from seeps and springs and would like to do so without major physical or visual impact to these sites within designated wilderness.

Measuring the flow from springs and seeps is almost always difficult because flows tend to be dispersed and rarely concentrate into well-defined channels amenable to discharge measurement. Consequently, the hydrologist needs to be resourceful and creative and devise ways to concentrate the flow.

The most accurate method of measuring small discharges is by observing the time required to fill a container of know capacity, or the time required to partly fill a calibrated container. The basic equipment is a stopwatch and a calibrated container.

A simple way to calibrate a container is to add known volumes of water by increments and measure the depth of water in the container. Calibration can also be accomplished by weighing the container with varying amounts of water in it, noting the depth in the container, and using the formula:

$$V = (W_2 - W_1)/w$$

where: V = volume of water in the container, W_2 = weight of container with water, W_1 = weight of empty container, and w = unit weight of water. Simpler yet, purchase a calibrated container such as a graduated cylinder or graduated beaker of sufficient size.

The basic field procedure consists of interrupting the flow and collecting the water. Sometimes earth dams can be constructed to divert the water through a small diameter pipe for capture. Sometimes, it is possible to place a trough or half of a stove pipe against the spring or seep to carry the water to the calibrated container. Use cloths, clay, or other materials to temporarily seal cracks and force the water to go where you need it. In some situations, soft plastic pails, containers, or beakers can be placed directly in contact with the spring to directly capture the outflow. Where flows come out of the ground in a number of distinct sources or if they are scattered over a broad area, you may need to add up the results of several different measurements.

Use the stopwatch and allow a sufficient period of time so any error in measuring time is negligible. If water is ponded or otherwise diverted, allow the flow to stabilize before beginning. Repeat each measurement three or four times to be certain no errors have been made and to achieve consistent results.

Sometimes springs and seeps are large enough to concentrate discharge into a defined channel but still too small to allow measurement with a Pygmy current meter. Under these conditions, a portable weir plate or a portable Parshall flume may be useful.

One suitable device is a 90º V-notch weir fabricated out of 10- to 16-gage galvanized sheet iron. The weir can measure flows from 0.02 to 2 cfs within 3 percent accuracy. Portable weir size plate dimensions can be found in the reference at the end of this article, however, you will have to find someone to fabricate the weir for you and individually calibrate it.

A portable Parshall measuring flume is another device that can be used to measure flows when the depths are shallow and velocities low. A modified Parshall flume is recommenced because of its simplicity, relatively light weight, and ease of installation. The flume is installed by placing it in a hole dug in the channel and by filling in around it to prevent any water from bypassing it and leveling it with a carpenter's level. Discharge is determined by staff gage readings and a flume rating table.

Parshall measuring flumes with throat sizes as small as 2 inches are available for about $300. The 2 inch size is somewhat portable. It weights 23 pounds, is about 2 feet long, and can measure flows from 0.0065 to 0.47 cfs. One supplier is CISCO Culverts and Industrial Supply Company, Casper, WY (307) 472-7121.

For additional information about flumes and weirs, see: Buchanan, T.J., and Somers, W.P., 1968. Discharge measurements at gaging stations. U.S. Geological Survey Techniques, Water-Res. Investigations, Book 3, Ch. A8, 65 p.

Doctor Hydro invites you to send in written questions via the mail, on the Data General, FAX, or E-mail to: "Ask Doctor Hydro." With each issue of STREAM NOTES, we will select at least one question of widespread interest and provide an answer.

The RIVER Field Book

Dr. Luna B. Leopold has sent us information about a new field tool, *The RIVER Field Book*, specifically developed to assist hydrologists, fisheries biologists, geomorphologists, engineers, and others working with rivers with field data collection.

The RIVER Field Book is a standard 4.5" x 7" hard cover, water resistant field book. What makes this field book unique is the addition of a variety of specialty pages useful as forms for data recording, data analyses, and the measurement of channel cross-sections, longitudinal profiles, channel materials, and streamflow—all of the basic information one generally needs to measure to begin to understand a river.

The book also contains 15 pages of graphs, charts, and data relationships useful when working around rivers. Examples include bankfull discharge as a function of drainage area for selected regions, a set of Rosgen stream classification diagrams, current meters rating tables, channel flow resistance data, and plotting paper for peak flow frequency, flow duration, and pebble count data.

Prices are comparable with standard field books. Information on pricing and ordering is available from:

Wildland Hydrology Books
13341 East Highway 160, # 8
Pagosa Springs, CO 81147
Tel: (970) 264-7100 or 7120
FAX: (970) 264-7121

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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.

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