STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

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REDUCING OBSERVER BIAS IN PEBBLE COUNTS

The pebble count technique developed by Wolman in 1954 has long been used to document the surface particle size distribution of coarse riverbed material. Research has concentrated on determining the minimum number of particles needed for a representative sample and on determining if results from the pebble count method are equivalent to results from areal and volumetric techniques. The standard 100-count systematic technique applied in transects has been shown to provide equivalent results to the grid approach.

Little work has been done however to determine the variability associated with different observers collecting data from the same site or the same individual repeating measurements. Understanding this variability is critical for determining whether differences between sites, or at a site over time, are real or the result of observer bias and sampling error. A recent article *Pebble Counts and the Role of User-dependent Bias in Documenting Sediment Size Distributions* (Marcus et al., 1995) sheds light on these questions.

This study showed that user bias plays a significant role in data generated from pebble counts. All of the observers involved in the study obtained results that were significantly different from those of other observers for at least some size classes. Bias resulted from incorrect measurement technique and biased selection of particles from the streambed.

The standard deviation of single observer data ranged from ±2.6 mm for 2 mm particles to ±35 mm for 300 mm particles. The standard deviation for multiple observer measurements were larger, ranging from ±4.2 mm for 2 mm particles to ±64 mm for 300 mm particles. From this the authors caution managers to take great care before basing biological, hydrological, or management decisions on pebble count data collected by different observers.

Sources of Observer Bias - The study examined two sources of bias: (1) selection of consistently smaller or larger rocks than other individuals, and (2) consistent undermeasurement or overmeasurement of rock sizes.

By comparing observer measurements done with a ruler with precise measurements done with a caliper, the study concludes that poor measurement tech-

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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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nique plays a small role in biasing size estimates for some observers. Measuring the true width of the intermediate axis was most consistent for rounder rocks and became increasing more difficult as rocks become more facetted, that is, where it was more difficult to identify the intermediate axis.

Pebble selection in the stream was determined to be the primary cause of sample bias. Based on field observations the senior author noted that some observers seemed to avoid large and visible rocks, perhaps because they did not want to automatically select all the large clasts. In other cases, where the sediment immediately below a sampler's finger consisted of fine sediment, the individual would allow the current to carry his or her finger into contact with a larger rock immediately downstream. Interestingly, pebbles collected with insulated waterproof gloves were not significantly different from those collected with bare hands.

"Whenever possible, only one individual should select and measure pebbles. Bias can be reduced by rigorous training of individuals, by using templates to measure sediment size, and by using grids on the stream bottom to select particles.
If two or more individuals collect samples, they should conduct replicate samples to provide a basis for later calibration of results."

Reducing Pebble Count Error - The measurement error problem is most easily corrected by using templates (gravelometers) to measure particles. Templates mimic a sieve, and by placing particles through the smallest possible opening, errors associated with identifying the intermediate axis are reduced. Templates however cannot be used to measure large embedded rocks frequently encountered in streams. This problem is common to other measurement techniques as well.

Observers should receive training to consistently identifying the intermediate axis in the same manner. Testing observers with a set of previously measured particles is suggested.

Eliminating selection bias is difficult. The authors hypothesize that a fixed grid or points along a transect should theoretically remove this source of bias, but point out that even with a grid, individuals may select different particles beneath a fixed point. An adjustable quadrant that can be fixed to the stream bottom is suggested, but information on how to construct one of these devices is lacking. In the absence of a device for establishing a fixed grid or transects, replicate samples at a site to document the relative bias of individuals and to calibrate readings among different observers are strongly recommended.

For the complete article see:

*Marcus, W.A., Ladd, S.C., Stoughton, J.A., and J.W. Stock, 1995. **Pebble counts and the role of user-dependent bias in documenting sediment size distributions.** Water Resources Research, Vol. 31, No. 10, p. 2625-1631.*

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SOME THOUGHTS ON SOLO SURVEYING

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With decreasing budgets and reductions in personnel, it is becoming increasingly difficult to put together field survey teams — or even to find one person to accompany you in the field. So I have developed procedures to go it alone — to take measurements of physical stream parameters without an assistant.

These procedures are not intended for stream channel reference sites or similar situations where precision is essential, but rather for general surveys where stream measurements are desired to classify streams (Rosgen classes, etc.) or otherwise characterize a large number of streams quickly.

Working alone in the field requires extra safety precautions. These might include taking proper clothing and equipment, including emergency and first aid items; carrying a radio; and telling someone where you will be and when you will return. In some locations and some situations, safety concerns may preclude solo surveying.

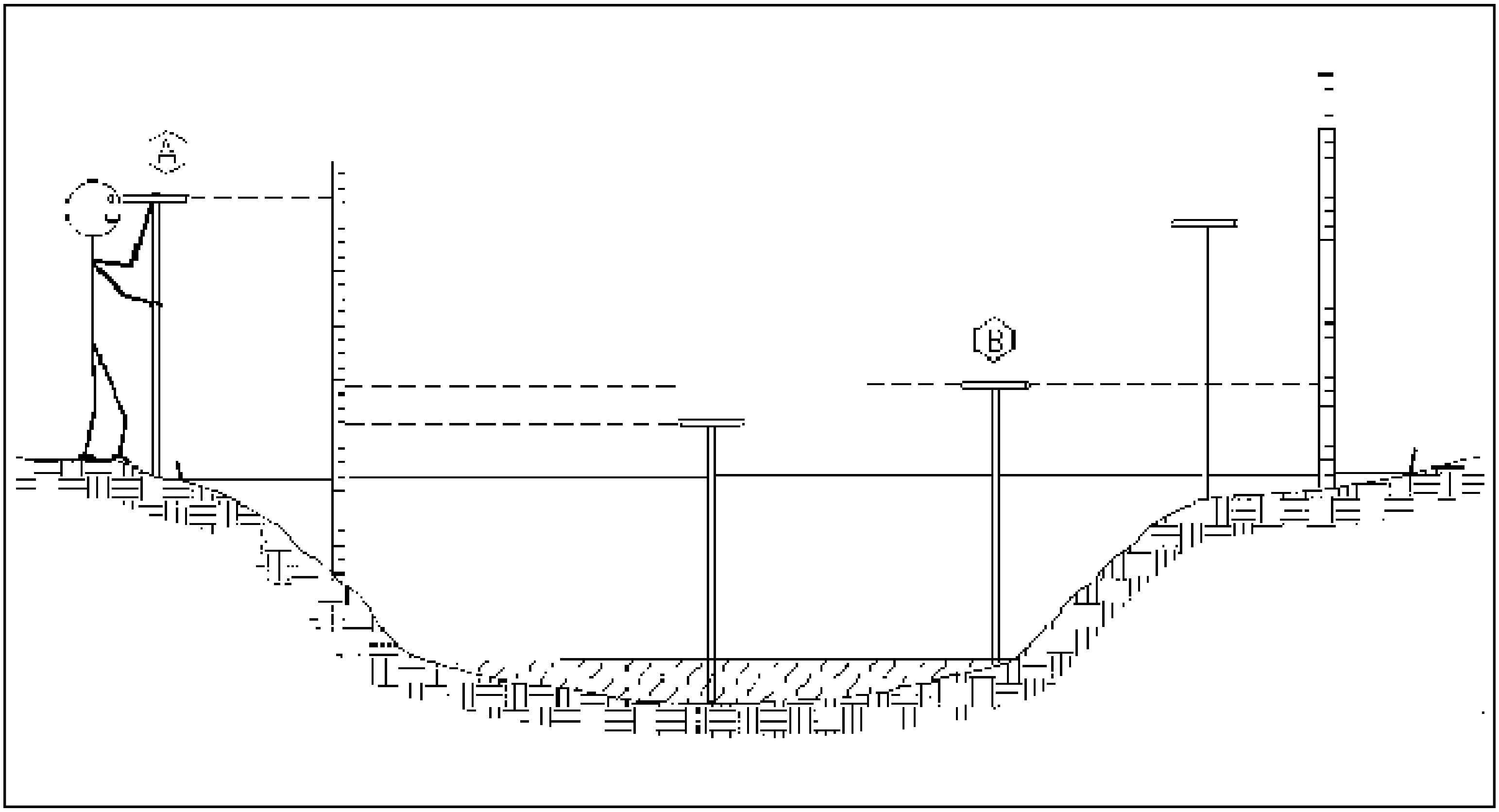
Pebble Counts — Use of a voice-actuated pocket-size tape recorder, fastened in a shirt pocket, makes this simple. The tape is started by your voice and turns off a few seconds after you quit speaking. The recorder's sensitivity can be adjusted so that background noises will not activate it. Since the first word spoken will be somewhat garbled as the tape starts up, I always preface the size class with a preparatory word, such as "and...", so that the tape is in motion before the size class is spoken. After each measurement, I click a tally counter to keep track of the number of pebbles measured. After I have taken the desired number of measurements, I replay the tape and tally the measurements on a data sheet. This procedure takes only 25-30% longer than with another person as recorder. A suitable tape recorder can be purchased for about $60.

Cross-Section — A laser level will allow solo surveying of cross-sections and gradients, but these instruments are expensive, bulky, heavy, and relatively fragile — not very appropriate for back country measurements.

In my approach to measuring cross-sections, I stretch a measuring tape, attaching it to a survey pin at each end of the cross-section (see figure on next page). I then set up a folding rod or a pocket rod. At appropriate points along the tape, I then set a 5X magnification hand level on top of a vertical stick (I use a five-foot folding rule) and take readings on the rod ("A" in figure). If, as I move along the tape, the rod becomes obscured or too distant, I move the rod, taking from one location a reading on the rod both before and after moving it, thus establishing a turning point. Or I set up a second rod, again taking from one location a reading on both rods ("B" in figure).

Here, also, I use the voice-actuated tape recorder to record distances along the tape and readings on the rod, writing these down on a data sheet as soon as I finish all the measurements.

The rod should be set as vertical as possible. To keep it upright, it can be secured to a tree or limb. A range pole tripod can also be used to hold the rod upright. Leaning the



rod against a tree or limb gives acceptable results if the lean is kept to 4 degrees or less. This introduces an error of less than 0.2 percent.

Another method for taking cross-section measurements quickly is to stretch a string (a mason's chalk line works well) or tape across the channel. Check to see that the string or tape is truly horizontal across the channel. A folding rule or rod can then be used to measure distances from the string or tape to the channel bottom.

Another approach that works well for wide channels is the sag-tape method. Verticals are measured from a metal tape stretched across the cross-section. This tape will have a moderate sag in it. The computer program R2-CROSS compensates for the sag, based on a measure of tape tension from a spring scale attached to the tape, and computes corrected depths. For details of the sag-tap procedure, refer to: *Measuring Cross Sections Using a Sag-Tape: A Generalized Procedure*, USDA Forest Service General Technical Report INT-47, Ogden, UT, by Gary Ray and Walter Megahan, 1979.

Gradient — I set up a rod near the middle of the reach over which gradient is to be measured. At an appropriate point upstream, I set my vertical stick at the water surface, place the hand level on top of the stick, and take a reading on the rod. I then go downstream, below the rod, and take another reading. The difference between the two readings is the drop of the stream between the two points. I measure distance with a tape or hipchain. Where the gradient needs to be measured over longer distances, turning points should be used, as described above.

Sinuosity — For field measurements of sinuosity, I walk up the channel pulling a hipchain. I keep the string on one side of the channel, looping it around twigs, etc. along the bank. Measuring sinuosity along one bank should not be significantly different from measuring it up the center of the channel as long as full meander wavelengths are measured. After measuring the channel length, I use the hipchain to measure valley length.

SOME THOUGHTS ABOUT LASER LEVELS

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The advent of laser levels and surveying instruments makes surveying easier than ever allowing one person to do simple surveys such as stream channel cross-sections and channel slope measurements. Laser levels project a beam in a circular plane through a rotating prism. A special leveling rod with a detector is moved up or down until the beam intersects it. The use of laser levels is deceptively simple - set the instrument up, turn it on, watch the laser spin, get out the rod, wait for the magical beeping sound, record the data and you're done.

New technology offers many advantages. At the same time surveyors need to remember that basic surveying principles are unaltered by the new equipment. This is especially true regarding error trapping and equipment checking. Even with a laser level it is wise to run a closed level loop to verify that the data is within accepted standards. Some additional things we learned includes:

1. Check the calibration of the instrument each time you use it. Do the standard two peg test or set the laser up, take a reading on a fixed point, rotate the instrument 90 degrees and take a second reading on the fixed point repeating this procedure as you rotate the instrument 180 and 270 degrees. All of the reading should be identical. If they are not, the instrument needs to be calibrated.

During our last outing with a laser level, we were told that the laser is always in calibration as long as it spins. If the laser is no longer level, it simply won't run. We found out the hard way that this is not true. Our laser appeared to work fine but yielded a closure error of about one meter at the end of the day. Check the calibration each time you use it and especially if it is bumped, dropped, or otherwise jolted.

2. Never run two crews with two lasers in an area at one time to increase productivity. The sensor on the rod doesn't discriminate between the laser beams sent out by each instrument. By projecting two laser light planes at one time, you may inadvertently switch from reading one laser to the other. If you don't catch it, the result is garbage data.

3. Avoid shooting excessively long distances. Even though the laser is capable of shooting elevations 3,000 feet away, this is not a good idea. Remember, the earth is not flat! Try to keep the distance between the laser and the point you are shooting for elevation to distances of less than 300 feet. If you need the elevation of a point 3,000 feet away, move the instrument several times by establishing a number of turning points.

4. If you are working in brushy terrain (like riparian areas with heavy willow vegetation), a traditional level often "sees" through the bushes better than a laser. Don't throw away your old equipment. In some cases, it's better than the new.

5. Keep good notes. If you have two laser levels, record the serial number in the field notes at the beginning of each day so that if one instrument malfunctions, you can salvage some of the day's work . Always close each survey in the field and do the computations before you take down the instrument and depart for the office.

Ask DOCTOR Hydro

Dear Doc Hydro: A local conservation district is working with riparian land owners to implement riparian and stream channel improvements. We have just experienced a significant rain on snow event. Ice damming was common and caused overbank flooding. Temperatures prior to the event were below zero for some time so formation of ice was common. Some land owners contend that the presence of riparian vegetation contributes to the build up of ice and therefore to the potential higher water when the dam breaks. From a technical viewpoint, what is the function and occurrence of ice formation on contrasting good and poor quality stream systems?

In summary, deep streams bordered by thriving healthy riparian areas (i.e., trees and shrubs) are less likely to have ice build-up problems than shallow, exposed streams.

The formation of ice in a stream involves the same basic processes of heat exchange, nucleation, and growth that lead to the formation of lake ice. The major difference is that with streams, the fluid is in motion and therefore, the evolving ice crystals must oppose the forces of the moving water if they are to grow and ultimately form a solid ice cover.

Surface flow velocity plays an important role in ice formation. Conditions most suitable for ice formation occur where flows are laminar, permitting supercooling of the surface. Flow velocities less than 0.5 feet/second are common along shores of most reaches and may also occur over the entire stream. Under these conditions, a surface layer of supercooled water can develop on the low velocity flow. Once nucleated, the ice sheet can quickly spread across the entire surface. The first ice normally forms along the margins of the stream, near the banks, although it can be initiated mid-stream and progress simultaneously upstream, downstream, and toward the shore. Ice growth rates under slow velocity conditions can be extremely fast and there are reports of a reach of river forming an ice cover over a 5 mile distance in less than 15 minutes.

In turbulent sections of the stream, water supercooled at the surface constantly mixes with the underlying flow and ice formation slows. The entire cross section must reach 0°C and then with a slight degree of further cooling (about -0.1°C), small ice particles, called frazil ice, begin to form. Because the supercooling that controls frazil formation is not great, slight changes in the thermal regime, such as frictional heat produced by rapids, can appreciably affect frazil ice production.

Hydrometeorological conditions most favorable for ice production include cold clear nights with large heat loss by long-wave radiation and a strong wind accompanied by cold, dry air which produces large convective and evaporative heat losses. It is fairly typical for frazil ice formation to follow a diurnal cycle characterized by rapid growth at night and cessation during the day. Given adequate temperature conditions, frazil ice continues to grow and a stationary ice sheet may be formed either by having border ice completely cover the stream or by some mechanism which produces a physical halt of the ice flow in the stream. When the stream is shallow and the turbulence of the water is high enough to bring supercooled water to the bottom, ice may attach to underwater objects and produce anchor ice. Given suitable hydrometeorological conditions, anchor ice can form blankets of ice on the stream bottom. Anchor ice most often forms at night. Once the stream begins to warm slightly, or when solar radiation penetrates to the bed, the bond between the bottom and the anchor ice disintegrates and the ice releases. Floating anchor ice is readily discernible because it often contains embedded gravel and other bed material.

Once a surface ice cover is established, it thickens as the freezing front migrates vertically downward into the water column. A surface snow cover tends to retard the growth of static ice by slowing heat loss to the atmosphere. In high-northern climates, ice growth and low winter flows can be severe enough to cause complete freezing of the bed of small streams.

Break-up of ice occurs as ice decays due to thermal degradation of the ice cover. Break-up at a site depends on a number of variables including cover thickness, ice strength, river geometry, flow velocity, and stage. The severity and pattern of breakup is influenced by the alignment of the stream relative to the local climate. On streams in which snowmelt, runoff, and ice break-up proceed downstream with the seasonal advance of warm weather, the ice jam and flood risk is heightened because the spring flood wave is always pushing against an intact ice sheet. On streams flowing in a direction opposite to that of regional warming, risk is reduced because thermal ablation of the ice pack greatly reduces the probability of ice jamming.

Collapse of an ice jam and the release of water in channel storage can produce a surge characterized by dramatic increases in downstream water levels and velocities. The magnitude and rate of the surge has a far more catastrophic flood potential than that possible under similar open-water flow conditions. The abrasive action of rapidly moving break-up fronts can be an important modifier of channel beds and banks, particularly in alluvial rivers.

So what does all of this have to do with good or bad stream conditions or the vegetative state of the riparian area? Specific literature linking ice to channel and riparian condition is rare, but inferences can be drawn from the physical processes described above.

The larger the surface area to volume ratio, the more quickly a stream exchanges heat with the atmosphere. Hence, given the same meteorological conditions, wide shallow streams cool most rapidly while deep rivers are usually the last to freeze. Since excessive grazing often result in a widening of the stream channel, we can infer that ice problems are exacerbated.

We also know that open water streams without forest cover freeze earlier because the missing canopy allows for outward radiation from the water surface, especially at night. The presence of a canopy reflects heat radiation back to the stream surface, thus keeping the stream warmer relative to an exposed reach. From this we can infer that well-vegetated streams bordered with riparian trees and shrubs will tend to have less severe freezing than stream reaches devoid of streamside vegetation.

For additional reading about ice see:
Maidment, D.R., 1992.
Handbook of Hydrology. McGraw-Hill, New York. Chapter 7: Snow and Floating Ice.
Ashton, G.D., 1986.
River and Lake Ice Engineering.
Water Resources Publication, Littleton, CO.

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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