# LET RIVERS TEACH US

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River channels are being altered on a massive scale for many purposes, including flood control, road engineering, fishery improvement and erosion control. Geomorphic principles of river form and process are known to few of the designers of such works. It is proposed that that there be established a center for case study storage and dissemination so that knowledge of successes and failures adds to our ability to maintain and improve river environments.

Only a few weeks ago I received notice from one of the federal resource agencies that they plan to do fisheries habitat improvement work in local wetlands. The improvement will consists of five log drop structures and ten log-and-rock revetments in a reach of 220 feet of channel. This, they say, will reduce erosion and the impacts of sediment deposition.

Unfortunately, many fisheries specialists, federal engineers and consulting firms have made no attempt to absorb our rapidly increasing fund of knowledge of river process and channel behavior.

Rivers do not construct drop structures. Rivers construct and maintain, by process of erosion and deposition, channels of particular characteristics including dimensions, planforms, cross sections, gradients, and distributions of sediment materials. These morphologic parameters are scaled to the size of the drainage basin and the nature of the rocks of the area. But they are scaled appropriately to maintain quasi-equilibrium.

The idea of check dams or drop structures became a widespread practice in western United States in the 1930's, when the newly formed Soil Erosion Service faced the formidable gullies dissecting alluvial valleys. I remember very well the philosophy of those erosion engineers who stated flatly that a check dam in a gully would cause aggradation all the way to the watershed divide and the gully would be filled its entire length.

That this was not happening, they attributed to the limited time of observation. In time, they said, the gully would fill its entire length. It is clear that the experience over a thousand years in Palestine, in Mexico and elsewhere was quite unknown to the erosion engineers.

It is obvious to most of us today that a grade control structure flattens the channel gradient upstream for only a short distance and intrudes an unnatural-anomaly into the fluvial system. Such an anomaly will be attacked by the flow and, given time, will be eliminated. It will ultimately be destroyed by undercutting, by lateral erosion of the abutments, by scour hole erosion at the toe, or by some combination of these.

If a reach of channel is suffering unusual bank erosion, downcutting of the bed, aggradation, change of channel pattern, or other evidence of disequilibrium, a realistic approach to amelioration of these problems should be based on restoring the natural combination of dimension and form characteristics of similar channel in quasi-equilibrium. These characteristics include appropriate values of width, gradient, pool and riffle sequence, length, radius, amplitude of curves and meanders, and hydraulic roughness.

A procedure might, in principal, include the following steps. Inspect the channel upstream and downstream of the reach exhibiting problems. Inspect nearby or similar valleys that appear more natural. Choose a reach of a natural river, which appears to represent the condition of the problem channel before it was disturbed or disrupted.

At this point it is useful to remind ourselves what are the principal morphologic features of the river channel that must be retained or restored. First, the slope or gradient of the channel must be the same as it is in the natural or undisturbed reach of the river. The deviation from this natural slope is the clearest reason that drop structures cannot be permanent and should be avoided.

The second imperative is the channel width. The width must represent the bankfull dimension such that when the normal bankfull discharge is exceeded, the water will overflow onto a flood plain of much greater width. This means that both width and depth at bankfull must be considered and an overflow area provided for greater discharges.

If the river curves or meanders present in the undisturbed reaches have been eliminated or importantly changed in the disturbed area, they must be reinstalled by physically constructing them. The layout of curves is the principal way the desired gradient is maintained or restored. No natural channel is straight, so the reconstruction of curves of appropriate size and shape is a main element in river restoration. The bed elevation should vary, in that pools occur in the curved reach and shallower zones in crossover.

The dimension of width, depth, meander, length, radius of curvature, slope, and other features have been published for many regions in the United States. These dimensions can be used as a rough check on those measured in undisturbed reaches of the river in question.

To give a few examples of such dimensions, the channel width tends to increase downstream as the square root of the bankfull discharge. The mean velocity at bankfull is, for small to medium size rivers, about five feet per second. A single sequence of a pool and a riffle usually has a length along the stream of five to seven channel widths. The radius of curvature for most channel bends is about two to three times the channel width. The bankfull level closely corresponds to the mean height or mean elevations of the point bar that commonly extends streamward from the convex bank of a channel bend.

There are a few generalizations drawn from scientific studies of channel form that can be useful in practical problems of river restoration or maintenance. Width is the morphologic parameters most easily altered by the river. If the river is deprived of some of its natural discharge, it will narrow its channel. Bank erosion usually will follow unusual or unnatural alteration in sediment supply or a change in water-sediment relation. An alteration in channel gradient (slope) is the most disruptive to the natural equilibrium. The increase in gradient is the main reason channel straightening or channelization is so destructive to river systems. Also, river curves provide an essential source of hydraulic resistance necessary for equilibrium.

Paucity of field data is a major roadblock to river work. To approach any of these matters quantitatively one must have some data measured in the field. The value of river parameters can be estimated, but with no assurance of verity. Unfortunately, too many professionals approach such problems with the supposition that computer can do all. In river work, computer modeling is an insidious procedure in which an air of surety hides questionable assumptions. A computer gives numerical answers, but the bases on which the computation rests are hidden.

Some of the most important parameters are measured at gaging stations of the U.S. Geological Survey but the number of measuring stations has been reduced in recent years. Moreover, some of the needed values are not measured at gaging stations at all, especially slope, a carefully selected representative cross section and the size distribution of bed material. No field determination of bankfull stage is part of gaging station procedure. Suspended load is measured at about one station of ten, and bedload at only a few of the suspended load stations. But more important than the small number of locations, the number of days on which sediment is measured is only 10 to 15 days per year, often too few to span a range of discharge values. The number of days bedload is measured is even fewer, 2 to 10 per year. Some consultants who are involved in river restoration are gradually beginning to collect field observations as part of their regular practice, but this is not yet common. There is too much reliance on computer models with no field measurements to support the computations. Indeed, even the Corps of Engineers tends to rely on computers and estimates rather than engaging in actual measurement in the development of a design for river improvement. In fact, with the increase in river improvement work, there is even less data being collected than in previous decades.

With the reduction of data collected at gaging stations and the increase in work to be done, other agencies of federal and state government will have to start collecting data themselves. This will be an unfortunate direction because there will be no standard of excellence of the process and the results will not be published as has been the case under the Geological Survey.

For example, the Environmental Protection Agency states that sediment is one of the most important pollutants from non-point sources. Yet it makes no measurement of this pollutant. It will probably be necessary for them to get into the field collection of sediment data.

The Corp of Engineers has certain responsibilities in granting permits for some kinds of work on rivers. Yet various offices of that agency have totally different ideas of what works are harmful and what are beneficial. Experience does not seem to be discussed among offices, much less gathered, collated and disseminated. If there is not central information base in a single-agency, imagine the variety of practices among the several federal agencies doing river channel work: the Soil Conservation Service, (now the Natural Resources Conservation Service), Forest Service, Bureau of Reclamation, Fish and Wildlife, to name a few. In addition the state agencies do such work using engineers, fishery biologists, highway people. And there are private organizations.

There are a lot of people harming rivers. There are also people who are improving them. But we do not know who is doing what. We are all trying as best we know how to do effective maintenance and improvement work. But there is no attempt to learn from each other. No doubt mistakes are repeated. No doubt success goes unnoticed.

We have a problem in river restoration that presently is leading to serious consequences but is also possible of solution. The problem is lack of communications and trading of experience. As a result, successes in field restoration are little known, while mistakes are repeated indefinitely.

There are many handbooks, instruction manuals, and how-to-do-it pamphlets on channel improvement. There are none I have seen that makes an evaluation of different techniques with explanation of the initial condition, the recommended solution, and the result of the treatment. What is needed is a gradually accumulating file of case studies describing with text the illustration the original condition, an assessment of the basic cause of the problem, the techniques and construction details of treatment, and an objective analysis of the result.

If such a file was initiated and all operatives urged to contribute, it is certain that we would learn from each other and our techniques would become more closely tailored to the type of river and the type of problem.

I propose an expanded effort that hopefully would involve federal and state personnel, consultants, and academics. Who or what organization should take the lead is not specified. But one thing seems clear. We must let the river teach us. Not just a few of us. Let the river teach all of us.