

# STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station

January 2000

## Alluvial River Ecosystem Attributes

by Bill Trush and Scott McBain

The foundation of a river ecosystem is the dynamic interaction of flowing water, sediment, and riparian vegetation. In our work to restore river ecosystems, too often we were informed that restoring the fishery came first, and restoring the river ecosystem came second. Although early methodologies such as the Instream Flow Incremental Methodology expounded the need for an integrative perspective to managing regulated rivers, single species management reigned in the 1970s and 1980s. Most flow prescriptions centered on specific habitat needs of salmonids, rather than addressing ecosystem needs. The 90s witnessed a progressive realization that single species management, the icon of the Pacific Northwest and elsewhere, is failing. However, demonstrable failure has not been enough to fully reverse attitudes and institutions.

The alluvial river attributes emerged from necessity. We desperately wanted a straightforward (a.k.a. simplified) presentation of river ecosystem needs adaptable to a broad range of rivers. We wanted to avoid becoming mired in definitions, such as river health or river integrity (though we find the terms useful). The river ecosystem needs had to be quantifiable, directly applicable to management prescriptions, and explicitly relevant to fish species of concern. They had to make intuitive sense to non-

geomorphologists and the informed public alike. "Do these things and your restoration plan is blessed" is not what we expect from applying the attributes.

River ecosystems are extremely complex; successfully predicting many cause-and-effect relationships in the near future remains uncertain. But we are reasonably certain that fluvial geomorphic processes sustain an alluvial river ecosystem's structure and function. Therefore, managing regulated rivers by restoring natural geomorphic processes, within contemporary sediment supply and flow constraints to the greatest extent possible, is a realistic start-up strategy for restoring and managing alluvial river ecosystems when encountering inevitable uncertainties. The present set of alluvial river attributes addresses cobble and gravel-bedded alluvial rivers, such as the many Sierra rivers crossing California's Central Valley.

We identify ten attributes (see table next page) of cobble and gravel-bedded alluvial rivers necessary to help recover and sustain ecosystem integrity in regulated alluvial rivers. These attributes integrate the need for variable inter- and intra-annual hydrographs, a balanced sediment budget, dynamic riparian plant communities, and diverse alternate bar morphologies. Many of them require flow thresholds. Attainment of these attributes should foster a structurally

*STREAM NOTES is produced quarterly by the Stream Systems Technology Center, Rocky Mountain Research Station, 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, and limited to two pages. Graphics and tables are encouraged.*

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# General Attributes of Alluvial River Ecosystems

## **Attribute No. 1. Spatially complex channel morphology.**

*No single segment of channelbed provides habitat for all species, but the sum of channel segments provides high-quality habitat for native species. A wide range of structurally complex physical environments supports diverse and productive biological communities.*

## **Attribute No. 2. Flows and water quality are predictably variable.**

*Inter-annual and seasonal flow regimes are broadly predictable, but specific flow magnitudes, timing, durations, and frequencies are unpredictable due to runoff patterns produced by storms and droughts. Seasonal water quality characteristics, especially water temperature, turbidity, and suspended sediment concentration, are similar to regional unregulated rivers and fluctuate seasonally. This temporal “predictable unpredictability” is the foundation for river ecosystem integrity.*

## **Attribute No. 3. Frequently mobilized channelbed surface.**

*Channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge, which on average occurs every 1-2 years.*

## **Attribute No. 4. Periodic channelbed scour and fill.**

*Alternate bars are scoured deeper than their coarse surface layers by floods exceeding 3- to 5-year annual maximum flood recurrences. This scour is typically accompanied by re-deposition, such that net change in channelbed topography following a scouring flood usually is minimal.*

## **Attribute No. 5. Balanced fine and coarse sediment budgets.**

*River reaches export fine and coarse sediment at rates approximately equal to sediment inputs. The amount and mode of sediment storage within a given river reach fluctuate, but also sustain channel morphology in dynamic quasi-equilibrium when averaged over many years. A balanced coarse sediment budget implies bedload continuity; most particle sizes of the channelbed must be transported through the river reach.*

## **Attribute No. 6. Periodic channel migration.**

*The channel migrates at variable rates and establishes meander wavelengths consistent with regional rivers having similar flow regimes, valley slopes, confinement, sediment supply, and sediment caliber.*

## **Attribute No. 7. A functional floodplain.**

*On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage. Lower terraces are inundated by less frequent floods, with their expected inundation frequencies dependent on norms exhibited by similar, but unregulated river channels. These floods also deposit finer sediment onto the floodplain and low terrace.*

## **Attribute No. 8. Infrequent channel resetting floods.**

*Single large floods (e.g., exceeding 10-yr to 20-yr recurrences) cause channel avulsions, rejuvenation of mature riparian stands to early-successional stages, side channel formation and maintenance, and create off-channel wetlands (e.g., oxbows). Resetting floods are as critical for creating and maintaining channel complexity as lesser magnitude floods.*

## **Attribute No. 9. Self-sustaining diverse riparian plant communities.**

*Natural woody riparian plant establishment and mortality, based on species life history strategies, culminate in early- and late-successional stand structures and species diversities (canopy and understory) characteristics of self-sustaining riparian communities common to regional unregulated river corridors.*

## **Attribute No. 10. Naturally fluctuating groundwater table.**

*Inter-annual and seasonal groundwater fluctuations in floodplains, terraces, sloughs, and adjacent wetlands occur similarly to regional unregulated river corridors.*



complex channel morphology essential as habitat. Initiation of channelbed mobility (Attribute No. 3), scour deeper than the channelbed surface (Attribute No. 4), floodplain inundation and deposition (Attribute No. 7), and riparian seedling scour (Attribute No. 9) are not gradual processes but occur over narrow flow ranges. Their identification, quantification, and use in assessing restoration prescriptions are critical to determining annual flow regimes for regulated river systems.

Large unregulated rivers with morphologies comparable to pristine conditions are rare, making within-basin comparisons between regulated and unregulated river systems flawed or simply impossible. Therefore, quantifying general fluvial geomorphic and riparian processes common to contemporary unregulated river ecosystems outside a basin can be the best alternative for establishing restoration and monitoring baselines.

The attributes provide a mechanism for quantitatively equating variable inter- and intra-annual flow regimes to variable physical processes. For example, an alternate bar is not created or maintained by a single flow with a characteristic magnitude, duration, frequency, and timing. Physical processes in Attributes No.'s 3, 4, and 8 all require different inter- and intra-annually occurring flows. The timing and duration of flows in Attribute No. 9 also are vital: a dry water year with a seasonally early snowmelt runoff period may be just as important in allowing successful seedling establishment as a wet year that scours seedlings.

Often, river restoration plans go to great lengths describing future channel form, e.g., projected pool/riffle ratios, without addressing the necessary processes. The attributes prescribe process and form as quantitative restoration goals. Processes are rates. Requiring physical rates as restoration goals may require re-thinking by many agencies accustomed to morphological restoration goals, but measuring and evaluating rates should be essential to any adaptive management plan. Why not make these rates goals? By documenting the ecological consequences of maintaining a dynamic alternate bar morphology (as

we are doing on several California rivers), variable flow regimes generating the processes that create and maintain alternate bars can be quantitatively linked to fish, other species of concern, and the river ecosystem. This quantitative linkage is one of our primary expectations from the attributes. We doubt successful adaptive management is possible without it.

Resource managers frequently assume the attributes apply only to unimpaired flow regimes, and that accommodating physical thresholds to recover natural processes is unrealistic given water contracts, dam limitations, and human encroachment. Not all attributes may be attainable regardless of effort or funding. But the natural processes addressed in the attributes can often be achieved without requiring the entire unregulated flow regime. Although post-dam flow regimes often radically impair sediment transport capabilities, dams also eliminate bed material supply from the upstream watershed. High flow releases that can transport the remaining sediment contributed from downstream tributaries need not have pre-dam magnitudes or durations. This tradeoff between reduced sediment supply and transport capability has consequences. In the case of the Trinity River, a restored channel morphology below Lewiston Dam may not mirror its pre-dam morphology, but a scaled-down channel morphology could function similarly.

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The complete article, McBain, S. and B. Trush, 1997. *Thresholds for managing regulated river ecosystems*. In S. Sommarstrom (editor), Proceedings, Sixth Biennial Watershed Management Conference, Water Resources Center Report No. 92, Univ. of California (Davis), p. 11-13, may be viewed and downloaded from the Watershed Management Council Web site (<http://watershed.org/wmc/>) by clicking on "1996 WMC Conference Proceedings."



## Bob Deibel Joins Instream Flow Effort

National Forests face major challenges in providing adequate instream flows to maintain channel systems, sustain streamside vegetation, provide vital aquatic habitat, and meet public expectations. Faced with increasing workloads in hydropower relicensing, Ditch Bill and related activities that involve complex and contentious instream flows issues, the Washington Office Director of Lands established a National Instream Flow Technical Coordinator to support the National Hydropower Initiative. The position will work jointly with other units, such as the National Stream Systems Technology Center and the National Aquatic Ecology Center as necessary to provide geomorphic, biologic, and other expertise to Forest projects. Instream flow policy matters, especially as they relate to water rights, adjudications, and land management planning, remain with the Washington Office, Watershed and Air Staff.

**Bob Deibel** will lead the effort to provide technical support to hydropower relicensing. The position will strive to:

- Achieve consistent application and implementation of instream flow studies and analyses across National Forests;
- Transfer technology to project level staff pertaining to hydropower relicensing;
- Develop technically rigorous and legally defensible national standards for comprehensive instream flow analyses;
- Coordinate and communicate with Regional, Forest, and District level staff on hydropower instream flow issues;
- Maintains close contact with the National Hydropower Assistance Team (NHAT);
- Set national technical standards for hydropower instream flow studies that will serve as the foundation for developing management options to achieve resource based outcomes for flow dependent resources; and
- Coordinate and communicate with the watershed and Air Staff on instream flow and forest planning policy issues.



Bob has extensive experience as a fisheries biologist in the practical application of instream flow studies and has previously worked for the Federal Energy Regulatory Commission (FERC) on hydropower relicensing issues. Much of his first year was spent coordinating hydroelectric relicensing instream flow issues and developing a national instream flow assistance contract. Focus in FY 2000 will be to develop a hydroelectric relicensing “toolbox” for instream flow studies and to provide training in areas such as scoping the issues, appropriate application of technology, and monitoring.

Although Lands administers hydropower relicensing, hydrologists and fishery biologists are integral to determining resource effects and mitigation measures for hydroelectric licensing and relicensing that will take place on National Forest System lands over the next decade. Bob is available to assist you with hydropower relicensing instream flow-related matters.

Bob Deibel’s office is located at the Pacific Northwest Regional Office in Portland, Oregon. He can be contacted by phone at (503) 808-2977, (503) 808-2499 (FAX), or by e-mail at [rdeibel/r6pnw@fs.fed.us](mailto:rdeibel/r6pnw@fs.fed.us).



# Regional Hydraulic Geometry Curves of the South Umpqua Area in Southwestern Oregon

by Todd D. Kuck

The Roseburg District Bureau of Land Management (BLM) has conducted stream surveys at gaging stations in the South Umpqua River basin to produce regional hydraulic geometry curves. These curves provide information to estimate bankfull discharge, mean depth, width, and cross-sectional area at ungaged sites within the watershed. The regional curves were developed using methodology from Dunne and Leopold (1978) and Rosgen (1996).

Eight active gaging stations were surveyed to develop the regional curve relating bankfull discharge to drainage area. Drainage areas for these sites ranged from 54.4 to 456 square miles. All of the gaging

stations are maintained by the U.S Geological Survey (USGS) or the Water Resources Division, Douglas County, Oregon.

Surveys were also conducted at discontinued gaging stations and ungaged streams where restoration activities are planned. These four additional sites allowed us to include data from smaller streams and were used in conjunction with data from active gaging stations to develop the regional curves of mean depth, width, and cross-sectional area plotted against drainage area. These relationships are therefore based on 12 sites which range in basin area from 0.42 square miles up to 456 square miles.

## Regional Curve of the South Umpqua Area

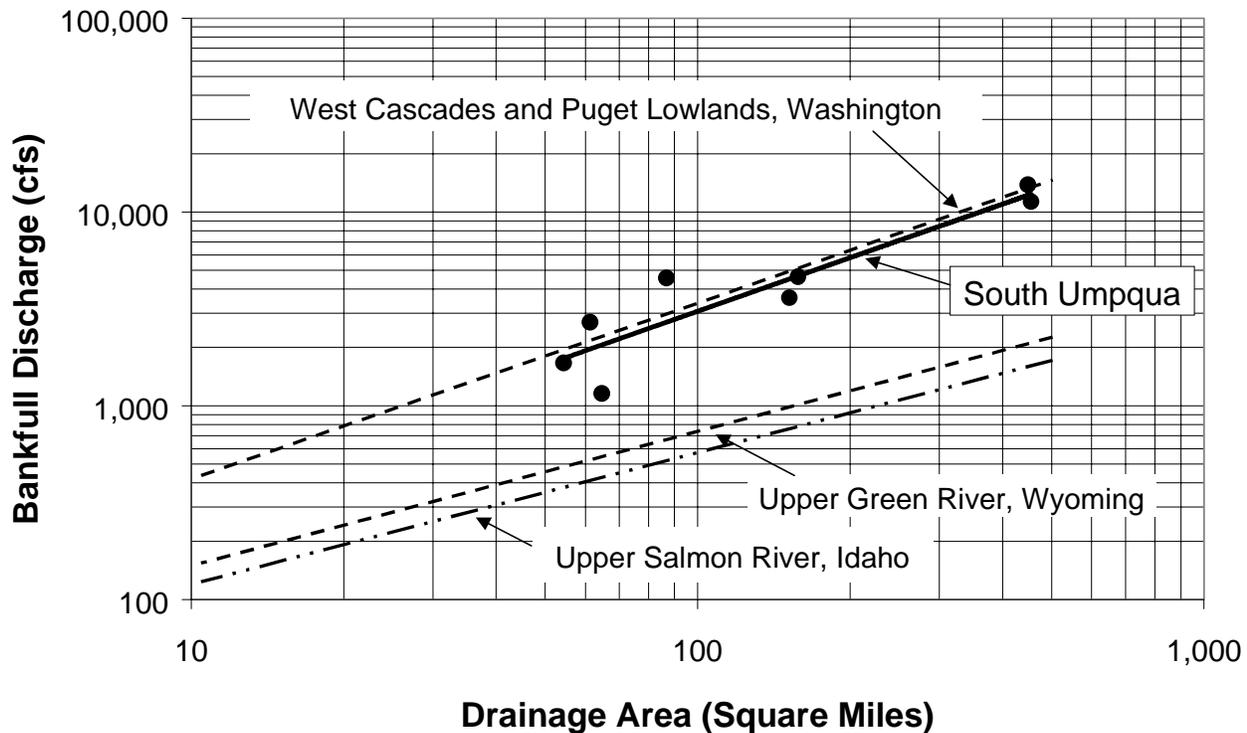


Figure 1. Regional curve for the South Umpqua Area, Oregon.



Bankfull discharge was determined using field techniques described by Rosgen (1996) and a video produced by the U.S. Forest Service (USFS, 1995). The average recurrence interval of bankfull discharge for the gaged sites was 1.5 years. Castro (1997) also reported an average recurrence interval of 1.5 years in her study of the Western Cordillera Ecoregion which includes all of our surveyed sites.

Rosgen (1996) stream types surveyed at the gaged stations were Bc, C, and F channels. At the ungaged sites, A and Aa+ stream types were surveyed.

The National Oceanic and Atmospheric Administration (NOAA) weather station at Riddle, Oregon is located within the area surveyed for this project. Mean water year precipitation collected at this site was 32.1 inches annually from 1949 to 1998.

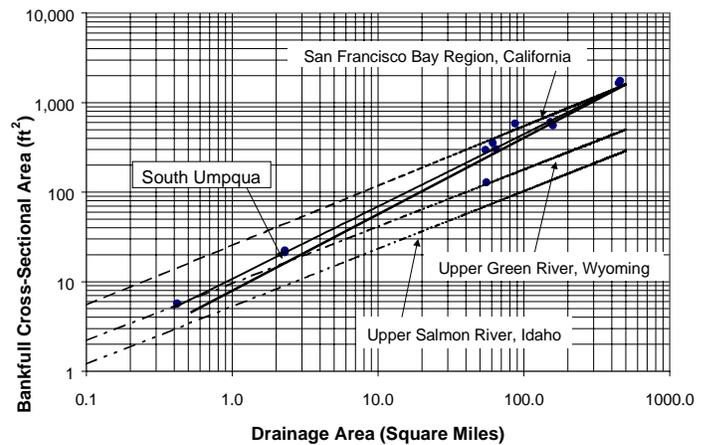
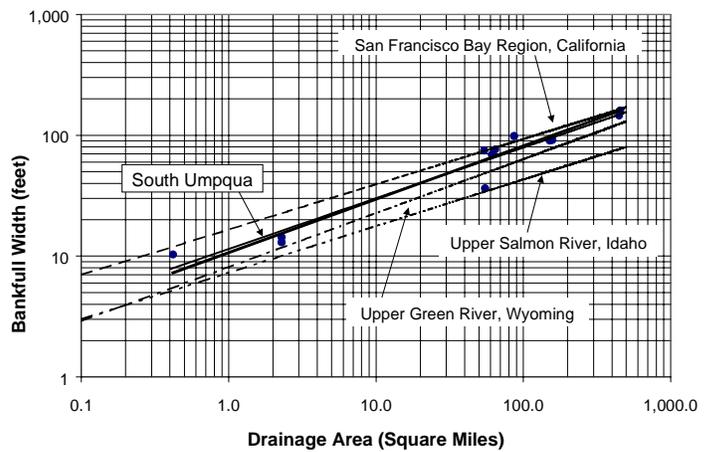
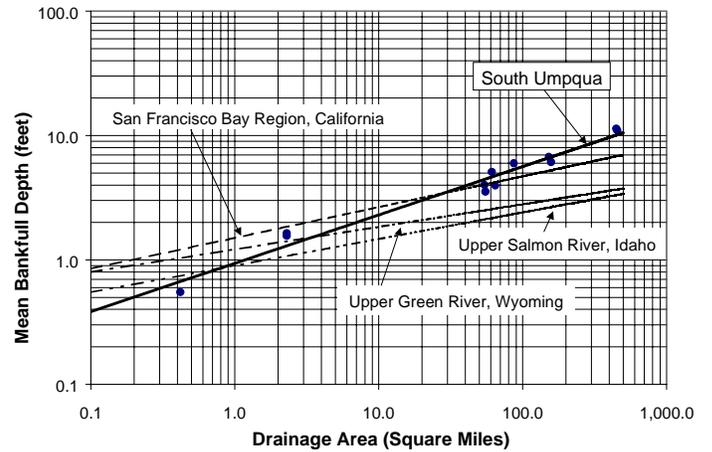
## Results

Figure 1 illustrates the South Umpqua regional curve for bankfull discharge based on drainage area along with three other previously published curves (Dunne and Leopold, 1978) for other areas in the western United States.

The relation between bankfull discharge and drainage area determined for the South Umpqua area is  $Q_{bkf} = 44.8 DA^{0.918}$ , where  $Q_{bkf}$  is bankfull discharge in cubic feet per second (cfs) and DA is the drainage area in square miles. The regression equation has a correlation coefficient ( $R^2$ ) of 0.85.

Figures 2, 3, and 4 show regional hydraulic geometry curves for the South Umpqua area (and curves from other studies) for mean bankfull depth, bankfull width, and bankfull cross-sectional area as a function of drainage area.

The relation between mean depth (D) in feet and drainage area (DA) in square miles for the South Umpqua area is  $D = 0.9 DA^{0.389}$  ( $R^2 = 0.97$ ). The relation between bankfull width (W) in feet and drainage area is  $W = 11.5 DA^{0.419}$  ( $R^2 = 0.94$ ). The relation between bankfull cross-sectional area (A) in feet and drainage area is  $A = 10.8 DA^{0.809}$  ( $R^2 = 0.98$ ).



**Figures 2, 3, and 4. South Umpqua regional hydraulic geometry curves of mean bankfull depth, bankfull width, and bankfull cross-sectional area as a function of drainage area, respectively.**



The slope of the regional curve for bankfull discharge of the South Umpqua area is very similar to the slope for the West Cascades and Puget Lowlands in Washington state (Figure 1). The intercept for the South Umpqua area curve is, however, slightly lower than the other Washington site. Comparing the South Umpqua curve to those from Wyoming and Idaho shows them to be generally higher as expected indicating higher unit discharges and larger channel dimensions for similar watershed areas.

For the other regional curves (Figures 2, 3 & 4), slopes for the South Umpqua area with respect to bankfull depth, width, and cross-sectional area were generally steeper than curves from other western U.S. regions. Unfortunately, data from Washington state for these parameters were unavailable for direct comparison.

### Conclusions and Recommendations

The regional hydraulic geometry curves of the South Umpqua River in southwestern Oregon will allow hydrologists and others to estimate a number of bankfull characteristics based on data from ungaged streams in the region. Since all of the curves are estimated using drainage area, it will be relatively simple to check expected bankfull characteristics in the field. This in turn will facilitate interpretation and design of stream restoration projects, assessment of stream health and future project planning.

Currently, the Roseburg District BLM is conducting similar surveys of gaging stations in the North Umpqua River basin. These surveys will be used to produce hydraulic geometry relations for comparison purposes to determine if there are differences in the two basins.

Additional data needs for the Umpqua basin include the development of dimensionless rating curves using stream survey and gaging station data (as described in Dunne and Leopold, 1978) and the development of dimensionless ratios for reference reaches by stream types (Rosgen, 1996). In addition, reestablishing discontinued gaging stations on small streams and establishing crest-stage gages on small streams will provide invaluable data that is currently unavailable.

### References Cited:

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- Rosgen, D.L., 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.
- USDA Forest Service, 1995. A guide to field identification of bankfull stage in the western United States (video). Rocky Mountain Forest and Range Experiment Station, Stream Systems Technology Center, Fort Collins, CO.

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### Editor's Note:

The utility of channel geometry curves has been widely recognized by hydrologists and others as a valuable tool. At the present time, channel geometry curves are being developed in many parts of the United States in large part due to the influence of Dave Rosgen and Luna Leopold.

Recently published channel geometry relationships include those for streams in the upland Ozarks (Manner, 1999), southern California (Azary, 1999), North Carolina (Harman et al., 1999), and the Southwest United States (Odem and Moody, 1999). All of the above papers can be found in: Darren S. Olsen and John P. Potyondy (Editors), 1999. Wildland Hydrology, AWRA Specialty Conference Proceedings, June 30-July 2, 1999, Bozeman, Montana, TPS-99-3, 536 pp.



# STREAM NOTES

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## STREAM NOTES



### STREAM TEAM Relocates to Natural Resources Research Center



The Fort Collins Natural Resources Research Center is a collaborative effort between federal agencies and Colorado State University. A key objective is to bring together more than 1,000 Federal research and development scientists, information resource management specialists, and support personnel at a single location to foster integration of expertise, knowledge, and resources in the most cost effective manner.

#### Our new mailing address is:



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#### Our new phone numbers are:



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