STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

July 1997

Applying a Fluvial Geomorphic Classification System to Watershed Restoration

Terry Benoit and Jim Wilcox

Numerous articles discuss the merits and shortcomings of the Geormorphic Stream Classification System developed by Dave Rosgen (1985). This article discusses the Feather River Coordinated Resource Management (FR-CRM) group's experience using this system in the FR-CRM watershed restoration program.

Rosgen first exposed the FR-CRM to the classification system in 1988. The system has been revised since then (1994), as should be expected with any new technology. The FR-CRM, a 21-entity consortium of public and private agencies and landowners, was formed in 1985 and began an ambitious program of geomorphic watershed assessment and channel restoration. Beginning in 1990, Rosgen was frequently involved with the group as a project designer and a trainer of local resource professionals in geomorphic restoration techniques and classification system use. The groups active restoration professionals accepted the classification system as a common language in referencing channel conditions throughout the 3,222 mi Feather River watershed that contains virtually every streamtype described by the system.

The classification system provides for a 4 level hierarchy in river inventory. The most commonly used component of the system incorporates Level I, geomorphic characterization, and Level II, morphological description, to identify fluvial geomorphic characteristics that typify a channel's *current* condition (class). When these inventories are completed, reaches are assigned a single letter/single number classification (B2, F4, E6, etc.). This information allows assessment of the channel's present stability/instability, past conditions, and probable trend if left undisturbed.

The nature of the geomorphic assessment also provides insight into possible habitat improvement or restoration alternatives using the channel and valley characterization provided by this system. Data intensive Level III, stream condition assessment, and Level IV, field data verification, inventories are then performed to analysis flow regimes, sediment loads, size distributions, debris, watershed condition, hydraulic geometry, vegetative, and biological data. Upon completion of the 4 inventory levels, specific design alternatives can be

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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evaluated through numerous iterations, and frequently, additional data collection.

We will use one of the FR-CRM geomorphic restoration projects to illustrate use of the Geomorphic Stream Classification System for evaluating current conditions and restoration alternatives. The Big Flat/Cottonwood Creek Project, located on lands administered by the Plumas National Forest (PNF) in the northern Sierra Nevada mountains of California, was identified as a high priority stream and meadow restoration project through the scheduled Allotment Management Plan update process.

Big Flat Meadow has been used for haying and livestock grazing since before the turn of the century. The watershed has been impacted not only by grazing but also by logging, road building and stand-replacing fire. The PNF and the current permittee identified similar objectives for Big Flat. These objectives were reduced bank erosion, improved meadow condition, and improved late summer flows with opportunity for an improved fishery. The PNF requested FR-CRM assistance in 1993 to develop, fund, and implement a restoration project.

The Feather River FR-CRM staff began geomorphic assessment and data collection in the fall of 1993. Data collection and analyses were performed simultaneously on the project reach and on the 10.3 mi watershed. Results were presented, through the CRM process, to the PNF and permittee in the spring of 1994.

Big Flat is a 47 acre alluvial meadow that lies at an elevation of 6,000 ft. The average annual precipitation of 20 inches, which is mostly snow, falls on a watershed that is predominately meta-volcanic with moderate to gentle relief. Cottonwood Creek entered Big Flat Meadow as a stable, low gradient, meandering, riffle-pool streamtype (C4) then quickly changed to gullying (G4) and deeply incised (F4) streamtypes (Figure 1) through the 3,000 ft length of the meadow before returning to an existing C4 streamtype below the meadow. The deeply incised (10 to 15 ft), high to moderately entrenched (F4) channel, left the meadow as a high terrace, no longer subject to flood flows at any stage. The meadow vegetation was converting from wet meadow herbaceous species to more xeric, herbaceous species and sagebrush. Valley-wide (250 to 700 ft) cross-sections revealed the presence of a variety of remnant relatively stable channels on the meadow.

Geomorphic inventory and classification led to the development and analysis of several alternatives to meet some or all the stated objectives. Only three alternatives were evaluated in detail.

One alternative would have stabilized the channel within its newly forming valley. This was rejected because it met only one objective (reduced bank erosion) at high cost and significant long-term risk of failure as the entrenched valley widened.

A second alternative would have installed 30 loose rock check dams to step flows down the meadow. This alternative would partially meet all objectives but at an unacceptable expense and with long-term maintenance requirements. The check dams installed in alluvial material would change the streamtype to flat gradient pools with very steep gradient riffles (the structure). Sediment deposition and transport in the pool areas would eventually result in channel migration and structure end runs.

The third alternative, which was implemented, proposed obliterating the existing entrenched channel and recreating natural meandering (C4, E6, and B6) streamtypes through the meadow (Figure 2). Implementation resulted in a 4,330 ft system of slightly to moderately entrenched, moderate to highly sinuous channels. The expansive floodplain minimizes stress to vegetated streambanks and greatly reduces the need for hard (rock, rootwads, etc.) bank protection. This alternative met all objectives for the least cost, lowest long-term maintenance **and** risk.

Level IV, field data verification, provided final design dimensions for bankfull channel widths, depths, width/depth ratios, and other hydraulic geometry parameters as well as sediment transport capability for the three different streamtypes constructed.

Returning Big Flat to its full natural function was the first demonstration of this technique in California. There were strong concerns over the risks of building a brand new channel (e.g.. Why won't this channel gully like the other?) and obliterating a gully with ponds and plugs (e.g., overland flow could cause headcuts and gully the ponds).

The Fluvial Geomorphic Classification System was a valuable tool for assisting the decision-making resource professionals and for helping the public understand the morphological characteristics of the different alternatives and the probable responses and risks. The classification system is also a successful tool that helps increase our power of scientific observation. The system is not the answer in itself, but is a mechanism for seeking answers. We have demonstrated the use of a powerful tool, which when combined with knowledge and experience, provides very satisfactory results.

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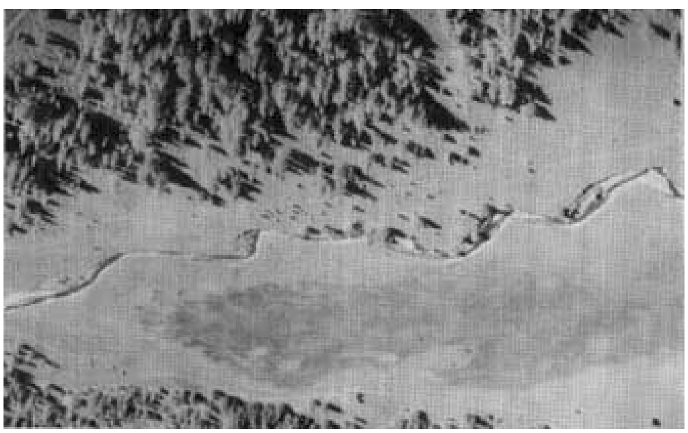

Figure I. Big Flat Meadow and gully prior to restoration.

Figure 2. Big Flat Meadow after restoration. Note obliteration of gully with ponds and plugs and new sinuous (E6) channel.

Peak Flow Effects on High-Gradient, Low Order Stream Channels of the Ouachita Mountains: A Research Progress Report

Daniel A. Marion

Small, step-pool channels occur in virtually all forested mountain landscapes. Often these channels occur within or immediately downstream of timber harvesting areas. Despite this, little is known about how these channels function and maintain their form. The physical structure and transport processes within step-pool channels are assumed to be controlled by peak-flow events, however the specific relationships are unknown.

The Peak Flow Effects study has three objectives:

• Characterize sediment transport processes within a representative step-pool channel

• Evaluate how these processes interact with channel form characteristics

• Assess how these processes and interactions vary with peak-flow magnitude.

In conducting this research, an artificial system was used to replicate peak-flow events in a study channel within the Ouachita National Forest. Developing an "experimental laboratory" without being unduly invasive of the immediate forest area was a large challenge. Fortunately, a site was located in the Ouachita National Forest where an old logging road occurred near both a representative mountain stream and a flood-control reservoir.

The system used in this study controlled water releases from a 172,000-gal tank (Figure 1) to mimic natural peak-flow characteristics within an undisturbed study reach. This system allowed more rigorous experimental control than possible using natural events and avoided many of the operational problems inherent in storm event sampling. High frequency peak-flow events were studied because these events are more likely to be affected by natural or management related disturbances. Data were collected on a large number of hydraulic, sediment, and channel form characteristics using a variety of automated and manual sampling methods.

Figure I. Aerial view of the modular containment system used in the project.

This study is still in progress. The peak-flow simulation system was constructed, instrumentation installed, and all experimental runs were conducted during 1994 and 1995. Data analysis is currently underway. While this project has not yet been completed, some significant accomplishments and preliminary results can be noted.

Flow Modelling

Existing flood-frequency and hydrograph models for this region were tested against unpublished data from the study site and nearby streams and found to be very inaccurate. Using these and other existing data, more accurate regional flood-frequency and hydrograph models have been developed. These new models are applicable both to the study site and small mountain streams throughout the upper Ouachita Mountains.

Velocity Profiles

Estimation of streamflow discharge and other hydraulic characteristics is dependent upon the vertical distribution of flow velocity within a channel. Hydraulic theory predicts a logarithmic distribution of flow velocity, yet some recent studies in gravel-bed channels document significant variation from this expectation. Similarly, preliminary results from this study indicate that vertical velocity distributions are not logarithmic in step-pool channels either. Streamflow velocities varied over several orders of magnitude both vertically and horizontally during the experimental runs.

Sediment Transport and Channel Morphology

Sediment transport processes and their interrelationship with channel morphology were observed to be very complex in the step-pool channel studied. Sediment yields varied greatly at similar flows and at different locations within the study reach. While cross sections showed no appreciable change either after individual runs or cumulatively after all runs, individual sediment deposits within the study reach showed remarkable change. Scour and fill occurred frequently in many of the patches of small sediment (predominantly sand and gravel) deposits within the channel bed, yet bank erosion was non-existent. In general, coarse woody debris was highly resistant to displacement from the flows studied, yet when individual pieces did move, they moved large distances. Individual sediment particle transport showed similar behavior in that most marked grains did not move, but when they did finally become mobile, they moved relatively large distances.

The potential applications and implications of this research are several. The models developed through this research will improve the accuracy of flow predictions in small Ouachita Mountain streams. Better designs for culvert sizing, stream crossing structures, fish habitat enhancement, and channel restoration projects should result from use of these improved models. Results from this research will improve our understanding of how step-pool channels operate. With this knowledge our ability to assess the possible effects of changes in peak flow characteristics as the result of forest management practices will be improved. Furthermore, the experience gained in conducting this project will allow more focused experiments in the future and these should provide even greater knowledge about how these ubiquitous channels function.

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In addition to the Southern Station, this study was supported by NCASI, the Rocky Mountain Station, the Ouachita National Forest, and the University of Iowa.

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Expanding Sediment Research Capabilities in Today's USGS

The U.S. Geological Survey (USGS) held a Sediment Workshop on February 4-7, 1997 titled, "Expanding Sediment Research Capabilities in Today's USGS." The first half-day of the workshop, held at the USGS National Center in Reston, Virginia, was devoted to presentations and a panel discussion from nine federal agencies on the subject of sediment research and monitoring needs. Discussions during the following days of USGS-only meetings in Harpers Ferry, West Virginia, centered on how the USGS can better combine and use its sediment expertise that includes new capabilities due to incorporation of the former National Biological Service as the USGS's Biological Resources Division.

A description of the Workshop and papers presented by the USGS and other federal agencies are available on the World Wide Web at: http://www.rvares.er.nsgs.gov/osw/workshop/

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