STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid In Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station **January 2003**

Identifying Bankfull Stage in Forested Streams in the Eastern United States

Hydrologists and aquatic biologists often have a need to identify bankfull stage in the field. In 1995, the Stream Systems Technology Center produced a 31-minute video, ***A Guide to Field Identification of Bankfull Stage in the Western United States***, that discussed key concepts and demonstrated field techniques to consistently identify bankfull levels in a variety of stream types in the western United States. Technical presenters in the Western video include recognized experts such as Luna Leopold, Bill Emmett, Lee Silvey, and Dave Rosgen.

While hydrologists and biologists throughout the United States found the Western video useful, concern frequently surfaced that streams in the eastern United States have unique and different characteristics that make bankfull identification especially challenging. Much of the concern centered around the different and more prolific vegetation typical of the East and the South and its relationship to bankfull features and past land use history and the effect this has on channels, terrace formation and stream equilibrium. In addition,unique stream systems occur in the East such as the wetland streams common to the Lake States that may have different bankfull features and flood frequencies.

The new video, ***Identifying Bankfull Stage in Forested Streams of the Eastern United States***, is 46 minutes in length and features a set of technical experts from the East and South. Technical presenters include:

- **M. Gordon ("Reds") Wolman**, Emeritus Professor of Geography and Geology, The Johns Hopkins University
- **William W. Emmett**, Research Hydrologist, U.S. Geological Survey (Retired)
- **Elon ("Sandy") Verry**, Research Hydrologist, USDA Forest Service, North Central Research Station
- **Daniel A. Marion**, Research Hydrologist, USDA Forest Service, Southern Research Station
- **Lloyd W. Swift, Jr.**, Research Hydrologist, USDA Forest Service, Southern Research Station (Retired)
- **Gary B. Kappesser**, Forest Hydrologist, USDA Forest Service, George Washington and Jefferson National Forests.

The video is limited to field identification of bankfull stage in forested streams because these are of primary concern to Forest Service technical specialists. Streams impacted

STREAM NOTES is produced quarterly by the Stream Systems Technology Center, Rocky Mountain Research Station, *Fort Collins, Colorado.*
Larry Schmidt, Program Manager

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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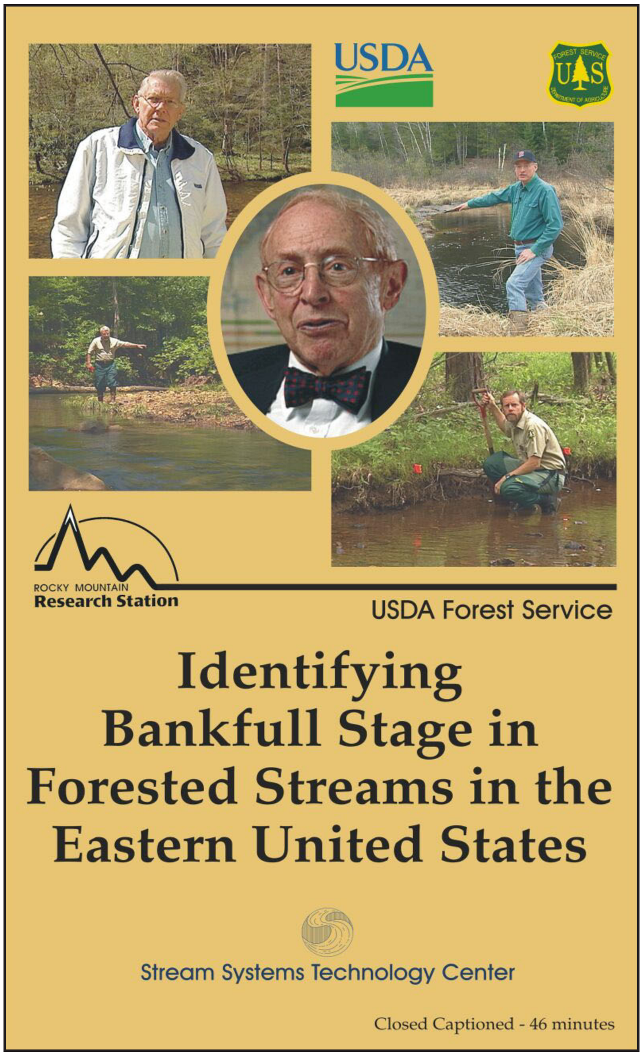

by urbanization or agriculture are typically more complex and may require different strategies to properly identify bankfull stage.

The video emphasizes identification of the relatively flat depositional surface of the floodplain along a reach of stream and the tops of point bars as the best and most consistent indicators of bankfull stage. Vegetation is listed as a poor indicator of bankfull because grasses, sedges, and near stream vegetation often grow below the bankfull elevation in the East and the South. Similarly, the use of other features such as the limits of moss growth, lichen lines on rocks, and the lower end of scoured roots is discouraged.

The video emphasizes the complex nature of stream channels and terraces in the East and South. For example, terraces may be formed by climatic change or by a change in watershed conditions. In the East and the South, changes responsible for formation of terraces typically include urbanization, logging, and historic agricultural practices. The video emphasizes understanding the geomorphic context and watershed history as one way to differentiate terraces formed by previous hydrologic regimes from dynamic channels that are still adjusting today.

Experts demonstrate and discuss bankfull identification in a variety of geographic settings including the Mississippi River and wetland streams in Minnesota, streams in the northern and southern Piedmont, Appalachian valley and ridge streams in Virginia, and streams in the Ozark uplands.

Copies of the video have been mailed to hydrologists and fisheries biologists on the National Forests, Forest Service Research Stations, and Stream Systems Technology Center cooperators. Copies are also available upon request from STREAM by e-mailing your name and mailing address in label format to rmrs_stream@fs.fed.us.

Bankfull WEST and Bankfull EAST Videos Available in DVD Format

The Stream Systems Technology Center now has a DVD that contains both videos on one DVD:

- ***A Guide for Field Identification of Bankfull Stage in the Western United States (1995)***
- ***Identifying Bankfull Stage in Forested Streams in the Eastern United States (2003)***

Request copies via e-mail from: rmrs_stream@fs.fed.us and include your name and mailing address in label format.

A Revised Hydropower Bypass Flow Regime Designed to Mimic Natural Processes

by Katherine Foster

The Manti City Lower Power Plant on the Manti La Sal National Forest in central Utah diverts up to 55 cfs and partially dewaters about 1.5 miles of Manti Creek. A licensed bypass flow required Manti City to release a fixed volume of water downstream for channel maintenance purposes. The "fixed" bypass flow forced the occasional shut down of the project, especially during the spring runoff period in dry, low flow years. Because of the complex stair-step time specific structure of the required bypass flow regime, the facility failed to fully comply with the flow requirements and was also required to annually bypass flows of doubtful geomorphic effectiveness.

Manti Creek below the power plant (Figure 1) is recovering from the effects of massive landslides and floods that occurred in the 1980s that significantly altered the stream channel. Restoration activities following the floods, changes in livestock and recreation management, and variety in the range of streamflows have allowed partial recovery of the stream and valley bottom, including reestablishment of some riparian vegetation and the beginnings of a meandering stream channel within the floodplain. Only a small amount of baseflow must be bypassed year round because Manti Creek lacks significant fisheries resources.

Neither the Forest Service nor the utility were totally happy with the flow situation because the Forest Service was unable to meet its resource management objectives and the utility was forced to bypass water that might otherwise have been used to generate electricity. To improve the situation, the Forest Service proposed a revised flow regime that mimics the natural hydrograph while also making a proportion of the flow available for diversion to hydropower generation. The facility benefits because Manti City has about the same amount of water and a more continuous supply of water available for power generation. As a result, the Forest Service has enhanced credibility with the hydropower community by showing willingness and interest in applying the best science to meet resource objectives.

The Former Bypass Flow Requirement

Until 2002, Manti City's Lower Power Plant operated under a Forest Service bypass flow requirement developed in 1986. The calendar-based flow regime was developed using the channel maintenance technology of the 1980s. The required flow regime consisted of a time specified, stair-step pattern of flow increases up to bankfull discharge, three days of bankfull flow, and then a shortened stair-step decrease back to a low flow discharge that was required year round (Figure 2). The stair-step claim was initiated the first day after May 5 when average daily flow reached or exceeded mean annual discharge (36 cfs).

Gordon (1995) identified several flaws with calendar-based stair-step approaches to channel maintenance. The rigid time specific nature of the claim was one such failure. The flow claim begins each year after May 5 when flow rates first reach or exceed mean annual flow and continues with its stair-step structure regardless of actual flows occurring in the channel.

Figure 1. The bypass reach immediately below the Manti City Lower Power Plant diversion facility. The diversion partially dewaters about 1.5 miles of Manti Creek.

This results in many years where the flow claim is out of sync with the natural flow regime and fails to deliver channel-maintaining flows through the bypass reach. A second equally serious flaw is the imposition of a bypass flow requirement even in dry years when flow fails to attain bankfull discharge, the so-called channel maintaining discharge. This means that in some years flows must be bypassed even when they fail to do geomorphically effective work.

The Scientific Basis of the Revised Bypass Requirement

Conceptually, the revised flow regime follows the pattern offered in McBain and Trush's general attributes of alluvial rivers (Stream Notes, Jan. 2000; McBain and Trush, 1997; Trush et al., 2000) and attempts to retain most of the natural hydrograph as part of the bypass flow structure. McBain and Trush argue that by restoring and maintaining natural geomorphic processes that support alluvial river ecosystem structure and function, it ought to be possible to restore and maintain the river ecosystem under regulated streams conditions. Therefore, we built our revised flow requirement around the concept of mimicking the natural hydrograph as much as possible while making available a proportion of the flow for diversion (Figure 3).

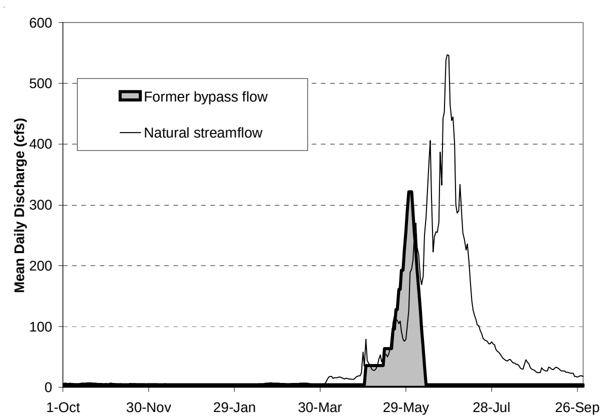

Figure 2. The former calendar-based, stair-step bypass flow regime is shown in light gray. Note that this calendar-based flow regime is sometimes out of phase with the natural hydrograph and is capped at 322 cfs, the old estimate of bankfull discharge. As a result, in this high runoff year, the utility is never required to bypass the channel maintaining flows according to the permit and is also unable to utilize the water for power production during a portion of the spring runoff period resulting in an inefficient allocation of water. During high runoff years like this example, channel-maintaining flows pass down the channel only because the power plant has a 55 cfs diversion capacity and not due to any license requirement.

We specifically used the following alluvial river attributes from McBain and Trush to derive the revised flow regime.

Attribute No. 2: Flows 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.*

Snowmelt-dominated streamflows on the Manti La Sal National Forest vary significantly from year to year. Variability includes when snowmelt runoff begins, its magnitude and duration, the number of peaks, and when flow returns to baseflow. To provide for variability, we replaced the time specific, rigid, stair-step hydrograph structure with all natural flows, minus some amount made available for hydropower production. The

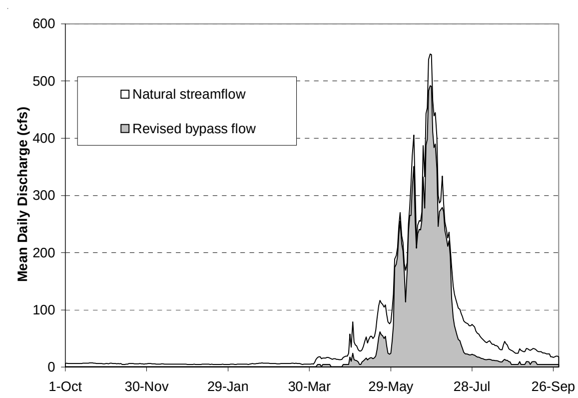

Figure 3. The revised bypass flow regime is shown in light gray. This flow regime requires passing most of the channel-forming flows through the by-pass reach and mimics the natural hydrograph. A small proportion of the flow is always allocated to power production making it possible to generate power continuously while bypassing most of the water to meet geomorphic objectives.

facility's hydraulic capacity of only 55 cfs represents only a small portion of the total flow allowing the majority of the naturally variable hydrograph to pass down the channel during the spring runoff period thereby providing the natural variability alluvial rivers require (Figures 4 & 5).

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. 7: A functional floodplain. *On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage.*

To accommodate these attributes we needed to have flows periodically exceed bankfull discharge. Research from the Rocky Mountain Research Station (Ryan et al., 2002) suggests that streamflow in alluvial channels begins to transport coarse sediment and to be geomorphically active at approximately 70% of bankfull discharge. Using the 1.5-year flow as a surrogate for bankfull discharge, we specified a range of flow from 70 to 115% of bankfull (178 to 300 cfs) to achieve the necessary mobilization of the channelbed surface. When flows are within this range, only 15 cfs may be diverted. This assures that sufficient sediment-transporting flow remains to pass down the channel.

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.*

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.*

To accommodate these attributes we require bypassing essentially all flows greater than the 3-year flow (300 cfs). When flows exceed 300 cfs, all remaining flows, except for the 55 cfs plant capacity, must be bypassed to provide for periodic channel scour and channel resetting floods.

Table 1 shows the revised bypass flow quantities and the apportionment of available water between channel (bypass) and hydropower (diverted) needs.

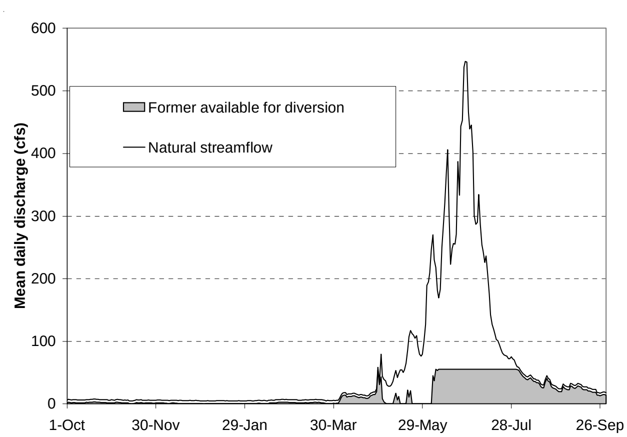

Figure 4. The former streamflow available for diversion and power production is shown in light gray. The facility has a maximum capacity of 55 cfs, however, water is unavailable for power production during a portion of the rising limb of the hydrograph because of the structure of the bypass flow regime.

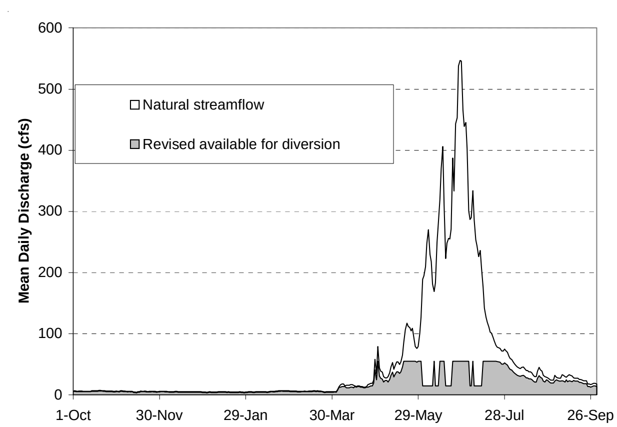

Figure 5. The revised streamflow available for diversion and power production is shown in light gray. This flow regime provides about the same amount of water for power production as the former structure; however, water is proportioned between by-pass and power production throughout the year allowing continuous generation of electricity.

Natural Streamflow (Q)	Bypass Flow	Diverted Flow
If Q is less than 16 cfs (minimum baseflow)	1 cfs	Remaining flow
If Q is equal to or greater than 16 cfs but less than 30 cfs (arbitrary flow amounts to allow for a gradual transition to peak flows)	4.5 cfs	Remaining flow
If Q is equal to or greater than 30 cfs but less than or equal to 178 cfs (proportional partitioning of flows among competing uses)	30% Q plus flows exceeding plant capacity	70% Q up to plant capacity of 55 cfs
If Q is greater than 178 cfs but less than or equal to 300 cfs	Remaining flow	15 cfs
If Q is greater than 300 cfs (Q_3)	Remaining flow	55 cfs

Table 1. Manti City Lower Power Plant revised flow regime.

Discussion

Manti City, the U.S. Fish & Wildlife Service, and the Utah Division of Wildlife Resources received the revised flow regime favorably and the Federal Energy Regulatory Commission approved it. During 2002, the facility operated under the new guidelines for the first time.

Manti City presently manages the revised bypass flow by adjusting the quantity of water diverted twice a day using real-time measured streamflow data. An analysis of the historical record for water years 1965-1974 and 1979-2000 suggests that the former bypass requirement would have required the power plant to shut down an average of 21 days per year. Applying the same historical period to the revised regime suggests that Manti City can generate electricity continuously.

This paper provides an example of integrating hydrology and geomorphic understanding with project operation and flow levels to achieve resource objectives. Under both the former and revised flow regimes, the majority of the channel maintaining high flows are passed down the channel due to the limited capacity of the facility to divert water, arguably making the impact of the change to the downstream channel and system recovery minimal. While the revised flow regime is by no means a perfect solution in that it involved a fair amount of subjective judgment about some of the required bypass flow discharges, the revised regime reasonably balances competing uses of water, uses the best available science, and provides a win-win situation for the Forest Service and the hydropower facility. Similar accommodations may be impossible where diversions take larger amounts of water or where fisheries or other aquatic values need instream flows.

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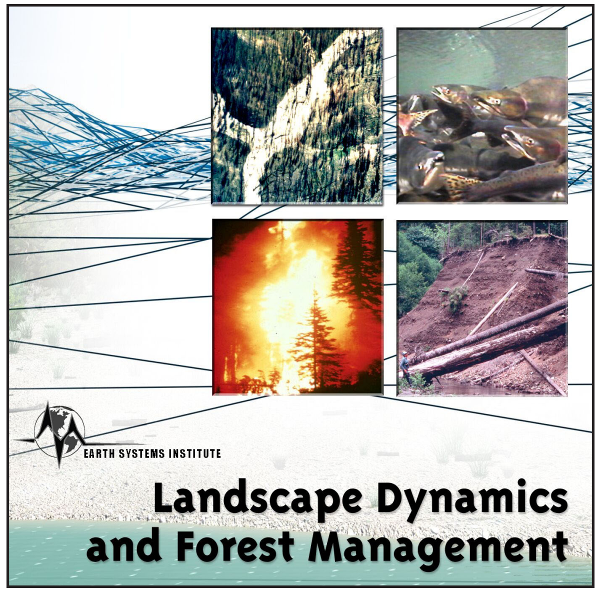
Landscape Dynamics and Forest Management: A Rich-Media CD-ROM Presentation



General Technical Report RMRS-GTR-101CD

Climatically driven disturbances such as wildfires, rainstorms, floods, and landslides regularly move across landscapes and are often perceived as disasters. Yet these disturbances are an intrinsic part of landscapes and they are responsible for the diverse habitats that create healthy riverine ecosystems.

Most aquatic and riparian habitats form within deposits of sediment and organic material derived from erosion and most erosion occurs during periodic disturbances. How do natural resource managers, regulators, scientists, environmentalists, and the public put disturbances, either natural or human related, into context?

This instructional CD is intended to help managers better understand the dynamic nature of landscapes. When landscapes and riverine attributes are perceived as dynamic over decades to centuries, better informed management choices about analysis, monitoring, and management actions may result.

In the CD-ROM, ***Landscape Dynamics and Forest Management,*** **Lee Benda** and **Dan Miller** of the Earth Systems Institute in Seattle, Washington, explore perspectives of watersheds and landscapes with periodic disturbance as a central paradigm. Using videography, aerial photography, computer simulation, visualization techniques and a Landscape Simulator, they examine landscape behavior over decades to centuries to show how landschapes and stream channels change in response to disturbance.

The Landscape Simulator is software that creates a four-dimensional virtual landscape from digital maps and databases. The simulator is a tool for modeling the role of disturbance in creating and maintaining landscape structure using probabilistic disturbance scenarios.

Landscape Dynamics and Forest Management examines the dynamics of how fire affects the landscape for up to 300 years into the future and how sediment and large wood might be routed through the landscape. The Simulator explores and displays example management scenarios to help managers appreciate the consequences of different management scenarios over long time frames. The CD uses animations to visually illustrate landscape and sediment routing dynamics over decades and centuries. Relevant literature that elaborates on the concepts is included, along with a bibliography and GIS software tools that support these kinds of analyses.

Presentation of these ideas in a rich-media format was the brainchild of **Mike Furniss**, PNW Research Station, Aquatic and Land Interactions Program. Mike coordinated the project which is the result of collaboration and support involving many partners including the Earth Systems Institute, Humboldt State University Coursework Development Center, USDA Forest Service Pacific Northwest Research and Rocky Mountain Research Stations, Stream Systems Technology Center, Willamette National Forest and Pacific Northwest Region, Bureau of Land Management, and California Department of Forestry.

Copies of the CD, General Technical Report RMRS-GTR-101CD, are available from the Rocky Mountain Research Station by going to Web site http://www.fs.fed.us/rm and clicking on "Publications: Orders/Questions."

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STREAM Web Page Has a New Look

http://www.stream.fs.fed.us

The Stream System Technology Center's Web page has been redesigned to give it a bright new look and to conform to Forest Service standards. We've added new links and content and organized the site to make it easier to navigate. Check it out and let us know what you think.

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