STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station **July 2006**

Measuring Stream Temperature with Digital Data Loggers

Stream water temperature has been and will continue to be an important parameter for monitoring water quality and assessing stream health. Stream water temperature is an easily measured parameter that is often the primary and sometimes the only attribute used to assess stream health because of its relationship to chemical and biological processes. Typical purposes of water temperature monitoring studies are to document the temperature regime of stream reaches important to aquatic resources, determine the response of stream temperature to land-use activities, characterize spatial patterns of stream temperature in a watershed, determine if water quality standards for maximum stream temperatures are being exceeded, and assess changes in maximum temperature regime over time.

With the widespread use of water temperature data to assess water quality and stream health, the USDA Forest Service, Rocky Mountain Research Station recently published a document, ***Measuring Stream Temperature with Digital Data Loggers: A User's Guide,*** that presents water temperature sampling guidelines to improve the quality and usefulness of data collected with digital temperature data loggers (fig. 1). The paper identifies and discusses several potential important issues affecting the quality and usefulness of water temperature data (table 1). The paper provides numerous examples of potential problems that may occur with water temperature data if the issues identified in table 1 are not considered or addressed when setting up a water temperature monitoring program.

The publication, ***Measuring Stream Temperature with Digital Data Loggers: A User's Guide,*** is organized into four major sections that corresponds to a series of steps that users should follow when using temperature data loggers. These sections or steps are:

1) Study planning;
2) Field procedures;
3) Data processing; and
4) Data storage and archiving.

Step 1 discusses the importance of defining the objectives of the water temperature monitoring project, features to consider when choosing a digital temperature data logger, calibrating the digital temperature data logger, and choosing the appropriate sampling interval. Also included in this section is a useful table that lists various types of data

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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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Table 1. Water temperature sampling issues addressed in the paper, ***Measuring Stream Temperature with Digital Data Loggers: A User's Guide.***

Issue	Examples
Instrument error	Accuracy and precision, range of measurement, lag time in temperature recording
Calibration	Post- and preuse calibration of data loggers, "drifting" of temperature readings, reliability of calibration conditions
Measurement interval	Effects of temperature measurement interval on probability of detecting important maximum and minimum temperatures
Field sampling	Locating representative sampling sites to make inferences about temperatures of interest (for example, surface versus benthic temperatures), effects of data logger housings on temperature readings
Error screening	Numerical filters for detecting outlier and erroneous observations, visual inspection of thermal patterns to detect possible errors
Data summaries	Choice of statistical summaries of temperature, correlations among different temperature metrics, methods for defining "exceptional" conditions

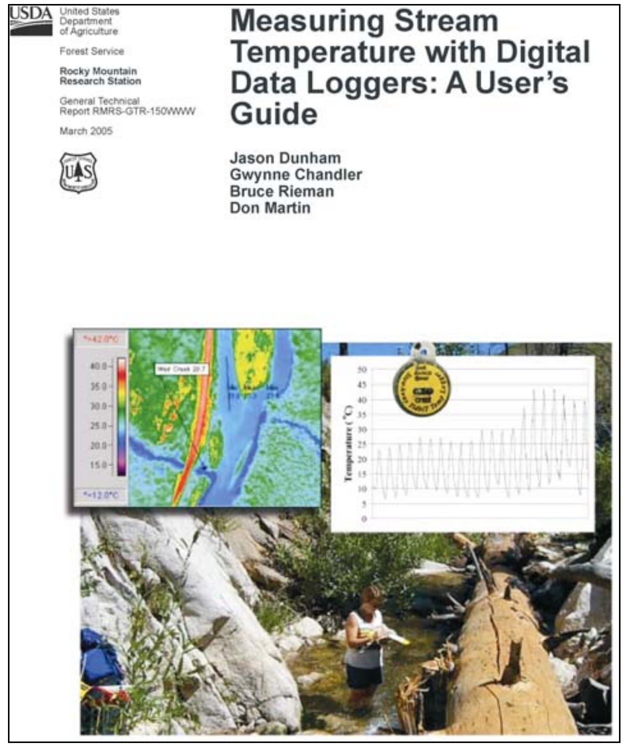
loggers currently available along with their capabilities.

Step 2 discusses field procedures for selecting a sampling location and protecting the digital temperature data logger. The discussion on spatial patterns of thermal variability is especially useful background information to consider when determining where to locate sampling sites.

Step 3 describes procedures for screening the data for potential errors because of data logger malfunctions or dewatering of the site and statistically summarizing the temperature data. The discussion in this section provides several examples of how to summarize stream temperature data and examine correlations between selected temperature metrics.

Step 4 describes a procedure for archiving the thermograph data along with pertinent pre-deployment, field deployment, and post-deployment information that should be collected. An example of a field deployment datasheet is presented that provides a useful checklist of basic field data needed to be collected at a given site.

This publication is an excellent resource for personnel involved in water temperature monitoring programs and who may need to evaluate water quality conditions using stream


USDA United States Department of Agriculture
Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-150WWW
March 2005

Measuring Stream Temperature with Digital Data Loggers: A User's Guide

Jason Dunham
Gwynne Chandler
Bruce Rieman
Don Martin

Figure 1. Cover page of the paper, ***Measuring Stream Temperature with Digital Data Loggers: A User's Guide***.

temperature data. Those involved in water quality temperature monitoring need to be aware of the issues identified in table 1 so that the quality of past water temperature data can be critically evaluated. The same issues are useful to consider in evaluating whether current water temperature monitoring programs need to be modified to ensure the collection of quality water temperature data.

Measuring Stream Temperature with Digital Data Loggers: A User's Guide, was written by Jason Dunham, Gwynne Chandler, Bruce Rieman, and Don Martin. Electronic copies of this document, General Technical Report RMRS-GTR-150WWW, can be obtained online at: http://www.fs.fed.us/rm/pubs/rmrs_gtr150.html.

The citation for this publication is: Dunham, J.B., G.L. Chandler, B.E. Rieman, and D. Martin. 2005. Measuring stream temperature with digital data loggers: a user's guide. General Technical Report RMRS-GTR-150WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Using Multiple Indicators to Detect Geomorphic Channel Changes in Response to Wildfire

by Ronna J. Simon

A study was conducted on the Targhee National Forest to determine post-fire channel form and behavior changes in Moose Creek, a spring-dominated stream in eastern Idaho that burned during the 1988 Yellowstone fires. The approach of this study is unique in that it uses multiple, relatively simple measurement techniques such as pebble counts, channel cross-section surveys, and longitudinal profiles collected over a 12-year period by different individuals to provide an integrative interpretation of channel response. The use of multiple lines of evidence provides greater certainty that channel responses were correctly interpreted and a suggested practical alternative approach that avoids the need for statistical replication at multiple sites.

Study Area

Moose Creek is a 16.1 mi^2 tributary of the Henry's Fork in eastern Idaho (fig. 1). The watershed's geology is predominantly rhyolite ash-flow tuffs, riparian areas are in excellent condition, and past land use includes logging and road construction. Springs are the primary source of perennial flow to the stream, which originate at steep volcanic headwalls and the base of volcanic flows.

During July 1988, the North Fork Burn, one of the Yellowstone Complex fires, burned 60 percent of the Moose Creek drainage; approximately one-half burned at high intensity and one-half burned at low intensity. Rehabilitation efforts included aerial grass seeding, contour felling of logs on hillsides and in drainage bottoms, construction of sediment dams, and other measures. Heavy equipment was used to break water-repellant surface layers before seeding in areas with hydrophobic soils.

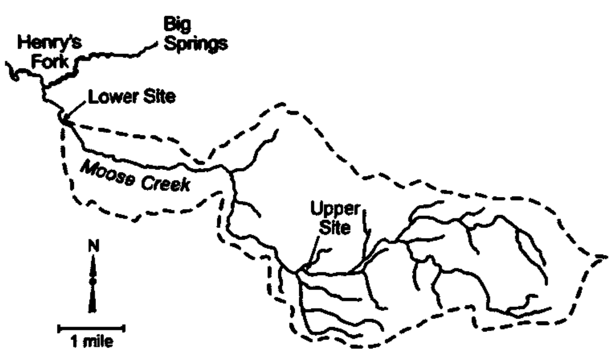


Figure 1. Map of Moose Creek study area and locations of sampling sites.

In spite of these efforts, high-intensity burn areas have been difficult to regenerate because of persistent high surface soil temperatures and hydrophobic soil conditions. Consequently, a large amount of soil remains exposed in the high-intensity burn areas. These conditions have led to accelerated headwater surface runoff in response to precipitation events. Due to the erodible nature of the parent material, the increased surface runoff has caused extensive gully and sheet erosion, erosion of road-related features, and delivery of sediment to streams. As a result, turbid flows in lower Moose Creek are often reported in association with spring and summer rain storms.

Methods

Two study sites, upper and lower Moose Creek, were originally established in 1985 as part of a monitoring effort to evaluate channel changes associated with roads and logging in the watershed. After the 1988 fires, the existing sites were used to evaluate channel changes caused by the North Fork Burn. Characteristics of the study sites are presented in table 1.

About 90 percent of the watershed above the upper Moose Creek site burned in 1988; about one-half at high intensity. The upper Moose Creek site is characteristic of a Rosgen C4 channel type with an entrenchment ratio of 3.7, a width/depth ratio of 8.7, a bankfull slope of 0.7 percent, a channel sinuosity less than 1.2, and substrates comprised predominantly of gravel. The reach is situated in a confined valley resulting in a lower channel sinuosity and width/depth ratio than would be normally expected for a C channel. However, reaches immediately adjacent to the study site are more typical of C channels.

Table 1. Moose Creek study site characteristics.

Parameters	Upper Moose Creek	Lower Moose Creek
Drainage area (km^2)	19.8	41.6
Valley gradient (percent)	1	0.4
Rosgen channel type	C4	E4
Area of watershed burned above site (percent)	90	55

The lower Moose Creek site is a Rosgen E4 channel type with a gradient of 0.1 percent, a channel sinuosity greater than 1.5, a width/depth ratio of 8.0, and channel material comprised predominantly of gravel. The channel flows through meadows of sedges and grasses, which provide excellent bank stability. About 55 percent of the watershed above this site burned in 1988.

As is common with many administrative studies, data were collected sporadically between 1985 and 1997 limiting the interpretive value of the study. Pre-fire data from 1986 were only available for some of the channel parameters discussed. Only post-fire data collected in 1991, 1994, and 1997 are discussed in this paper.

Although measurements were made of discharge and bedload transport, only the channel parameters of channel-bed material, cross section, and longitudinal profile are discussed here. A Wolman pebble count was used to characterize channel-bed particle sizes and a contingency table and chi-square test was employed to statistically compare pre– and post-fire differences in percent fines (particles < 2 mm in diameter). A single cross section was surveyed at each site with a level and rod and referenced to a permanent benchmark. A longitudinal profile of bankfull, water surface, and channel thalweg elevations were surveyed 100 ft upstream and downstream from the established cross sections at each site.

Results

Bed Material Composition

In general, bed materials were finer at the lower Moose Creek site than the upper Moose Creek site (fig. 2). Since pre-fire particle size data were not available for the upper Moose Creek site, it is difficult to draw definitive conclusions regarding channel response. The particle size data lacks any apparent trend following the fire; fines < 2 mm are not statistically different from each other (fig. 2).

At the lower Moose Creek site, the post-fire (1991, 1994, and 1997) percentage of fines < 2 mm were statistically higher than the 1986 pre-fire conditions with almost 50 percent of the particles on the channel surface being less than 2 mm in size three years after the fire (1991 post-fire data) (fig. 2). The percentage of fines < 2 mm decreased six and nine years after the fire, but not with a consistent temporal trend.

Channel Cross Section

Unfortunately, cross-section surveys were not conducted at the upper Moose Creek site before the fire. However, all post-fire changes in the cross-section appeared to be taking place with respect to channel depth and floodplain elevation rather than lateral movement because the bank is stabilized by riparian vegetation and the confined valley. The most interesting development at this site is progressive vertical floodplain building above bankfull stage on the right bank in the years following the fire (fig. 2).

At the lower Moose Creek site, post-fire cross-sectional area computations show net degradation at the site compared to the pre-fire data, but no major changes in cross-section form are visually evident. The greatest net change occurred three years after the fire (1991 post-fire data) as the channel incised (fig. 2). Six and nine years after the fire, the channel aggraded and approached an elevation similar to the 1986 pre-fire channel elevation. All changes occurred within the bankfull channel partly because overbank flows failed to occur at this site. The cross-section was also generally stable due to the presence of bank vegetation that provided excellent bank stability.

Longitudinal Profile

Pre-fire longitudinal profiles do not exist for either site. At the lower Moose Creek site, a regression analysis of bankfull elevation (floodplain) versus distance downstream showed very little change in elevation between 1994 and 1997 (fig. 2). At the upper Moose Creek site, however, the regression

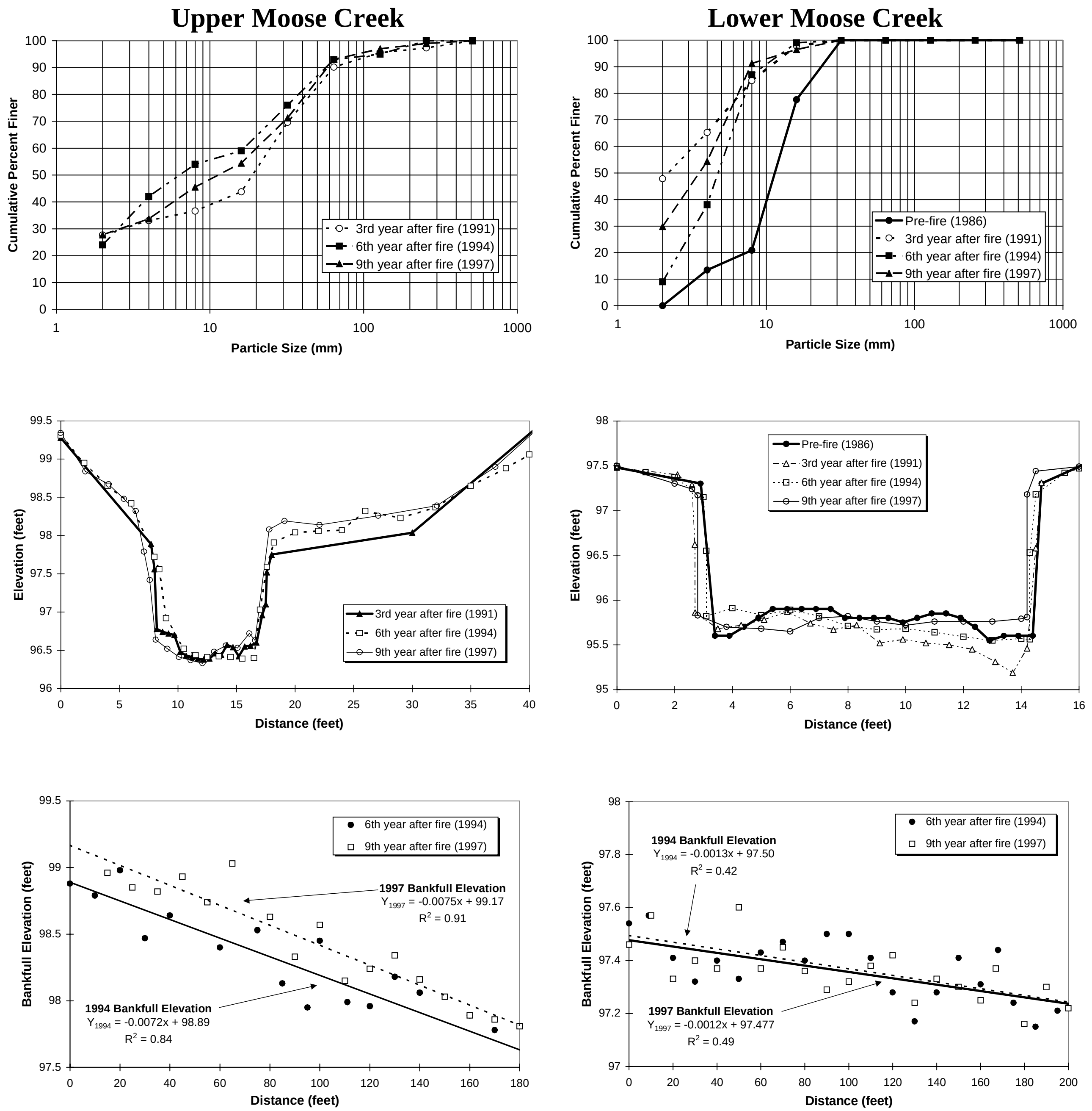


Figure 2. Particle size, cross section, and longitudinal profile data describing channel responses to wildfire in the Moose Creek watershed. The steep and confined channel at the upper Moose Creek site showed relatively minor changes to channel-bed particle sizes, but it is difficult to draw definitive conclusions because of the lack of pre-fire data. However, the upper Moose Creek cross section data clearly shows post-fire floodplain building resulting from the deposition of fines on the floodplain. This evidence is supported by data from the longitudinal profile which confirms a similar increase in the elevation of bankfull stage. At the low gradient and unconfined channel of the lower Moose Creek site, the particle-size data shows a substantial and statistically significant increase in post-fire channel-bed fining that continues to persist nine years after the fire. Cross section data shows that the largest degradation occurred three years after the fire in 1991, but that the channel remained relatively stable with no major changes within the bankfull channel or on the floodplain. The longitudinal profile data confirms the lack of change in bankfull elevations at the cross section. While no individual channel parameter provides conclusive evidence of geomorphic channel change in response to wildfire, by examining the data in a holistic manner within the context of our understanding of geomorphic processes, it is possible to draw scientifically valid conclusions of channel responses to wildfire.

analysis of bankfull elevation versus distance downstream showed an increase in elevation confirming the increase in bankfull elevation identified in the cross-section data (fig. 2).

Discussion

The increase in sediment supply following the 1988 fires is assumed to comprise the majority of the Moose Creek sediment load. This inference is based on increased sediment availability caused by decreased vegetative cover in the watershed compared to pre-fire conditions. This lack of vegetation allowed increased surface erosion and facilitated sediment delivery to channels. The inferred increase in sediment availability is further supported by observed erosion in the burn area and storage of this material in the upper watershed. The Moose Creek drainage network, however, is fully capable of transporting sediment delivered from the burn area through the system.

The lower Moose Creek site exhibited an increase in fine materials (< 2 mm) three years after the 1988 fire. Measurements made in subsequent years contained smaller percentages of fine material than those made in 1991, but higher percentages than observed in 1986. Although there were no pre-fire data at the upper Moose Creek site, levels of fine materials there were higher in 1991 and 1997 than in intervening years, as was the case at the lower site. A logical cause for the 1991 increase in fines was the fire, which resulted in loss of vegetation, creation of hydrophobic soil conditions, accelerated erosion from the watershed, and delivery of fine sediment to the stream. The 1997 increase in fines can be attributed to continued sediment production from the burn area, where revegetation was still not complete, and where high amounts of fine sediment were still being delivered downstream.

A comparison of pre– and post-fire cross sections at the lower Moose Creek site indicates net degradation (a net increase in cross-sectional area) between pre– and post-fire periods. Since 1991, however, net aggradation appears to be taking place at the lower site. No floodplain building is taking place and although the floodplain is frequently wet, overbank flows have not been observed and all changes are restricted to the channel bottom and banks.

Net changes in cross-sectional area at the upper Moose Creek site since 1991 indicate that the channel bed has not been aggrading, but the right bank floodplain elevation has been increasing, accounting for the calculated net change in cross-sectional area. Overbank flows have had extensive access to the floodplain, and increased flows and continued high sediment input in recent years would explain this development. Fresh overbank and lateral accretion deposits observed in other channel reaches in 1997 support the floodplain aggradation measured at the cross-section.

Changes in floodplain elevations were not evident in longitudinal profiles at the lower site, where lack of overbank flows precluded any major change. Longitudinal profiles at the upper site, however, show a trend of increasing bankfull (floodplain) elevations from 1994 to 1997, which confirmed the cross-section evidence that the floodplain is building vertically.

Conclusions

A series of different geomorphic measurements provided valuable tools to understanding channel responses in this study. Rather than interpreting one piece of evidence, such as changes in percent fines, multiple indicators allowed for an integrated interpretation of channel function. The various techniques reinforced each other to allow inferences of stream processes, assuring greater certainty in having correctly interpreted channel changes. Multiple indicators also help to overcome data deficiencies that frequently occur during non-research monitoring studies.

For additional information and references, please refer to the following publication: Simon, R.J. 2000. Observed geomorphic channel response to wildfire of Moose Creek, a spring-dominated stream. Intermountain Journal of Sciences. 6: 143-158. Electronic copies of the paper can be obtained from the STREAM website: http://www.stream.fs.fed.us/publications/documentsNotStream.html.

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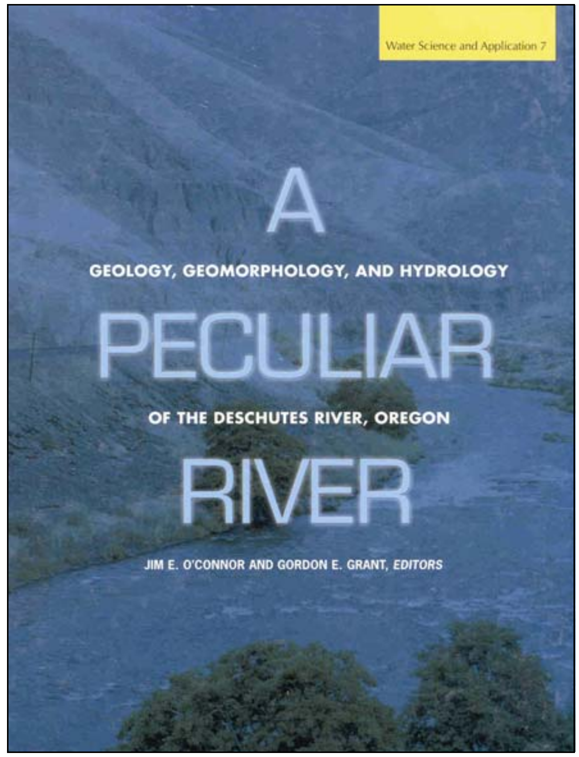
A Peculiar River: Geology, Geomorphology, and Hydrology of the Deschutes River, Oregon



A Peculiar River: Geology, Geomorphology, and Hydrology of the Deschutes River, Oregon is a multi-disciplined collection of papers based on seven years of studies to assess the effects of flow regulation and reduced sediment input on the hydrology, geomorphology, and ecology of the Deschutes River. The unexpected lack of geomorphic evidence of channel changes along the Deschutes River from flow regulation makes it a "peculiar" river and challenged investigators to explain why. By examining the Deschutes River at multiple temporal and spatial scales, the various studies began to recognize the importance of the basin's geologic and climatic setting and history in controlling hydrological, geomorphic, and ecological processes prior to and after flows becoming regulated on the river by the Pelton-Round Butte dam complex.

The editors, Jim E. O'Connor and Gordon E. Grant, state that the intent for this monograph is to provide "an example of a holistic approach to understanding rivers – one that recognizes each river is unique and will respond differently to environmental conditions depending on its current landscape setting as well its history." They strongly contend that "this type of approach is increasingly needed, not just to evaluate the hundreds of dams scheduled to be relicensed in the next decades, but also to provide the technical underpinning to decisions related to new dam construction (particularly in the developing world), dam removal, and river restoration efforts worldwide."

Within this framework, the nine separately authored chapters are organized into three sections:

1) Geology, hydrology, and fish of the Deschutes River basin;
2) The geomorphology and flood history of the lower Deschutes River; and
3) Geomorphic effects of dams on the Deschutes and other rivers.

As one progresses through the book, each section examines various topics at decreasing spatial and temporal scales. Section 1 consists of three chapters that provide a broad overview of the geology, hydrology, and fish of the Deschutes River basin. Section 2 consists of four chapters that examine the role of past floods and the current flow regime on geomorphic features and fluvial processes along the Deschutes River downstream from the Pelton-Round Butte dam complex. Section 3 consists of two chapters that assess the downstream effects of the Pelton-Round Butte dam complex on the Deschutes River.

Scientists and resource managers involved in assessing the effects of reservoirs on hydrological, geomorphic, and ecological processes will find this monograph a useful reference as many of the study approaches conducted on the Deschutes River are applicable elsewhere. ***A Peculiar River: Geology, Geomorphology, and Hydrology of the Deschutes River, Oregon*** is published by the American Geophysical Union and can be purchased for $63 ($44 AGU members) online at https://www.agu.org/cgi-bin/agubookstore.

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