THE BLANCO RIVER

John J. Berger

Introduction

This case study discusses scientific, technological, and administrative aspects of the Blanco River reconstruction project in southwestern Colorado (Figure A.10). It focuses on the channel stabilization and fishery problems encountered and the processes used to solve them.

Before repair work began in 1987, target sites on both branches of the Blanco River were broad, shallow, and braided with no pools. In the course of the 3-year river reconstruction project directed by hydrologist D. L. Rosgen, the river's bank-full width was reduced from a 400-ft-wide braided channel to a stable, 65-ft channel with a high pool-to-riffle ratio (personal communication during site visit to

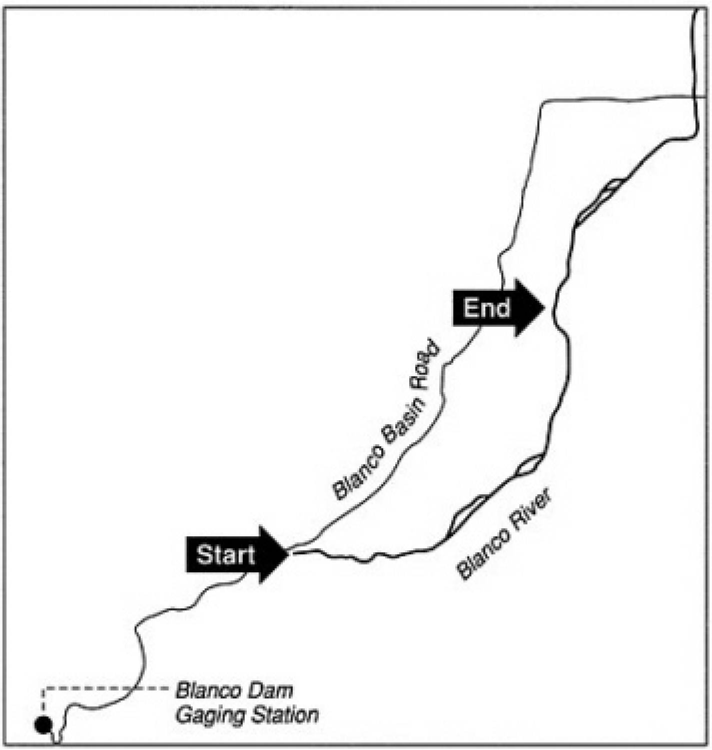

FIGURE A.10 Map of the Blanco River.

Blanco River, June 1990; D.L. Rosgen, telephone interview, January 1991). Even before project conclusion in 1990, major improvements had occured in the fishery and in the appearance of the site.

General Description

The Blanco River is located 20 miles southeast of Pagosa Springs, Colorado, on Highway 84, 10 miles east of Blanco Basin Road. The project area is about 2.7 stream miles in length and drains a basin of approximately 56 square miles. The site has been used for grazing for about 50 years. Mean precipitation in the basin is approximately 42 inches per year; runoff is dominated by snowmelt. Major floods in recent years have been caused by late summer and fall high-intensity thunderstorms.

The river has a slope of about 1.5 percent. Bed materials are heterogeneous unconsolidated cohesive particles ranging from fine sand to very coarse cobbles. The mean river depth is 3.5 ft, and the river in the project vicinity is a fourth-order Horton stream. In the stream classification system of the hydrologist who repaired sections of the Blanco and San Juan Rivers (Rosgen, 1988), both project reaches of both rivers were designated as D1 streams and were reconstructed as C1 streams.

A D1 stream has a slope of 1.5 percent or greater; a braided channel; and a cobble bed with a mixture of coarse gravel, sand, and small boulders; it is slightly entrenched without valley confinement, and is found in coarse glacial outwash depositional material in a reach with an excess sediment supply of coarse-size material (Rosgen, 1988).

The C1 target stream has a gradient of 1.2 to 1.5 percent; a sinuous channel with a sinuosity ratio of 1.5 to 2.0; a width-to-depth ratio of 10 or higher (18 to 20 in the case of the reference streams used as models for the Blanco restoration); and a cobble bed with a mixture of small boulders and coarse gravel; it is moderately entrenched and moderately confined by its valley, and is found in predominantly coarse-textured, stable, high alluvial terraces (Rosgen, 1988; D.L. Rosgen, telephone interview, January 1991).

Origin of the Problem: Improper Flood Control

A major difference between the Blanco and the San Juan River is that the Blanco was channelized by the U.S. Army Corps of Engineers (COE) after a 1970 flood in an effort to protect adjacent land from flooding. The flood control effort resulted in channel instability and in the creation of a braided reach. By contrast, the channel instability in the San Juan River was caused by extirpation of stream-bank vegetation.

After the 1970 flood, COE straightened portions of the Blanco River, increased its slope, and entrenched the river within a levee system so that what once was the low-flow channel, terrace, and floodplain became a wide, flat-bottomed trapezoidal channel. The loss of meanders and steepening of the river caused the channel bed to degrade. This, in turn, resulted in stream-bank failure and erosion. This erosion typically travels upstream and eventually contributes to sedimentation and aggradation of downstream reaches.

Replacement of the natural river morphology by the wide artificial channel induced sediment deposition through a reduction in shear stress. The shear stress is a function of stream gradient, specific gravity of water, and the hydraulic radius. Enlarging the width-depth ratio by channelization reduces the shear stress or entertainment capacity of the stream at any flow. This can cause sedimentation and a braiding channel. Channel confinement also prevented the floodplain from functioning (the floodplain is necessary to dissipate energy). Another problem was COE's use of highly erodible riverbed material to build the levees.

After channelization, a broad range of hydrological problems began to appear. The river began to spread out from its channel, becoming broad and shallow, detaching riparian vegetation, and eroding banks as it migrated. The active bank erosion contributed high sediment loadings to the stream, which in turn led to bar building and other types of sediment deposition. Agricultural land along the river was made unusable and agricultural facilities, including a barn, were threatened. Because the shallow river experienced high summer temperatures and full freezing in the winter, and had lost its pools and other trout refugia, few fish could be found; those taken were generally small brook trout. As on the East Fork of the Blanco (another Rosgen channel stabilization site), much of the Blanco sediment was contributed by a relatively short stretch of the river.

Since COE's flood control intervention, there has been continual progressive erosion of the property owner's land near the Blanco, threatening portions of the remaining land and facilities. Since COE changed the natural riverine hydrology, the landowner has had to spend thousands of dollars over many years trying to stabilize the riverbanks, but to no avail. Until he learned of Rosgen's successful work on the nearby San Juan River, the landowner was uncertain how to proceed, because he did not want to use conventional COE engineering approaches that rely on unsightly concrete and riprap to imprison the river.

Restoration Goals and Objectives

The major goal of the Blanco reconstruction was to stabilize the river in a well-incised but natural looking permanent channel that would enable it to handle floods, without requiring creation of an artificial-looking concrete channel. The "soft engineering" approach used by Rosgen required rebuilding the river's width-to-depth ratio, and re-creating a natural channel geometry containing a low flow channel, floodplain, and terrace.

In selecting design criteria, Rosgen first located undisturbed similar streams in the vicinity of the Blanco and found that their dimensions and patterns were consistent with those of the C1 stream type in his stream classification system. He then sought to use as design criteria the values of this very stable stream type existing in the local area on the same gradient and within similar channel and bank materials.

In Rosgen's work on the East Fork of the Blanco, he modeled the reconstruction on a stable section of the river about a mile down-stream from his project site. To verify that the candidate stream type selected should be stable, he studied a long time series of aerial photos taken from the 1940s until recent years. This historical record included a period that extended many years before and after major floods. Inspection revealed that the C1 stream type exhibited postflood self-stabilization. Rosgen therefore concluded that the C1 stream type had held up and would hold up very well.

Another reconstruction goal was to increase bank storage. Previous to Rosgen's stabilization work, the Blanco River project sites were so wide that the floodplain had been eroded away, and no land was adjacent to the active channel.

Cost and Benefits

Restoration costs on the Blanco, about $30 per lineal foot of stream, were half those on the San Juan River project, because equipment operators had been trained during the earlier project and were able to work more efficiently (D.L. Rosgen, telephone interview, January 1991). Total costs to the private landowner on whose property the Blanco River work was done were about $400,000. Spawning channels and a new spring-fed, floodplain-level trout pond on the Blanco added about another 15 percent to total project costs (D.L. Rosgen, telephone interview, January 1991).

From his $400,000 investment, the landowner gained the 168 to 170 acres of agricultural land that was once again made available in the floodplain. The recreated floodplain varied from about 400 to 800 ft in width, and the cost of its creation per acre was about the going rate for purchase of land in the area.

Where fish were scarce and small, it is now not unusual to catch 16- to 18-inch brown and rainbow trout that have been stocked. Fishing has also been improved by construction of narrow, sinuous fish spawning channels ranging from 20 or 30 to 500 yards in length and connected to the main branch of the river, as well as by creation of an acre-and-a-half, spring-fed trout pond. Through revegetation with willows and cottonwoods, major aesthetic improvements were also made at the site.

Another way to assess the value of the project beyond landowner satisfaction with the fishery, land reacquisition, aesthetic improvements, and property protection values would be to estimate the avoided damage from stream sedimentation. Rosgen points out that Pacific Gas and Electric Company pays $4 per cubic yard of sediment kept out of Wolf Creek, which it manages in California. Sediment not kept out of the creek and accumulating in a company holding pond must be dredged and disposed of at a cost of about $6 per cubic yard. Because of the very active bank erosion in progress before the project began, use of this sediment-to-dollars conversion factor would result in a very large estimated project benefit based solely on avoidance of sediment damage.

Project Permits

The Blanco River project design was reviewed by the following agencies prior to the granting of a construction permit under Section 404 of the Clean Water Act of 1977 (P.L. 95–217): the Colorado Division of Wildlife, the U.S. Fish and Wildlife Service, the Environmental Protection Agency, and the U.S. Forest Service. The project almost failed to materialize when COE subjected the unique design to expert review and was told by its reviewers that the new system would not contain flood flows. The project design was then sent for review to Professor Luna Leopold at the University of California, Berkeley, Department of Geology and Geophysics; Leopold praised the project and expressed confidence that it would work. On the basis of his recommendation, COE withdrew its reservations, and the project was allowed to proceed.

No federal funding was applied for, although it is possible that matching funds could have been obtained through the Agricultural Conservation and Stabilization Service.

Restoration Process: Major Stages

Rogens attemps in a mathematical way to match the observed stream morphology of stable streams to the reconstruction design criteria for his projects. He takes theoretical relationships regarding channel geometry and then observes the empirical relationships in the field for verification of the theory. Observations are then linked to his standardized empirical stream classification system. In effect, he matches stream data and other variables to the model. The principles employed work in any physiographic region, because sediment grain size and slope are physical characteristics that can be observed anywhere in the world, and the laws of physics are also universal. Over time, Rosgen continues expanding and refining his classification system by adding newly observed stream types.

Rosgen began the Blanco project with research to identify the causes of the river's problem. This entailed inventorying of hydrological conditions, locating stream flow records from the U.S. Geological Survey, and interpreting over time the behavior of stable and unstable channel forms and types.

Rosgen then created a design based on existing flow and other variables similar to the natural stable form for that flow. Dimensions for the channel were chosen based on flow data, and patterns for the channel were developed based on the dimensions and flow. The river's meander geometry—the radius of its curvature, curve amplitude, and meander length—was designed commensurate with its width in the same proportion as a natural river of the model type.

Next, Rosgen obtained necessary permits using calculations based on permanent stream cross sections to calculate the necessary amounts of cut and fill (i.e., the yardage of excavations). He was also required to do an environmental assessment for his project and mitigation. Clearance of the Section 404 permit took about 60 days.

Rosgen then field-staked the active channel and its proper alignment and other aspects of its meander geometry using a laser beam level. Before construction began, he diverted the stream into a constructed bypass channel so the stream work could be done dry. Construction was done during seasonal low-flow periods.

Downstream of the construction area, Rosgen had constructed a settling detention basin outside the active channel via a diversion. Thus any sediment from the project was flushed into the pond.

Rosgen then directed the shaping of the channel with bulldozers and scrapers, so that material from bars and channel was deposited in the floodplain. The effect of the entire project was to bring about a transformation of the river. The problem with braided rivers is that they generally do not recovery naturally; recoveries are known but are extremely rare; and braided channels typically get progressively worse and are not self-correcting (D.L. Rosgen, telephone interview, January 1991).

Once Rosgen establishes the river geometry including cross-sectional dimensions, he delineates the flow pattern and then performs bank revetment work utilizing native material, including logs, root wads, boulders, and live vegetation. On the Blanco River, he used cottonwoods and willows to reestablish streamwide tree cover, and he used fescue, bluegrass, and clover, as well as nonnative timothy and orchard grass, to cover bank areas. Willows in this project were transplanted by front-end loaders from an adjacent terrace located about 150 yards from the river channel to the river banks. Cuttings were also taken from willows adjacent to the river, utilizing the same species of willows.

To reinforce banks, Rosgen used much the same procedure as on the San Juan River: he sank logs in the streambed, put boulders over them, and positioned logs on top of the boulders. After the logs had been covered with some soil, willows were planted in the newly created bank margins.

Project Indicators

Variables with which Rosgen was concerned on this project included river width, depth, velocity, discharge, slope, energy slope, roughness, sediment load, sediment size, sinuosity, width-to-depth ratio, dominant particle size of bed and bank materials, entrenchment of channel, confinement of channel, landform confinement of channel, landform features, soil erodibility, and stability (Rosgen, 1988).

Rosgen measured sediment particle size, substrate, aggregation, degradation, slope, longitudinal profile, bed load, suspended sediment, grading curves, and particle size on the very similar East Fork project reach on the Blanco and used that data in his design work on the main branch of the river.

In gathering this data, Rosgen's main concern was to verify that, given the sizes of sediment that moved through the new channel versus the old channel and the expected sediment input from the feeder channel, the reconstructed reach would be able to accommodate the demands placed on it.

Conclusion

The Blanco River project site now has new meanders, deep pools, new flood terraces, rebuilt floodplains, riparian vegetation, verdant pasture grasses, and banks stabilized with locally obtained root wads, tree trunks, and boulders. The current is focused into the center of the channel by strategic placement of "vortex rocks" in the channel to aim the force of the water away from the banks. The new stable channel complex has a natural look, compared with cement trapezoidal channels, levees, and riprapped banks. The fishing is a delight to landowner and visitors alike.

References

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THE KISSIMMEE RIVERINE-FLOODPLAIN SYSTEM

John J. Berger

I wondered... about this passion to make a place into something it isn't. We irrigate the desert and drain Florida. I suppose we'd bulldoze the Rockies if we could find a big enough bulldozer... What made south Florida unique was singled out for eradication.

G. Norman, 1984

Introduction

The restoration of the Kissimmee River needs to be understood in the larger context of the effort to restore the Florida Everglades. The Kissimmee River was once a broad, meandering 103-mile-long waterway that drained an upper basin consisting of a chain of lakes (Figure A.11). The river then flowed slowly through an expansive marshy floodplain into Lake Okeechobee, its southern terminus. The Kissimmee River basin, the enormous lake, and the Everglades together