BIOTECHNICAL BANK STABILIZATION ON THE PETALUMA RIVER, CALIFORNIA

Richard Nichols

Director of Biological Services, EIP Associates
601 Montgomery Street, Suite 500
San Francisco, CA 94111

Andrew T. Leiser, Ph.D.

Professor Emeritus, University of California, Davis
Davis, CA 95616

BIOGRAPHICAL SKETCHES

Richard Nichols

Richard Nichols is Director of Biological Services for EIP Associates, a San Francisco based environmental consulting firm. Mr. Nichols has 17 years of experience in plant ecology and natural resource management, including seven years of service for federal agencies such as the Bureau of Land Management and Department of Defense. Mr. Nichols holds a Bachelor's degree in Biological Sciences from California State University, Chico, and a Master's degree in Range Management from the University of California, Davis. He was awarded the General Thomas D. White Certificate of Achievement for Natural Resources Conservation by the U.S. Air Force and is licensed by the California Board of Forestry as Certified Rangeland Manager #45.

Andrew T. Leiser, Ph.D.

Andrew T. Leiser is emeritus professor of environmental horticulture from the University of California, Davis. He has over 40 years of experience in plant propagation and biotechnical erosion control. He co-authored with Donald Gray the pioneering textbook *Biotechnical Slope Protection and Erosion Control*. Dr. Leiser continues to teach courses on biotechnical slope protection and shoreline stabilization approaches for agencies such as the U.S. Army Corps of Engineers, University of Wisconsin, and Association of Bay Area Governments.

BIOTECHNICAL BANK STABILIZATION ON THE PETALUMA RIVER, CALIFORNIA

Richard Nichols

Director of Biological Services, EIP Associates
601 Montgomery Street, Suite 500
San Francisco, CA 94111

Andrew T. Leiser, Ph.D.

Professor Emeritus, University of California, Davis
Davis, CA 95616

ABSTRACT

Eroded streambanks subjected to high energy flows can be stabilized without hard structural treatments in a manner that is compatible with habitat restoration objectives. Erosion was threatening the site for a proposed shopping mall and riparian habitat restoration project on the Petaluma River. The Petaluma River is a low gradient stream at that location, with a muted tidal influence from the San Francisco Bay, which is approximately 19 kilometers (12 miles) downstream. Despite the mild gradient and relatively low flows during the dry summer, high flows following intense winter storms have the energy to cause extreme scouring and undercutting. The City of Petaluma, 64 kilometers (40 miles) north of San Francisco, California, required a "soft" approach to achieve both erosion control and habitat mitigation objectives. The solution included installation of 0.3 meter (12 inch) diameter coconut fiber cylinders in rows on contour to provide protection to the toe of slope. The upper bank was secured by rows of live willow wattling (cuttings in bundles) staked to form linear rows. Areas in between the rows of wattling and fiber cylinders were secured with 5.1 centimeter (2 inch) thick coconut fiber matting. Native riparian trees and shrubs were planted on the upper bank. The lower bank was planted with tules, rushes, and other native sod-forming herbaceous species. The stabilized bank withstood severe storm flows the first winter (1993–1994). The treatment remained intact after withstanding higher flow velocities from two severe floods in 1995. The treated streambank has now successfully held up to several storm events over four winters. An eroding bank unable to support vegetation and with little wildlife use has now been stabilized and restored to a valuable and scenic native riparian habitat, threats to adjacent land have been eliminated, and erosion/siltation minimized. This project demonstrates that biotechnical streambank stabilization is a viable alternative to riprap that can reduce erosion and sedimentation while enhancing habitat values.

BACKGROUND

Undercutting and riverbank erosion were threatening the site for a proposed factory outlet shopping mall, recreational bike trail, and associated riparian habitat restoration project. The Petaluma River is a low gradient (2–3%), deeply incised (about 9 meters [30 feet] from top of bank to low flow water line), and relatively large stream about 15 meters (50 feet) wide at the low flow line adjacent to the project site. It is subject to a muted tidal influence (1 to 1.5 meters [3 to 5 feet]) from the San Francisco Bay, which is approximately 19 kilometers (12 miles) downstream. The watershed upstream of the site is approximately 92 square kilometers (35.5 square miles), with elevations from 610 meters (2,000 feet) above sea level in the hills to the northeast to about 9.2 meters (30 feet) above sea level at the site. Annual rainfall averages between about 56 centimeters and 102 centimeters (22 inches to 40 inches) per year, over 90% of which falls from November to April. The project vicinity has a relatively high runoff coefficient (~ 0.5) because of a preponderance of low permeability clay soils and impermeable paved surfaces from urbanization (EIP Associates, 1993). Despite the mild gradient and relatively low flows during the dry summer, high flows following intense winter storms have the energy to cause extreme flooding, scouring and undercutting. The Petaluma River has flooded repeatedly, both upstream and downstream of the site, with large floods causing evacuation of portions of the City in 1982 and 1986. High flows in the Petaluma River in February 1993 undercut about 91 linear meters (300 linear feet) along the riverbank, causing a large willow tree to fall in the channel. Subsequent flows were diverted by the obstruction towards the bank downstream, resulting in further undercutting and sloughing. The result was a loss of several meters horizontally from the top of bank into the project area and a steep, barren, and unstable slope (Figure 1). Further erosion of the unstable bank would eliminate a required setback from the proposed parking lot for the mall and reduce the area for riparian habitat restoration that was needed as mitigation for the project. Other areas along the project riverbank were also unstable and showed evidence of less severe undercutting. Additional concerns focused on the stability of the bank to support a proposed bridge. A purely biotechnical approach without use of structures or riprap was required by the City of Petaluma to achieve both erosion control and habitat restoration objectives without the need for an individual Clean Water Act, Section 404 permit, which would have disrupted project schedules. Based on information from a consulting hydrologist, treatments needed to be designed to withstand velocities up to 3.7 meters (12 feet) per second.

Figure 1. Severely eroded riverbank on the Petaluma River, California, prior to treatment, with fallen willow tree in background center (May 1993).

THE PLAN

Because of these extreme forces, the high values that were threatened, and a very low tolerance for risk of failure, it was apparent that an intensive and innovative treatment was required for the severely eroded area. The resulting plan (Figure 2) proposed installation of planted coir (coconut fiber) fascines installed on contour in three to four rows along the bottom half of the bank, beginning at the low flow water line. High density Fiber Rolls® manufactured by Bestmann Green Systems were selected for fascines due to their ability to thwart high velocity flows and provide a secure medium for revegetation without using hard structures. The Fiber Rolls® used on the project are composed of shredded coconut husk fiber ("coir") packed at 144 kilograms per cubic meter (9 pounds per cubic foot) into a polyethylene mesh netting exterior. They are 30.5 centimeter (12 inch) diameter cylinders, 6.1 meters (20 feet) in length and weighing 65.3 kilograms (144 pounds) each when dry. As shown in the plan (Figure 2), 5.1 centimeter (2 inch) thick coir fiber mats were proposed for installation between the fascine rows. The plan called for the top half of the bank to be secured by three rows of contour wattling. Wattling in this case is composed of live willow (*Salix* spp.) branches tied into cigar shape bundles averaging about 1.5 meters (5 feet) in length and about 20 centimeters (8 inches) in diameter, and staked end to end to form linear rows on contour with about 10 centimeters (4 inches) of their diameter trenched in below ground and 10 centimeters (4 inches) exposed above ground (Gray and Leiser, 1982). The plan proposed planting the entire bank densely with native herbaceous wetland species. These species were selected using rhizomatous rooting characteristics as a criteria in order to provide for a dense sod to hold the bank in place. Planting of riparian trees and shrubs was planned only for the top half of the bank to prevent obstruction or diversion of flows.

INSTALLATION

Proper installation is critical to ensure any successful erosion control project. The success of this project is largely a result of the cooperative working relationship between the prime contractor for the mall, Koll Construction, the landscape contractor who provided the labor, North Bay Landscaping, and the authors, who were responsible for construction inspections and oversight. Landscape crews were unfamiliar with installation of these materials and the authors provided onsite training and daily supervision. Implementation began in October 1993, with careful grading

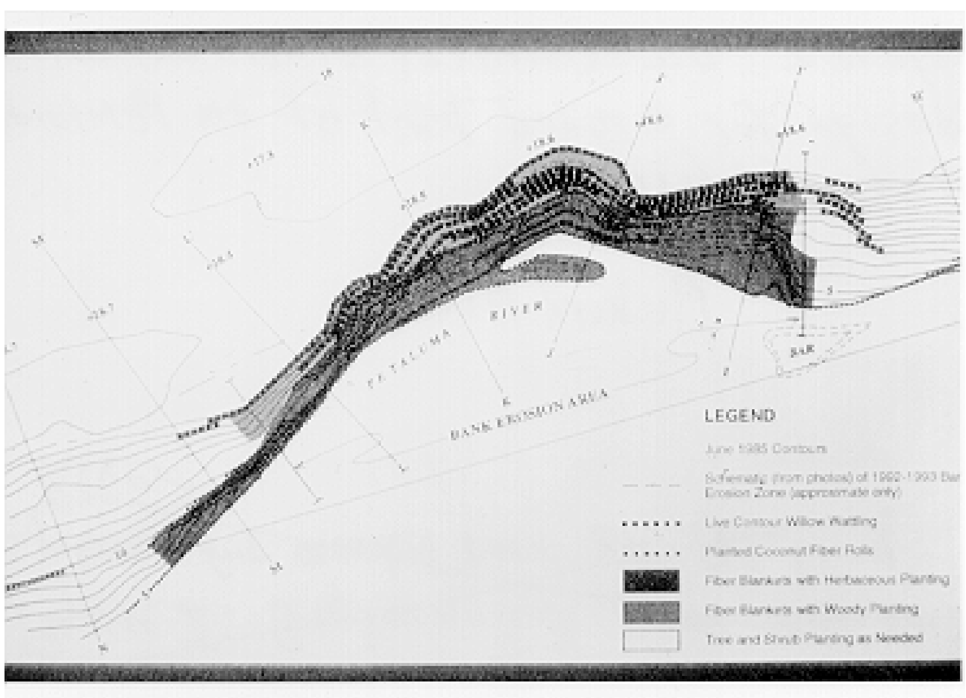

Figure 2. Biotechnical stabilization design for eroded bank of the Petaluma River, California.

of the vertical portions of the top of bank using a backhoe to create a more gradual slope (1:1 to 1.5:1) for improved stability and larger planting area. A row of hay bales was staked along the lower bank prior to grading as a sediment trap which prevented any soil from falling in the river. A biologist constantly monitored construction to ensure equipment stayed within construction limits and that sedimentation was minimized. The coconut fiber rolls were installed (Figure 3) securely with wooden stakes cut diagonally from 1.2 meter (4 foot) to 1.8 meter (6 foot) long construction lumber measuring about 5 centimeters thick by 10 centimeter wide ("two-by-fours"). The rolls were anchored by a network of polypropylene cords attached to notches in the stake and then hammered down taut with the surface. The upper bank was protected with rows of wattling trenched in on contour and wedged in with wooden stakes. An Abney level was used at frequent intervals during installation of the wattling and the fiber rolls to ensure they were placed on contour. This is important to prevent accumulation of water resulting in breaching of low spots. Areas between the fiber rolls and wattling were staked and tied down with coir mattresses also manufactured by Bestmann and called "Plant Carpets"®. These are 5.1 centimeter (2 inch) thick, 5 meter (16.5 feet) long, and 0.9 meters (3 feet) wide, each weighing 32 kilograms per cubic meter (2 pounds per square foot) when moist. Areas less severely undercut and the bridge abutment areas were treated with a single fascine row slightly below the low flow water line. In addition, willow wattling and Plant Carpets® were installed to stabilize disturbed areas under the bridge abutment. Installation was completed by the middle of November 1993.

PLANTING

The stabilized bank withstood high flows (measured up to 2 meters [6.5 feet] per second) the first winter, even prior to planting. Native herbaceous wetland plants were collected from the site and a total of approximately 9,000 plants were contract grown in 3.8 centimeter by 25.4 centimeter (1½" by 10") size tubule containers. Planting on about 45.7 centimeter (18 inch) centers commenced in the spring of 1994. Common tule (*Scirpus acutus*) was planted directly into the outermost and lowest fascines with alkali bulrush (*S. robustus*) and waterpepper smartweed (*Polygonum hydropiperoides*) at slightly higher elevations. The upper bank was planted with sedge (*Carex* spp.), umbrella sedge (*Cyperus eragrostis*) and Baltic rush (*Juncus balticus*). A temporary irrigation system was

Figure 3. Installation of coconut fiber rolls and carpets secured with "two-by-four" stakes and polyproplene cord (October 1993).

installed to allow for establishment during the dry summer. Intensive hand weeding was necessary to remove invasive species such as cocklebur (*Xanthium strumarium*), which compete with desirable species and do not provide good erosion protection due to sparse rooting characteristics. Willow sprouts from the wattling had attained heights up to 8 feet by July 1994, and the herbaceous species were rapidly covering the slope. A total of 816 native riparian woody plants of various species such as California box-elder (*Acer negundo ssp. californica*) and Oregon ash (*Fraxinus latifolia*) were planted in the fall of 1994. The shopping mall and recreational riverwalk were completed on schedule by Thanksgiving Day, 24 November 1994.

RESULTS AND DISCUSSION

As discussed previously, the severely eroded bank survived moderately high flows during the winter of 1993–1994, even prior to planting of anything but the willow wattling. The securely installed rolls and carpets provided sufficient protection to prevent erosion. A more severe test was to come, however. Heavy flooding in early January 1995 occurred on many streams in California, including the Petaluma River, leading to partial evacuation of the City. That flood sent high flows over the top of bank and inundated the mall's parking lot, which was designed as a flood detention basin. Some undercutting and sloughing occurred on adjacent untreated riverbanks, but the treated areas remained intact with no damage. Although the project team was pleased with the results, there was more of a test to come. Another flood, this one even more severe, hit the Petaluma River in early March 1995. Again, the bank was overtopped and the parking lot flooded. Post flood inspections revealed that the site was still intact, except for a small slide that was repaired easily. The site has withstood five rainy seasons (including this winter) with moderate to severe flooding. The previously eroded bank is densely covered with native emergent wetland and woody riparian vegetation (Figure 4). The adjacent recreational assets and property values have been protected, and a major source of sedimentation to the San Francisco Bay has been stabilized. Observations of wildlife use have demonstrated that a previously eroding riverbank with low scenic and wildlife values has been not only stabilized but restored to a viable native riparian habitat. This project is living proof that biotechnical approaches to erosion control in dynamic high energy river systems are feasible and can provide high levels of protection, while not only sparing damage to habitat values but actually enhancing them.

Figure 4. The previously unstable eroded riverbank has been secured and is densely covered with native riparian vegetation (July 1997).

The success of this project can be attributed to a number of factors including: 1) a thorough and well conceived plan that considered the character and magnitude of the prevailing erosive forces; 2) the selection and use of sturdy materials adequate to withstand those forces; 3) the selection of plants appropriate to the site and with strong, dense root systems; 4) proper and secure installation supervised by the project planners; 5) good cooperation and communication between the planners, responsible agencies, landowners, and contractors; and 6) adequate post-installation performance monitoring, maintenance and repair.

REFERENCES

Gray, G. H., and A. T. Leiser. 1982. Biotechnical Slope Protection and Erosion Control. Robert E. Krieger Publishing Co., Inc. Malabar, Florida. 258 p. plus appendices.

EIP Associates. 1993. Rainier Avenue Cross-Town Connector and U.S. 101 Interchange Project: Draft Environmental Impact Report #SCH 87050517. Prepared for the City of Petaluma.