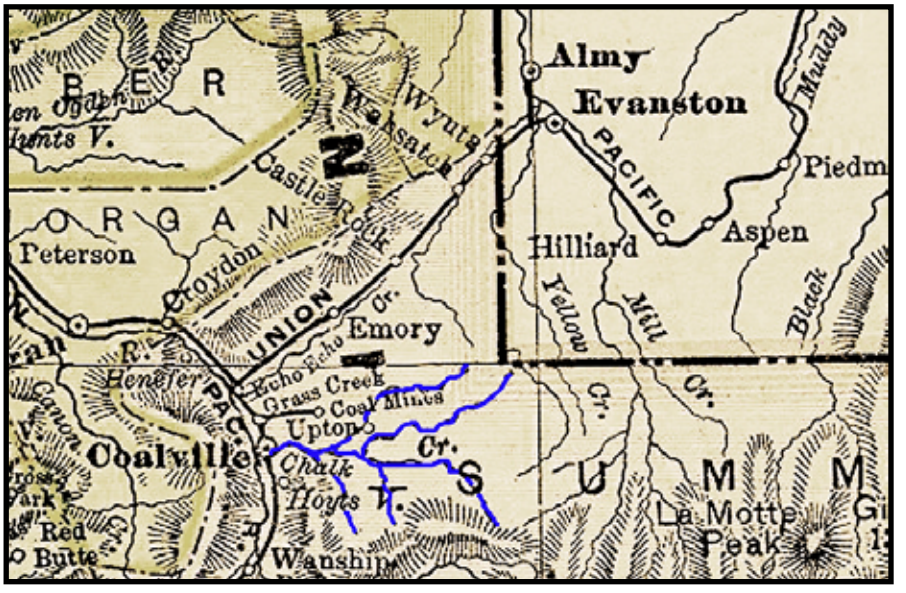
Case Study 1 Chalk Creek, Summit County, Utah



Issued August 2007

Cover photo: Stream restoration practices were used to prevent streambank erosion and improve fish habitat in this stream.

Advisory Note

Techniques and approaches contained in this handbook are not all-inclusive, nor universally applicable. Designing stream restorations requires appropriate training and experience, especially to identify conditions where various approaches, tools, and techniques are most applicable, as well as their limitations for design. Note also that product names are included only to show type and availability and do not constitute endorsement for their specific use.

Case Study 1 Chalk Creek, Summit County, Utah

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Overview

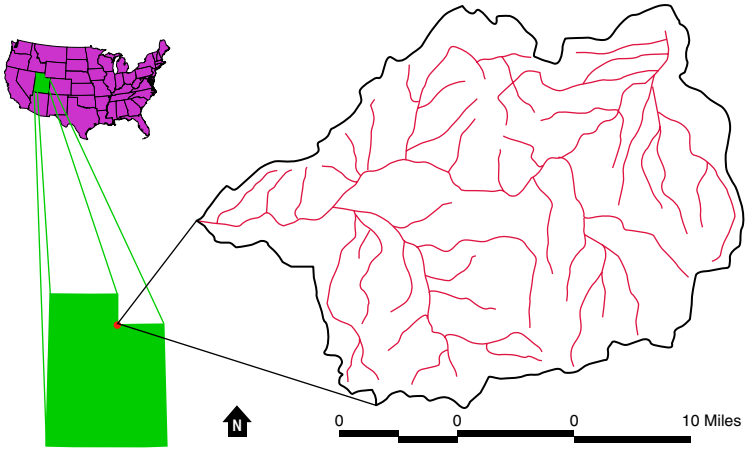
The Chalk Creek Watershed (fig. CS1–1) encompasses 172,000 acres in Summit County, Utah, 95 percent of which is rangeland. The Chalk Creek Nonpoint Source Water Quality Project began in 1991, when the Summit Soil Conservation District (SCD) organized a local steering committee to provide planning guidance decisions. This effort was in response to Chalk Creek being listed on the state 303(d) list (Clean Water Act) with sediment being the primary impairment to water quality. The committee consists of elected officials, landowners, wildlife groups, irrigation companies, and state and Federal agency personnel. The Coordinated Resource Management Planning (CRMP) process was followed and a Coordinated Resource Management plan (CRM) was published in 1994. Since that time, about $3.2 million have been spent in improvements involving 90 landowners and 84,092 acres within the Chalk Creek Watershed.

Trout habitat is one of the key resource concerns in Chalk Creek. The watershed holds the largest documented population of Bonneville cutthroat trout (fig. CS1–2) yet discovered at that time.

Landowners installed practices that have improved Chalk Creek's water quality and the overall health of the watershed. They voluntarily adopted conservation practices such as sprinkler irrigation systems, streambank protection, grazing management, riparian fences, and mine reclamation to control erosion and reduce runoff of sediments into Chalk Creek. This case study focuses on one of the streambank protection projects undertaken in this watershed.

Figure CS1–2 Bonneville cutthroat trout

Figure CS1–1 Chalk Creek Watershed



Chalk Creek

Example streambank protection project

In this case study, the landowner had recently acquired the property and was concerned about the amount of irrigated pastureland he was losing annually to bank erosion adjacent to Chalk Creek. In one instance, the stream channel encroached approximately 30 feet into the pasture during a single snowmelt runoff (fig. CS1–3, treatment section #4). Resource inventory revealed that past practices had removed woody riparian vegetation from many of the banks. Also, some apparent nick points or overfalls in the channel indicated active downcutting. Evidence of past channel dredging was apparent on a few reaches. At one location, a new bridge constricted the flow in the channel.

Design

In 1995, the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) designed streambank protection for this landowner. This project involved installing rock riprap barbs, juniper revetments, willow plantings, and low rock/vortex grade control structures. The project was an NRCS job class VI due to drainage area size. Figure CS1–4 shows typical project details. Streambank soil bioengineering practices are addressed in NEH654 TS14I.

The project involved stabilizing a 3,840-foot reach of Chalk Creek. Rock barbs were designed at places where active bank erosion was occurring. Willow plantings and juniper revetments were placed between rock barbs. These structures were needed to prevent bank erosion. On three of the treatment areas, berms were constructed to function as new streambanks protected with rock barbs, juniper revetments, and willow plantings. The borrow pits for the berm construction were adjacent to the stream and function as ponds. Existing vegetation was maintained on remaining areas.

The Chalk Creek drainage area at this location is approximately 156 square miles. The 25-year, 24-hour stormflow is approximately 1,450 cubic feet per second. Design bankfull flow is approximately 405 cubic feet per second, and bankfull width is 35 feet. This watershed typically has one annual channel-forming flow during snowmelt runoff.

The project was designed in accordance with the following NRCS Conservation Practice Standards in the Field Office Technical Guide: Streambank and Shoreline Protection (580), Channel Stabilization (584), and Channel Bank Vegetation (322).

The slope of the creek, channel width, alignment, and cross section were determined by field surveys. Utah Engineering Technical Note #7 was used to size and field-locate sites for the rock barbs. Rock was sized using criteria in Far West Design Standards. Rock gradation was selected based on criteria that the D_{100} is two to three times the median D_{50} rock size. The streambed materials at this site are a mixture of cobble, gravel, and sand. The streambank materials are a mixture of loam, sand, and gravels.

The low rock/vortex grade control structures were located in channel crossovers where active downcutting was occurring. Seven structures were located, based on field evaluation and an analysis of the survey. Typical criteria are to limit the drop per structure to 1 foot. The rock size was evaluated using criteria in Engineering Field Manual, chapter 16, Streambank and Shoreline Protection, allowing for debris and an impact factor.

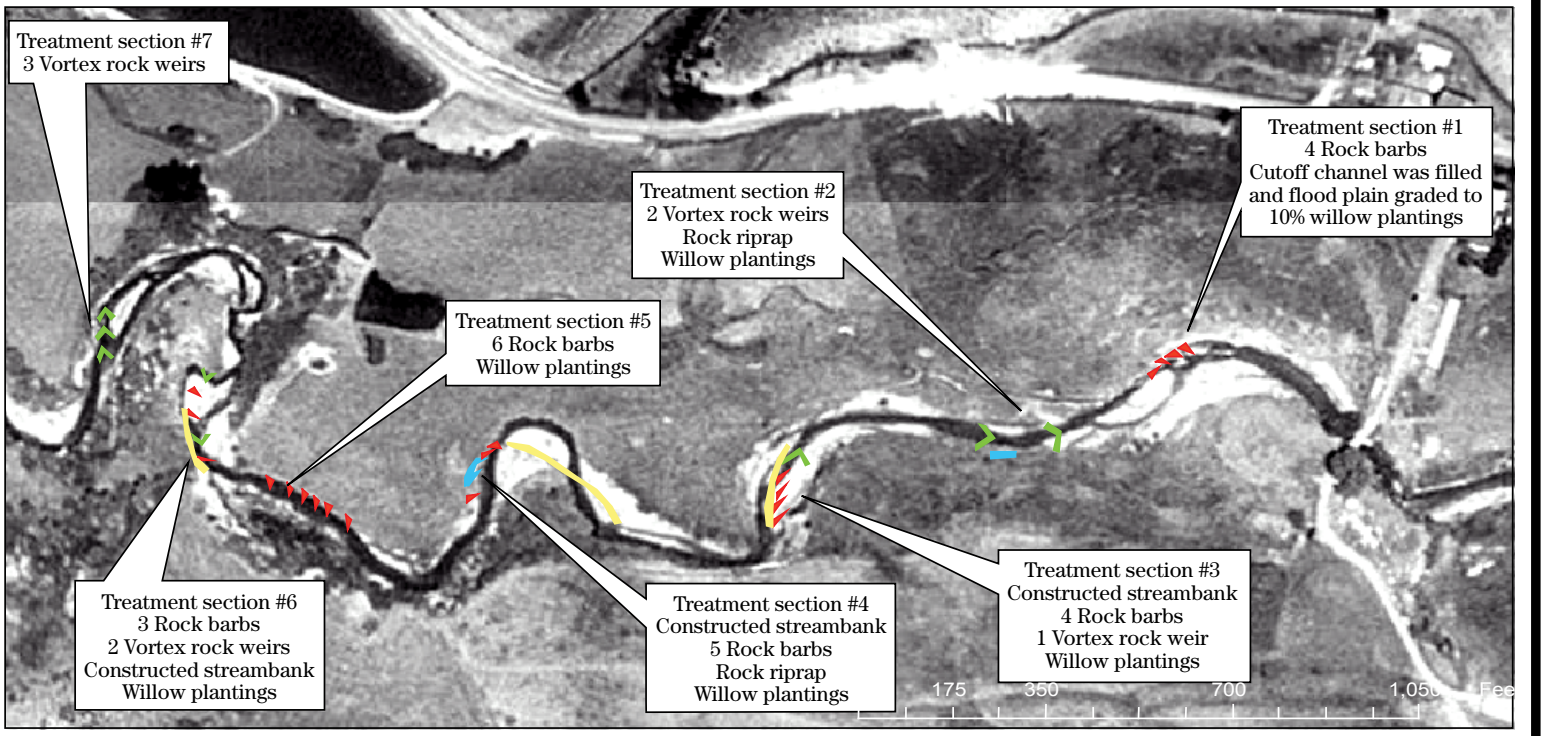
Chalk Creek Case Study design data

Rock gradation was determined using Utah Engineering Tech Note #7.

D_{100}= max 36 in, D_{75} = min 12 in
D_{100}= $2\times D_{50}$ = 24 in to $3\times D_{50}$ = 36 in
D_{75} = $1.5\times D_{50}$ = 18 in to $2.5\times D_{50}$ = 30 in
D_{50} = $1\times D_{50}$ = 12 in to $1.75\times D_{50}$ = 21 in
D_{25} = $.5\times D_{50}$ = 6 in to $1.15\times D_{50}$ = 14 in

% Passing	
100	36 in
100–75	24 in
75–50	18 in
50–25	12 in
25–0	6 in

Figure CS1–3 Chalk Creek example project, pretreatment view, 1989



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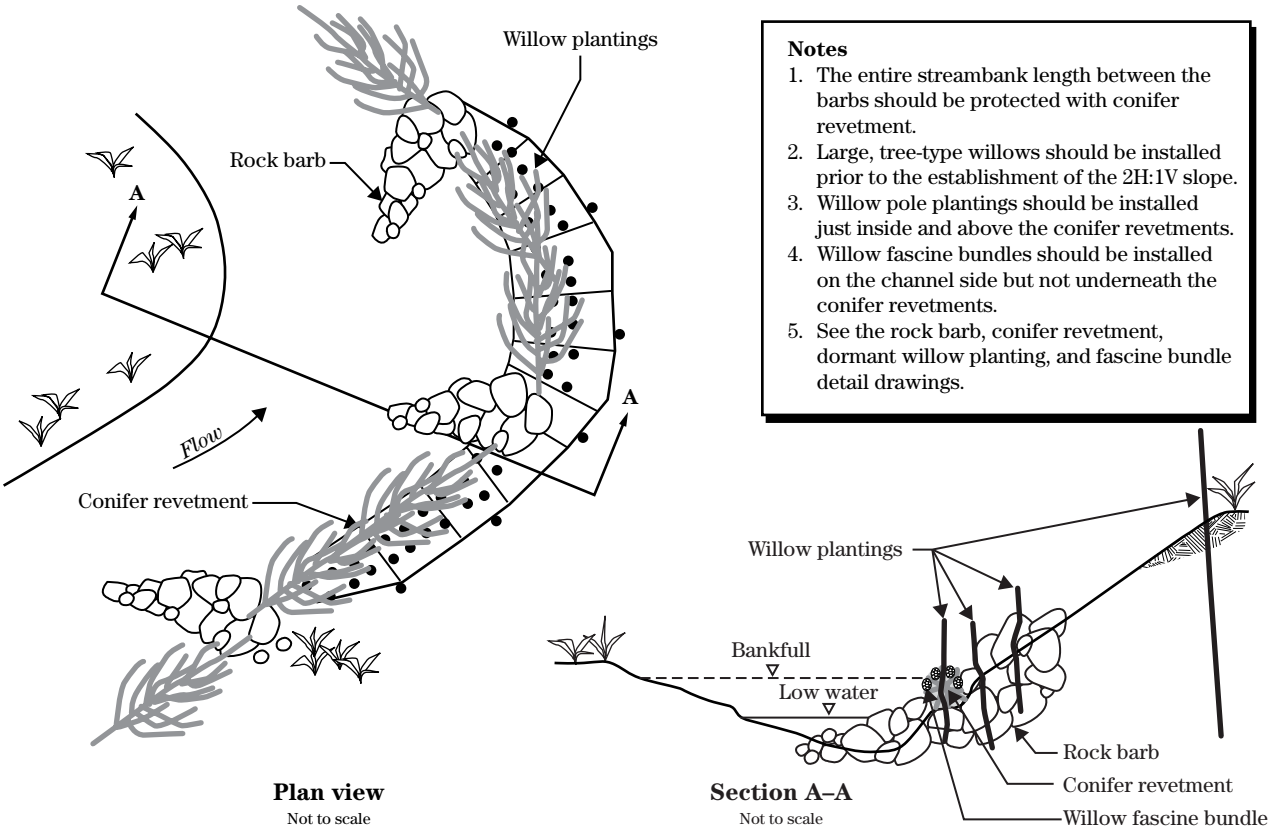
Treatment section #1 - the actively eroding bank was protected with a combination of rock barbs and willow plantings. A braided channel condition apparent in the photo was corrected by filling the cutoff channel and grading the flood plain to 10%.
Treatment section #2 - vortex rock weirs were installed to prevent downcutting following the installation of a bridge and the resulting constriction of the flood plain (see 2001 photo). A small section of rock riprap was installed adjacent to a vulnerable bridge abutment structure.
Treatment section #3 - an overwidened and braided channel condition was corrected by installing a berm, or constructed streambank. This structure was protected by rock barbs, and a vortex weir was installed to prevent downcutting.
Treatment section #4 - an oversized meander condition was corrected by installing a berm, or constructed streambank. Actively eroding banks protected with rock barbs, and later rock riprap was installed between two of the barbs (see 2001 photo).
Treatment section #5 - an actively eroding streambank was protected with rock barbs.
Treatment section #6 - a berm was constructed at a site on the streambank that was a risk for cutting off a very large meander shown in the photo. In 1995, a large runoff event began cutting a new channel that threatened to cut off this large meander. The eroding streambanks were protected with rock barbs, and a widened and braided channel was corrected by grading the flood plain to 10%. Two vortex rock weirs were installed to stop an active nick point from further downcutting.
Treatment section #7 - active nick points were prevented from further downcutting and upstream movement with three vortex rock weirs.

Legend

Practices

- Rock barbs
- Vortex rock weirs
- Constructed streambank
- Riprap

Figure CS1–4 Typical reach detail



Notes

1. The entire streambank length between the barbs should be protected with conifer revetment.
2. Large, tree-type willows should be installed prior to the establishment of the 2H:1V slope.
3. Willow pole plantings should be installed just inside and above the conifer revetments.
4. Willow fascine bundles should be installed on the channel side but not underneath the conifer revetments.
5. See the rock barb, conifer revetment, dormant willow planting, and fascine bundle detail drawings.

From the field survey:

- channel slope: 0.01 ft/ft
- bankfull width: minimum 45 ft, maximum 85 ft
- bankfull depth: minimum 2.2 ft, maximum 3.4 ft
- radius of curvature: minimum 40 ft, maximum 210 ft
- rock size calculated using the Far West Design Standards 6–13b:

$$D_{75} = \frac{3.5\gamma_w dS}{CK}$$

γ_w = specific weight of water = 62.4 lb/ft^3
d = bankfull depth = 3.4 ft
S = channel slope = 0.01 ft/ft
K = 0.72 for 2H:1V slope = 0.72
C = radius of curvature/width = 0.6

$$D_{75} = 18 \text{ in}$$

$$D_{50} = \frac{D_{75}}{1.5} = 12 \text{ in}$$

$$D_{100} = 3 \times D_{50} = 36 \text{ in}$$

All of the rock barb installations followed the typical reach detail shown in figure CS1–3 with the attendant conifer revetment and willow plantings. Willow planting techniques included pole plantings as shown on all areas, with willow brush blankets and willow fascines in selected areas (Bentrup and Hoag 1998).

The benchmark condition included livestock access to the stream from the adjacent irrigated pastures. The conservation plan included corridor fencing to facilitate livestock exclusion from the stream during the establishment and recovery of the woody riparian vegetation. Prescribed grazing is planned in the riparian area, following the recovery period for an early spring use only, to favor the woody riparian vegetation. Nutrient management, prescribed grazing, and irrigation water management were also components of the conservation plan for the adjacent irrigated pastures.

Project costs

The total cost for this case study was $41,934. A total of 1,484 feet of stream was actually treated within the 3,840-foot reach on this property. This amounts to a cost of $28 per linear foot for the treated sections of stream. Cost data taken from averages of the projects in the Chalk Creek Watershed show that a basic bank protection project as shown in the typical reach layout (rock barbs, conifer revetment, and willow pole plantings) costs about $18 per linear foot. This case study included numerous additions to the typical layout, such as vortex rock weirs, constructed streambanks, and flood plain grading, which resulted in the higher costs. It was difficult to separate the costs of some of the different components of this project because costs were combined on many of the invoices, but an approximation of the component costs is found in table CS1–1.

Project results

The landowner is pleased with the results of this project (figs. CS1–5 through CS1–7). The eminent threat of the stream changing course and cutting off a large meander at treatment section #6 has been alleviated. A few of the installed practices were not successful, however. Most notable was the failure of the barbs to stop bank erosion in treatment section #4. The stream was anticipated to follow the contour of the installed berm, but it started to curve away from the berm in subsequent years (fig. CS1–5). This caused a very tight radius of curvature on the bend where the erosion occurred between the barbs. A more careful analysis of the oversized meander and design of the placement of the berm may have prevented this. Bank erosion has ceased and woody riparian vegetation is recovering

Table CS1–1 Chalk Creek case study costs (at time of construction)

Practice	Cost per unit
Vortex rock weirs	$2,000 ea
Rock barbs	$ 500 ea
Constructed streambank (berm)	$ 11/lf
Willow plantings, dormant pole, 2 row, 3-ft spacing in each row	$ 3/lf
Conifer revetment	$ 4/lf
Rock riprap	$ 50/lf

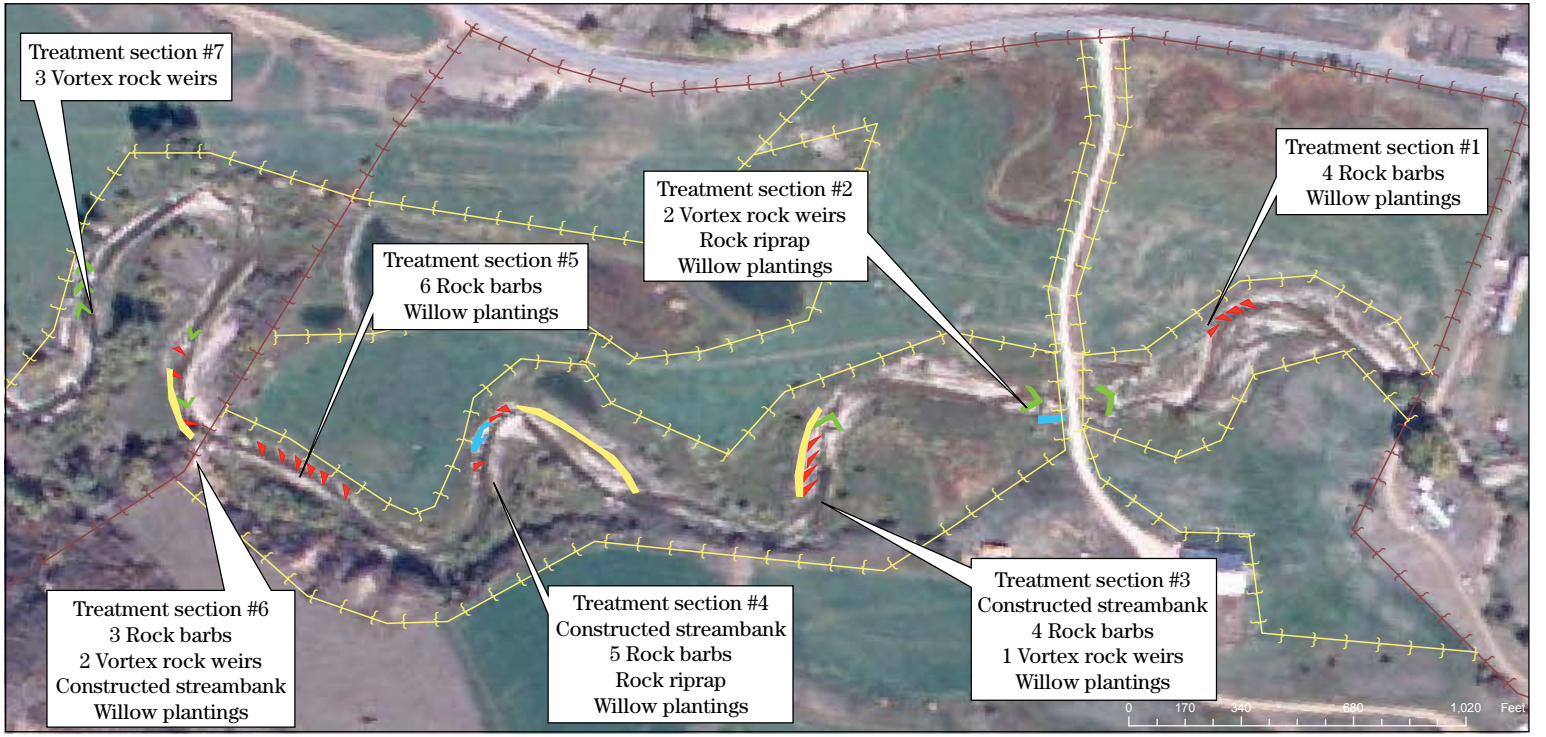
(CS1–6c). Note the function of the rock barbs as the current is focused away from the bank downstream of each barb.

A few of the willow plantings were not successful for various reasons including grazing (not getting the corridor fences built quickly enough). Also, there is some speculation that the willow brush mattress failed due to planting in the fall, rather than the spring. However, the pole plantings and fascines that were installed in the fall were all successful.

Figure CS1–7 shows treatment section #3 before, immediately following, and after treatment. Bank erosion has ceased and woody riparian vegetation is recovering. By 1998, the conifer revetments and rock barbs were necessary to provide protection for the evacuated material used to construct the new streambank. Note the improved width/depth ratio of the channel and removal of the braided condition.

The water quality impairments in Chalk Creek were due to excess sediment and phosphorus. Analysis of long-term water quality monitoring data collected in 1997 by the Utah Department of Environmental Quality shows that measurable reductions in phosphorus and sediment loads have occurred in Chalk Creek since the beginning of the project implementation in 1993. One explanation for this reduction is the implementation of many projects like the one described in this example that have occurred on Chalk Creek since the beginning of the project. Monitoring has continued, and continued improvement is anticipated.

Figure CS1–5 Chalk Creek Example Project, posttreatment view, 2001



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Treatment section #1 - the rock barbs were successful in stopping the active bank erosion; the willow plantings suffered from high mortality.
Treatment section #2 - the vortex weirs were successful in preventing downcutting of the stream. The one upstream was buried with a pulse of bedload and is no longer visible; however, the braided channel condition did not return, and the current channel is closer to the appropriate width to depth ratio. The willow plantings were unsuccessful here.
Treatment section #3 - all structures were successful and remain intact and functioning; willow plantings were also successful. The braided condition of the channel did not return, and the current channel is closer to the appropriate width to the depth ratio.
Treatment section #4 - the constructed streambank at this site remains intact; however, the channel took an unexpected move in the opposite direction (see photo). This resulted in a very small radius of curvature, and active erosion began between two of the barbs. This was corrected by installing rock riprap between these barbs. The willow plantings were successful. The borrow pit where the material was taken to build the berm is now functioning as a pond (see photo).
Treatment section #5 - the rock barbs and willow plantings were successful.
Treatment section #6 - all of the structures and plantings were successful at this site. The braided condition did not return, and the current has an appropriate width-to-depth ratio.
Treatment section #7 - all three weirs that were installed have been completely covered by a pulse of bedload and are no longer visible. The current channel has no apparent nick points and an appropriate width to depth ratio.

Legend

- Rock barbs
- Vortex rock weirs
- Constructed streambank
- Riprap
- Existing fence
- Planned fence

Figure CS1–6 Treatment section #4 (view looking upstream)

(a) 1995, before treatment

(b) 1996, immediately following treatment

(c) 1996, after treatment

Figure CS1–7 Treatment section #3 (view looking downstream)

(a) 1995, before treatment

(b) 1996, immediately following treatment

(c) 1996, after treatment