
Case Study 12

Grade Control Structures in Western Iowa Streams



Issued August 2007

Cover photo: Grade control structure on David's Creek in western Iowa

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 12

Grade Control in Western Iowa Streams

By John T. Thomas, Hungry Canyons Alliance

This case study summarizes 18 different methods of grade control for western Iowa alluvial streams in deep loess watersheds. Both successful and unsuccessful features of these designs are briefly summarized, along with lessons learned. Pictures of each technique are provided. The goals for each project are clearly stated. This information should be helpful to designers considering similar projects on degrading streams. Design of grade control is described in NEH654 TS14G.

Definitions of project description terms

Funding agency:

- Hungry Canyons Alliance (HCA) provides 80 percent of the total cost to install grade control including construction, design, contracting, and inspection up to \$120,000.
- Emergency Watershed Protection (EWP) program projects are administered by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The EWP program provides cost share to cover the cost of the construction. The counties provide matching funds in the form of labor for design, contracting, and inspection.

Grade control achieved: amount of stream gradient taken out or controlled by the structure

Total cost: equal to the total cost of construction, design, contracting, and inspection for HCA projects; equal to the cost of construction for EWP projects

Grade control cost: total cost to install grade control, considered to be 100 percent for weir projects, but usually about 20 to 40 percent of the total cost for flume bridge projects

HCA/EWP/NRCS/DOT cost share: total cost share provided to the county/landowner for project completion (NRCS—a cost share program other than

EWP, such as EQIP; DOT—Iowa Department of Transportation)

Estimated value of property protected: estimated value of property (bridges, utilities, farmland) protected by a project (which could include construction of multiple structures)

Ecology of reach: little to no fishery (poor stream habitat), questionable fishery (possible stream habitat), probable fishery (good stream habitat)

Stream processes: processes active in channel at time of construction

Stream stage: stage of channel evolution (six-stage Simon model (Simon 1989)) at the time of construction

Design criteria: If a bridge is present upstream, the grade control structure design discharge is equal to that of the bridge design discharge.

Major lessons learned

General notes:

- Each structure must be designed for its unique situation.
- There is a trade-off between design cost and maintenance. Grade control may be accomplished at less expense with a very basic design, but it may require more long-term maintenance.
- Make sure surveys run far enough downstream so that any future streambed degradation that may reach the outlet of the structure may be taken into consideration. If long surveys are not feasible, general information about the stream channel, such as an understanding of channel evolution, bridge inspection reports, and aerial photographs, may be used to estimate future erosion potential.
- The timing of construction is very important in determining the final cost, especially if dewatering of the construction site is required.

- The streambeds of small tributaries near their confluence with larger streams may be prone to fluctuations. The tributary may frequently serve as a backwater for the larger channel, causing aggradation. It will also be prone to channel erosion during infrequent locally heavy runoff events.
- Vertical drops or steep slopes (<4H:1V) will not allow catfish migration. However, shallow slopes (>20H:1V) have shown to allow catfish migration. Catfish cannot swim in flows higher than 2 feet per second (0.61 m/s) or in flows shallower than 1 foot (0.3 m). Research is in progress to determine the steepest weir slope where velocities are less than 2 feet per second, when flow is 1 foot in depth. Following the completion of this research, weirs will be built with slopes shallower than this critical slope.

What works

- Sheet pile is almost always used in HCA and EWP weirs. It is typically pounded into the streambed to a depth of about 20 feet. It represents “the last line of defense,” should channel degradation continue or other components of the weir, such as the riprap and concrete, experience instability or failure. It also provides a cutoff wall, preventing flow through the weir and forcing water over the surface of the weir, which is especially important for fish passage.
- Although grout may crack over time, especially near the water line, it still has a longer life expectancy than riprap, considering that loose riprap tends to move around and the quality of quarried rock in western Iowa makes it very susceptible to freeze-thaw weathering. Grouted riprap also helps to force flow over the weir slope when trying to promote fish passage.
- Scour may be prevented by extending bank protection farther downstream than the end of the stilling basin, especially if the outlet of the stilling basin has a different geometry than the rest of the stilling basin. According to an analysis of HCA structure performance, bank sloughing because of scour may be limited if the unprotected banks immediately downstream from the weir have slopes that are 2H:1V or less. Also, if the channel at the weir is wider

than the channel at the outlet, rock movement may be decreased and scour inhibited as flow is forced to the center of the channel.

- During construction of weirs, especially when dewatering is required, the channel is typically split into halves or thirds, and work is done on only one part of the stream at a time.
- A central grouted fish passage with baffles appears to allow fish migration. Tagged fish have been able to swim upstream over the structure. Tests of water velocities in the fish passage are in an acceptable range to allow the targeted fish species to migrate. Also, because the channel is divided into three different sections, dewatering is easier during construction or repair.

What does not work

- Barrier rails are no longer used due to their instability under high-flow conditions.
- Concrete blocks are difficult to work with during construction, mainly because of their size, and are prone to undermining by piping.
- The grouted riprap H-pile crib design is prone to leaking and piping.
- Unique energy dissipation concrete forms are difficult for a contractor to form during construction and are also difficult to repair.
- Energy dissipaters are prone to collecting trash, which then focuses water toward the banks.
- Riprap from western Iowa quarries will weather quickly. When placed on a weir slope, riprap will weather and gradually move downstream, eventually creating a vertical face at the weir, a long flat section in the middle, and steep tongues of moved rock at the weir outlet. When designing weirs for fish passage, riprap should be grouted to prevent movement and to minimize maintenance.

Hungry Canyons Alliance (HCA) Structure

Project number: 69-6114-2-1(4, 5)

Type of grade control: Double sheet pile weir

Grade control achieved: 7.7 ft

Other features: 4H:1V riprap downstream slope, 2H:1V riprap side slopes to full bank height, barrier rails cabled together and set in riprap pointing downstream and angled toward the center of the channel

Construction date: November 1993

Total cost: \$150,124

HCA cost share: \$150,124

Estimated value of property protected: \$280,000

Participants: Pottawattamie County, IA; HCA

Stream name: Little Walnut Creek

Soil type: Loess alluvium

Drainage area: 8.05 mi²

Channel width (top of bank): 80 ft

Channel depth (top of bank): 22 ft

Stream gradient: 16.9 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Limited to no fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Active channel downcutting and widening, active nick point/headcut migration

Stream stage (Simon): 3

Data collected: Topographic survey

Design criteria: Design discharge— Q_{50} —3,100 ft³/s

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: Barrier rails and loose riprap have experienced significant movement because of high-flow events.

Lessons learned: This project was one of the first funded by the HCA and was the precursor of the basic structure design used today. Sheet pile is almost always used in HCA weirs. It is typically pounded into the streambed to a depth of about 20 ft. It represents the last line of defense should channel degradation continue or other components of the structure, such as the riprap, concrete, etc., experience instability or failure. Barrier rails are no longer used due to their instability under high-flow conditions. Unless it is large riprap, it is no longer placed loose, but is grouted to prevent movement.



Emergency Watershed Protection (EWP)

Project Number: 73–52

Type of grade control: Sheet pile weir

Grade control achieved: 4 ft

Other features: Vertical drop at sheet pile weir, a row of six precast 3- by 3- by 1-ft concrete blocks 1 ft above the rest of the stilling basin, precast 3- by 3- by 1-ft concrete blocks lining bottom of stilling basin; precast 3- by 3- by 1-ft concrete blocks at a 2H:1V slope around the sheet pile weir and on banks to a fifth bank height; 2H:1V loose riprap side slopes to full bank height downstream and half bank height upstream

Construction date: February 1994

Total cost: \$246,952

EWP cost share: \$246,952

Estimated value of property protected: \$400,000

Participants: Page County, IA; EWP

Stream name: West Tarkio Creek

Soil type: Loess alluvium

Drainage area: 46.4 mi²

Channel width (top of bank): 70 ft

Channel depth (top of bank): 16 ft

Stream gradient: 8 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing stream-bed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{100} —9,400 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: The precast concrete blocks have had settling issues on this and many other projects. The vertical sheet pile is bowing in the center and has sprung a leak in the same location.

Lessons learned: Piping undermines some concrete blocks. A vertical drop will not allow fish migration and is now prohibited as a design on most streams by the Iowa Department of Natural Resources.



Emergency Watershed Protection (EWP)

Project Number: 307-07

Type of grade control: Grouted riprap chute

Grade control achieved: 30.8 ft

Other features: Grouted riprap chute with 3 ft channel depth; 4 ft straight drop sheet pile weir at end of chute; precast 3- by 3-ft concrete blocks (1-3 ft in depth) placed in stilling basin; 2H:1V grouted riprap side slopes to a third bank height

Construction date: September 1994

Total cost: \$149,898.50

EWP cost share: \$119,918.80

DOT cost share: \$29,979.70

Estimated value of property protected: \$300,000

Participants: Monona County, IA; EWP; DOT

Stream name: Soldier River Tributary

Soil type: Loess alluvium

Drainage area: 0.61 mi²

Channel width (top of bank): 75 ft

Channel depth (top of bank): 31 ft

Stream gradient: 42 ft/mi

Channelization: Channelization downstream in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Little to no fishery

Site controls: Culvert upstream, agricultural fields on both sides

Stream processes: Active channel downcutting and widening, active nick point/headcut migration

Stream stage (Simon): 3

Data collected: Topographic survey

Design criteria: Design discharge— Q_{100} —800 ft³/s

Goals: To prevent further streambed degradation with grade control. A 15 to 20-ft headcut had advanced 115 ft upstream in just 3 months toward a 10- by 10-ft RCB culvert under a major state highway.

Goals met: All goals met

Project performance: Water moving downward through the grout has entrained some of the sand bedding underneath the chute, flowed through some weepholes in the sheet pile, and deposited the sand in the stilling basin.

Lessons learned: Site has not experienced further degradation, but rather net aggradation; this tributary serves as a backwater for a major river 600 ft downstream more often than the channel is scoured out by flow coming down the chute.



Emergency Watershed Protection (EWP)

Project Number: 322-01

Type of grade control: Concrete block weir

Grade control achieved: 2 ft

Other features: Precast cubic yard concrete blocks and grouted riprap weir; seven H-piles protruding upward from stilling basin; 2H:1V grouted riprap side slopes to two-thirds bank height (modified to full bank height; loose riprap upstream from weir after new bridge construction)

Construction date: December 1994

Total cost: \$132,317

EWP cost share: \$109,840

Estimated value of property protected: \$270,000

Participants: Audubon County, IA; EWP

Stream name: East Nishnabotna River

Soil type: Loess alluvium

Drainage area: 52 mi²

Channel width (top of bank): 80 ft

Channel depth (top of bank): 16 ft

Stream gradient: 10.4 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Questionable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{100} —10,000 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: During construction, the concrete blocks had problems with shifting. Downstream from energy dissipaters, a sandbar needed to be removed that had been forcing waterflow toward the opposite bank.

Lessons learned: H-pile energy dissipaters are prone to collecting trash, which then focuses water toward the banks. Concrete blocks were difficult to work with during construction.



Emergency Watershed Protection (EWP)

Project Number: 315–10

Type of grade control: Grouted H-pile crib

Grade control achieved: 5 ft

Other features: Two-step, vertical drop, grouted riprap crib; grouted riprap stilling basin; 2H:1V grouted riprap side slopes to full bank height

Construction date: June 1995

Total cost: \$212,646.08

EWP cost share: \$212,646.08

Estimated value of property protected: \$400,000

Participants: Page County, IA; EWP

Stream name: Tarkio River

Soil type: Loess alluvium

Drainage area: 154 mi²

Channel width (top of bank): 200 ft

Channel depth (top of bank): 32 ft

Stream gradient: 8.5 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Active channel downcutting and widening, active nick point/headcut migration

Stream stage (Simon): 3

Design criteria: Design discharge— Q_{100} —15,000 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: The lack of a stilling basin has caused scour downstream and continued streambed degradation has undercut the end of the stilling basin. Another structure is planned immediately downstream to resolve this problem.

Lessons learned: The grouted riprap H-pile crib design is prone to leaking and piping. Concrete grout and riprap are prone to freeze-thaw weathering and cracking, especially near the water line.



Hungry Canyons Alliance (HCA) Structure

Project Number: 69–6114–7–6

Type of grade control: Five concrete block weirs

Grade control achieved: 3 ft each

Other features: One row of precast cubic yard concrete blocks laid across channel and cabled together; loose riprap 4H:1V downstream slope; 1.5H:1V loose riprap side slopes to two-thirds bank height

Construction date: July 1998

Total cost: \$41,460.87

HCA cost share: \$33,168.70

Estimated value of property protected: \$524,000

Participants: Montgomery County, IA; HCA

Stream name: West Nodaway River Tributaries

Soil type: Loess alluvium

Drainage area: 2.4 to 9.8 mi²

Channel width (top of bank): 34 to 78 ft

Channel depth (top of bank): 13.5 to 22 ft

Stream gradient: ~10 to 25 ft/mi

Channelization: Channelization downstream in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Limited to no fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: No hydraulic analysis performed, design based on experience

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: Rock movement has been caused by continued streambed degradation and/or high-flow events. The site furthest downstream, site 5, is experiencing erosion as the stream is trying to go around the blocks. This has been noted on several other concrete block sites, possibly because the blocks were not entrenched far enough into the banks or because of the lack of a cutoff wall.

Lessons learned: Grade control may be accomplished cheaply with this very basic design, but it may require more long-term maintenance.



Hungry Canyons Alliance (HCA) Structure

Project Number: 69-6114-9-6

Type of grade control: Sheet pile weir

Grade control achieved: 4 ft

Other features: 4H:1V grouted riprap downstream slope modified to 20H:1V by adding loose riprap to downstream slope; 1.5H:1V riprap side slopes to full bank height

Construction date: April 2000

Total cost: \$75,305.89

HCA cost share: \$62,305.89

Estimated value of property protected: \$354,333.56

Participants: Montgomery County, IA; HCA

Stream name: Walnut Creek

Soil type: Loess alluvium

Drainage area: 78 mi²

Channel width (top of bank): 80 ft

Channel depth (top of bank): 18 ft

Stream gradient: 7 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{50} —9,500 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: Compared to five other projects, upstream and downstream of this site, that were modified at the same time to 20H:1V downstream slopes by adding loose riprap, there has been little rock movement at this site.

Lessons learned: The design for all six projects was very similar with the only noticeable difference being that at this site; the channel at the weir is wider than the channel at the outlet. In this way, flow was forced to the center of the channel. All six projects are being modified by adding grout to the weir slope to prevent any future rock movement and to maintain the 20H:1V slope.



Hungry Canyons Alliance (HCA) Structure

Project Number: 98–8

Type of grade control: Sheet pile weir

Grade control achieved: 4 ft

Other features: Reinforced concrete 4H:1V downstream slope; reinforced concrete basin with second row of sheet pile at downstream end; 11 reinforced concrete energy dissipaters in basin; 2H:1V reinforced concrete banks to a third bank height and riprap extending to half bank height

Construction date: October 2000

Total cost: \$79,978.33

HCA cost share: \$63,982.66

Estimated value of property protected: \$239,312

Participants: Page County, IA; HCA

Stream name: Buchanan Creek

Soil type: Silty clay

Drainage area: 10 mi²

Channel width (top of bank): 150 ft

Channel depth (top of bank): 27 ft

Stream gradient: 18 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Questionable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Active channel downcutting and widening, active nick point/headcut migration

Stream stage (Simon): 3

Design criteria: Design discharge— $Q_{100} = 2,884 \text{ ft}^3/\text{s}$

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: One of the energy dissipating concrete hooks was damaged after being hit by a tree or ice.

Lessons learned: The energy dissipating concrete “hooks” are difficult for a contractor to form during construction and are also difficult to repair.



Hungry Canyons Alliance (HCA) Structure

Project Number: 69-6114-9-7

Type of grade control: Sheet pile weir

Grade control achieved: 3.4 ft

Other features: Reinforced concrete 4H:1V downstream slope; short (10 ft) reinforced concrete basin with second row of sheet pile at downstream end; 13 steel energy dissipaters in basin; 3H:1V reinforced concrete banks to a third bank height; grouted riprap to two-thirds bank height; and loose riprap extending to five-sixths bank height

Construction date: October 2000

Total cost: \$81,810.55

HCA cost share: \$65,448.44

Estimated value of property protected: \$303,665.20

Participants: Page County, IA; HCA

Stream name: West Tarkio Creek

Soil type: Silty clay

Drainage area: 53 mi²

Channel width (top of bank): 160 ft

Channel depth (top of bank): 29 ft

Stream gradient: 8 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{100} —10,080 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: The lack of a stilling basin has caused scour downstream. The streambed has continued to degrade, and if the situation continues to worsen, another grade control structure may be built downstream.

Lessons learned: A longer stilling basin would help to control stream energy and reduce scour.



Hungry Canyons Alliance (HCA)|Structure

Project Number: 99–8

Type of grade control: Sheet pile weir

Grade control achieved: 3.5 ft

Other features: 4H:1V grouted riprap downstream slope; grouted internal stilling basin with 1 ft rise at downstream end; 2H:1V riprap side slopes to two-thirds bank height (grouted to one-third bank height)

Construction date: July 2001

Total cost: \$71,771.83

HCA cost share: \$57,256.95

Estimated value of property protected: \$241,820

Participants: Audubon County, IA; HCA

Stream name: David's Creek

Soil type: Sandy clay

Drainage area: 48.2 mi²

Channel width (top of bank): 80 ft

Channel depth (top of bank): 18 ft

Stream gradient: 6 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{10} —4,805 ft³/s (based on bridge design discharge)

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control and prevent scour

Goals met: Scour has not been prevented.

Project performance: Even with an internal stilling basin, significant bank scour has occurred downstream because banks were not protected past end of stilling basin.

Lessons learned: Scour may be prevented by extending bank protection farther downstream than the end of the stilling basin, especially if the outlet of the stilling basin has a different geometry than the rest of the stilling basin. According to an analysis of HCA structure performance, bank sloughing because of scour may be limited if the unprotected banks immediately downstream from the structure have slopes that are 2H:1V or less.



Hungry Canyons Alliance (HCA) Structure

Project Number: 69–6114–1–12

Type of grade control: Sheet pile weir

Grade control achieved: 6 ft

Other features: V-notch in sheet pile weir (outside 1 ft higher than center); 4H:1V lightly grouted riprap downstream slope; 2H:1V lightly grouted riprap side slopes to two-thirds bank height

Construction date: October 2001

Total cost: \$62,100.93

HCA cost share: \$49,680.74

Estimated value of property protected: \$136,468

Participants: Monona County, IA; HCA

Stream name: McCleerey Creek Tributary

Soil type: Loess alluvium

Drainage area: 5.1 mi²

Channel width (top of bank): 95 ft

Channel depth (top of bank): 25 ft

Stream gradient: 13.2 ft/mi

Channelization: Channelization downstream in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Limited to no fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{100} —3,163 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control and protect undermined flume bridge

Goals met: All goals met

Project performance: Performing well

Lessons learned: This is the standard Monona County design for streams with drainage areas of less than 10 mi². The Iowa DNR will closely regulate what can be built on streams with drainage areas of greater than 10 mi², because of fish migration concerns, and, hence, would not permit a structure design like this because of the steep downstream slope.



Hungry Canyons Alliance (HCA) Structure

Project Number: 99–14

Type of grade control: Sheet pile weir

Grade control achieved: 4 ft

Other features: 5H:1V grouted riprap downstream slope, grouted riprap stilling basin; 2H:1V grouted riprap side slopes to full bank height near weir (loose riprap side slopes up and downstream of weir to either a third or full bank height)

Construction date: October 2001

Total cost: \$124,051.88

HCA cost share: \$99,241.50

Estimated value of property protected: \$254,312

Participants: Crawford County, IA; HCA

Stream name: East Boyer River

Soil type: Silty sand

Drainage area: 131 mi²

Channel width (top of bank): 210 ft

Channel depth (top of bank): 18 ft

Stream gradient: 8.1 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Questionable fishery

Site controls: 24-in sewer main running across river, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{50} —13,513 ft³/s

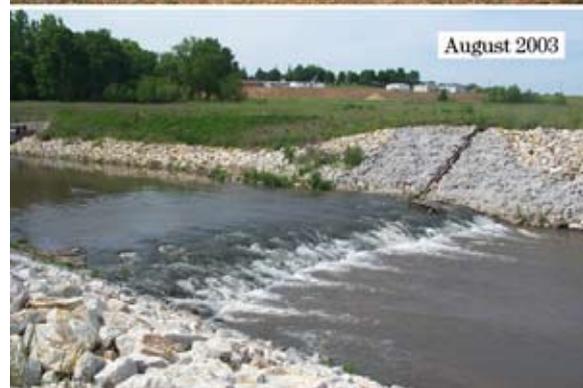
Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control and protect an important 24-in sewer main, exposed by streambed degradation, for the City of Denison

Goals met: All goals met

Project performance: Performing well

Lessons learned: The structure type must fit the situation. In this situation, absolute stability was needed to protect the sewer main, so the weir was heavily grouted. During construction of grade control structures, especially when dewatering is required because of grout application, the channel is typically split and work is done on only one half of the stream at a time. This structure may need to be modified in the future with a 20H:1V weir slope to allow fish passage.



Hungry Canyons Alliance (HCA) Structure

Project Number: 69–6114–1–06

Type of grade control: Grouted riprap weir

Grade control achieved: 3 ft

Other features: 20H:1V grouted riprap downstream slope; grouted and loose riprap stilling basin; 2H:1V grouted and loose riprap side slopes to a third bank height

Construction date: August 2002

Total cost: \$107,060.05

HCA cost share: \$85,647.95

Estimated value of property protected: \$423,234

Participants: Crawford County, IA; HCA

Stream name: Boyer River

Soil type: Silty sandy clay

Drainage area: 222 mi²

Channel width (top of bank): 137.5 ft

Channel depth (top of bank): 26 ft

Stream gradient: 4.2 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{100} —14,911 ft³/s

Data collected: Topographic survey

Goals: To protect bridge pilings and banks, allow for fish migration over the structure, and prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: Performing well

Lessons learned: The structure type must fit the situation.

In this situation, a low head dam was needed to restore some stability to the bridge pilings and the surrounding streambanks. Further streambed degradation is unlikely, so sheet pile was not needed. The timing of construction is also very important on streams with large drainages to have a low-cost, finished product.



Hungry Canyons Alliance (HCA) Structure

Project Number: 02-4-F

Type of grade control: Flume bridge replacement

Grade control achieved: 16.5 ft

Other features: Reinforced concrete flume outlet and basin on a new box culvert

Construction date: September 2002

Total cost: \$71,422.80

Grade control cost: \$16,672.85

HCA cost share: \$12,800

Estimated value of property protected: \$63,465

Participants: Fremont County, IA; HCA

Stream name: Walnut Creek Tributary

Soil type: Loess alluvium

Drainage area: 0.9 mi²

Channel width (top of bank): 40 ft

Channel depth (top of bank): 23 ft

Stream gradient: 53 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Limited to no fishery

Site controls: Bridge part of structure, agricultural fields on both sides

Stream processes: Channel widening and slowing stream-bed degradation

Stream stage (Simon): 4

Design criteria: Design discharge $Q_{25} = 470 \text{ ft}^3/\text{s}$

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control

Goals met: All goals met

Project performance: Performing well

Lessons learned: Make sure surveys are run far enough downstream to identify and design for any future streambed degradation that may reach the outlet of the structure. If long surveys are not feasible, general information about the stream channel, such as an understanding of channel evolution, bridge inspection reports, and aerial photographs, may be used to estimate future erosion potential.



Hungry Canyons Alliance (HCA) Small Structure

Project Number: SS-00-13-Mike Schomers

Type of grade control: Low-water crossing

Grade control achieved: 3 ft

Other features: 2- to 30-in-diameter corrugated metal pipes on a 20H:1V slope, one with alternating 3-in steel baffles; grouted riprap upstream (2H:1V) and downstream (5H:1V) slopes; sheet pile toewalls at upstream and downstream ends; 20-ft-wide concrete top

Construction date: September 2002

Total cost: \$38,156.05

HCA cost share: \$8,500

NRCS cost share: \$19,078.03

Estimated value of property protected: \$150,000

Participants: Landowner; HCA; NRCS

Stream name: Keg Creek

Soil type: Loess alluvium

Drainage area: 30.4 mi²

Channel width (top of bank): 50 ft

Channel depth (top of bank): 14 ft

Stream gradient: 10.4 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— $Q_{100} = 7,500 \text{ ft}^3/\text{s}$

Data collected: Topographic survey

Goals: To provide the landowner access to his property on the other side of the stream, prevent further streambed degradation with grade control, and allow for fish migration through the structure via the culvert w/fish baffles

Goals met: All goals met

Project performance: Performing well and has been overtopped several times by high flows

Lessons learned: Even though the structure has been overtopped several times, no bed scour has occurred. When the structure is overtopped during high flows, the flow depth may be so deep that scour cannot erode the streambed at the outlet.



Hungry Canyons Alliance (HCA) Structure

Project Number: 69–6114–1–23

Type of grade control: Sheet pile weir

Grade control achieved: 3 ft

Other features: Reinforced sheet pile weir and concrete floor with second row of sheet pile at downstream end; central 20H:1V grouted riprap fish passage with baffles; 2H:1V reinforced concrete side slopes to a third bank height; grouted riprap to half bank height

Construction date: June 2003

Total cost: \$73,613.09

HCA cost share: \$58,890.47

Estimated value of property protected: \$414,234

Participants: Page County, IA; HCA

Stream name: East Tarkio Creek

Soil type: Loess alluvium

Drainage area: 38 mi²

Channel width (top of bank): 92 ft

Channel depth (top of bank): 23 ft

Stream gradient: 10 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{100} —8,100 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control and allow fish to migrate upstream over the structure

Goals met: All goals met

Project performance: Debris is occasionally lodged in the baffles.

Lessons learned: The central grouted fish passage w/baffles appears to allow fish migration. Tagged fish have been able to swim upstream over the structure. Tests of water velocities in the fish passage are in an acceptable range to allow the targeted fish species to migrate. Also, because the channel is divided into three different sections, dewatering is easier during construction or repair.



Hungry Canyons Alliance (HCA) Structure

Project Number: 02–1–F

Type of grade control: Sheet pile weir

Grade control achieved: 4 ft

Other features: 20H:1V riprap downstream slope; cubic yard rocks placed in channel; 2H:1V riprap side slopes to full bank height (grouted to half bank height)

Construction date: September 2003

Total cost: \$111,422.98

HCA cost share: \$89,121.15

Estimated value of property protected: \$332,700

Participants: Audubon County, IA; HCA

Stream name: David's Creek

Soil type: Loess alluvium

Drainage area: 27.96 mi²

Channel width (top of bank): 100 ft

Channel depth (top of bank): 28 ft

Stream gradient: 5.19 ft/mi

Channelization: Stream channelized in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Questionable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing streambed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{10} —3,563 ft³/s (based on bridge design discharge)

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control and allow for fish migration over structure

Goals met: All goals met except cubic yard rocks not placed in riprap, but on top of—could lead to sliding of large rocks during high flows

Project performance: Performing well—the structure has experienced a bank full flow event, and none of the large boulders moved despite resting on an uneven base.

Lessons learned: Be more specific in explaining placement of large rocks to contractors. The downstream riprap slope should be grouted.



Hungry Canyons Alliance (HCA) Structure

Project Number: 02–16

Type of grade control: Sheet pile weir

Grade control achieved: 4 ft

Other features: V-notch sheet pile weir (outside 1 ft higher than center); 20H:1V grouted riprap downstream slope, grouted riprap stilling basin; 2.5H:1V grouted riprap side slopes to one-half bank height; loose riprap side slopes to three-fifths bank height

Construction date: December 2003

Total cost: \$98,316.18

HCA cost share: \$78,652.94

Estimated value of property protected: \$304,312

Participants: Crawford County, IA; HCA

Stream name: Otter Creek

Soil type: Loess alluvium

Drainage area: 30 mi²

Channel width (top of bank): 77 ft

Channel depth (top of bank): 12 ft

Stream gradient: 6.95 ft/mi

Channelization: Channelization downstream in past and now recovering

Watershed land use: Agricultural rural

Ecology of reach: Probable fishery

Site controls: Bridge upstream, agricultural fields on both sides

Stream processes: Channel widening and slowing stream-bed degradation

Stream stage (Simon): 4

Design criteria: Design discharge— Q_{50} —6,153 ft³/s

Data collected: Topographic survey

Goals: To prevent further streambed degradation with grade control while allowing fish to migrate over the structure

Goals met: All goals met

Project performance: Performing well

Lessons learned: Degradation prevention and fish migration required the structure to be built with a sheet pile weir and a 20H:1V downstream slope. Although grout will crack over time, it still has a longer life than riprap. Loose riprap tends to move around, and the rock in western Iowa is very susceptible to freeze-thaw weathering.

