US Army Corps of Engineers

(Albuquerque District)

Floodwater Lessons Learned:

Creede, CO

PDH: 1 Hour

Don Soards, P.E.

PDH Now, LLC.
www.PDH*Now*.com

Floodwater Lessons Learned: Creede, CO

PDH: 1 Hour

Don Soards, P.E.

PDH*NOW* Floodwater Lessons Learned: Creed, CO – 1 Hour

Table of Contents

Floodwater Lessons Learned: Creede, CO

1. Course Overview

This course satisfies 1-hours of engineering continuing education requirement for Professional Engineer license renewal.

One thing common to all engineering disciplines is protection against flooding. Our systems need to work when it rains.

This course in the Creede, CO project is intended to encourage the engineer to consider the big-picture result of field performance of many projects over many decades.

The engineer's duty is to make things work. Following instructions, complying with the law, and using current best practices are usually good enough for the present. But the engineer's task to make things work in the future. This requires making projections about future conditions and use. While engineers prefer hard facts, we are sometimes forced to work with "soft data" that require evaluating many possible options. Understanding project histories helps aid our judgement.

When I headed the Albuquerque District's Inspection of Completed Works (one of three major programs I had as Chief of Emergency Management for a dozen years), I noticed the same design/construction errors being repeated. The US Army's version of Total Quality Management (TQM) was Total Army Quality (TAQ). Under TAQ, the process of continuous improvement was building, feedback, and improved building.

The problem was a lack of feedback because flood control structures may sit for decades without being tested by significant flooding. I strove to compensate for this lack of immediate feedback by having studies made of the histories of over one hundred projects constructed by the Albuquerque District Corps of Engineers since 1948. I selected Professor Richard J. Heggen, a hydrology/hydraulics teacher at UNM, to write many of these, including Creede CO Lessons Learned. His interesting and entertaining lecture style is reflected in his writing.

2. Learning Objectives

Upon successful completion of this course, the participants will be able to:

- Recognize many defects in existing flood control structures.
- Review plans to avoid those defects.
- Consider how the life of flood control structures may impact current engineering systems.
- Inspect flood control projects.

3. Summary

In this course, we examined key features of flood control and bank protection projects that worked over time and a number of those that faced challenges during their long life. Suggestions for improvement were made for many of the problems encountered.

Reference Creede, CO Lessons Learned by Professor Richard J. Heggen

Creede, CO, Lessons Learned

June 12, 1998

The Project

Title:	Willow Creek Channel Improvements, Creede, CO
Contract:	DA-29-005 eng-301 W-29-005 eng-751
Sponsor:	City of Creede
Stream:	Willow Creek
Treatment:	Hand placed grouted stone channel
Completed:	September 1950

<u>Channel</u>

In 1944 Congress authorized construction of a timber crib wooden flume to replace the original wooden flume in Creede, CO constructed between 1890 and 1910. Fig. 1 shows the location. The War delayed the replacement and the Corps changed the design to grouted stone. Photos C-1-4 illustrate the history. Fig. 2 shows the layout. Channel length is 5527 feet. Bottom width is 8 feet. Depth is 7.5 feet. Sideslopes are 1.5:1. Slope is 0.015. Fig. 3 shows typical sections. Small, low clearance vehicular and pedestrian bridges cross the channel. Design discharge is 1800 cfs. Freeboard, based on the 0.012 design Manning's *n*, is as low as 1 foot in some reaches.

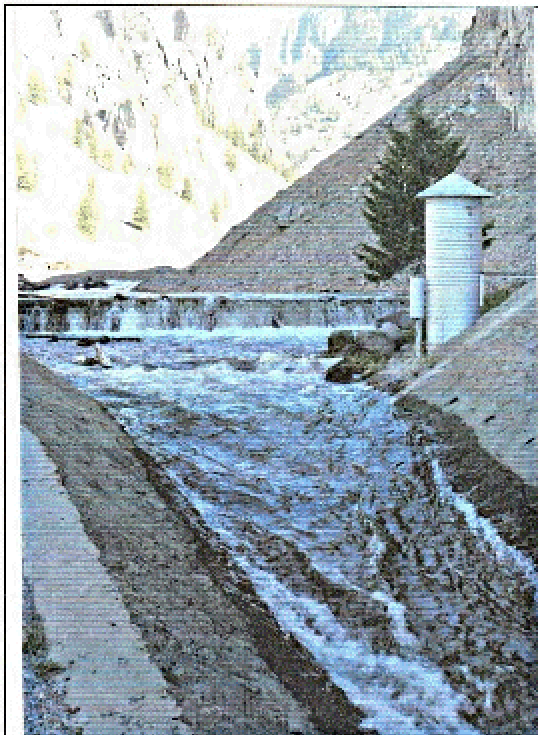


Photo C-5. Inlet, 1998

The site had four floods above 1000 cfs before the current channel was constructed, but a maximum of only 330 cfs since. Photo C-5 shows the project gage at the inlet.

In 1983, the Corps informed the City that the 100-year event was 800 cfs. Justification is absent. The Colorado Water Conservation Board estimated the 100-year event to be 1120 cfs for flood plain mapping in 1986. The Corps reestimated the 100-year event to be 1530 cfs in 1989. While the true 100-year value may be elusive, any decrease from 1800 cfs buys the channel needed freeboard.

Richard J. Heggen, Professor of Civil Engineering, University of New Mexico

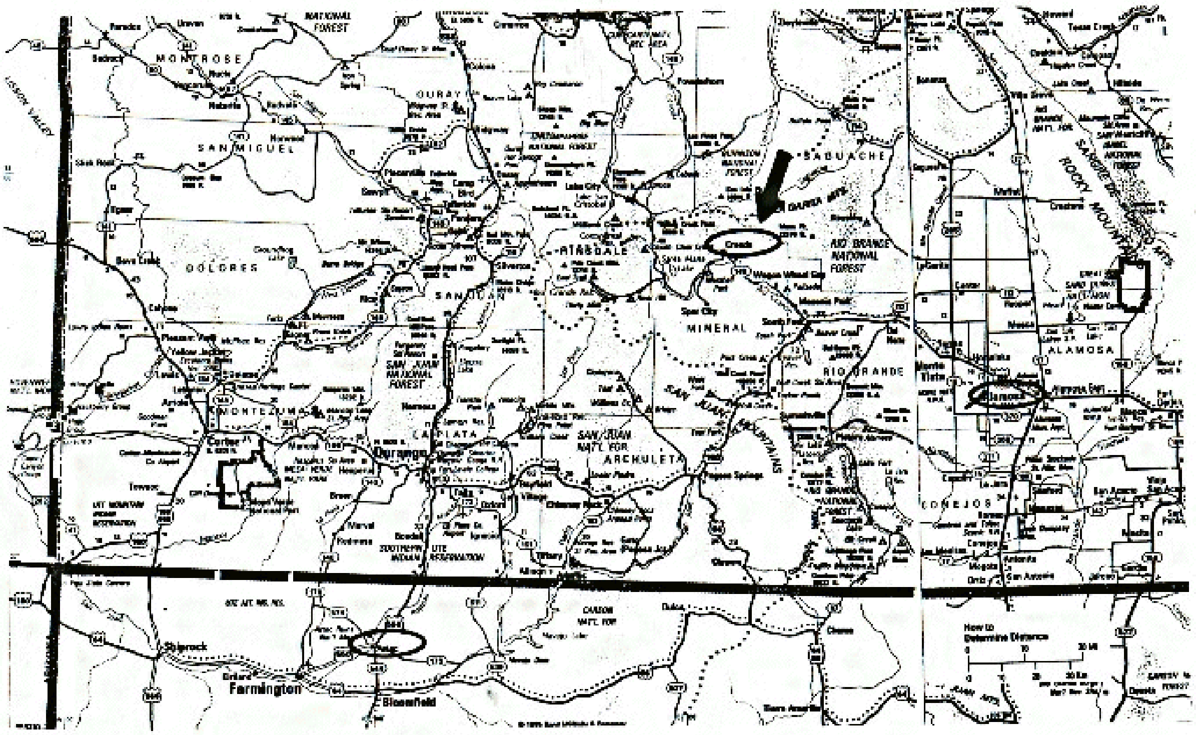


Figure 1. Project Location

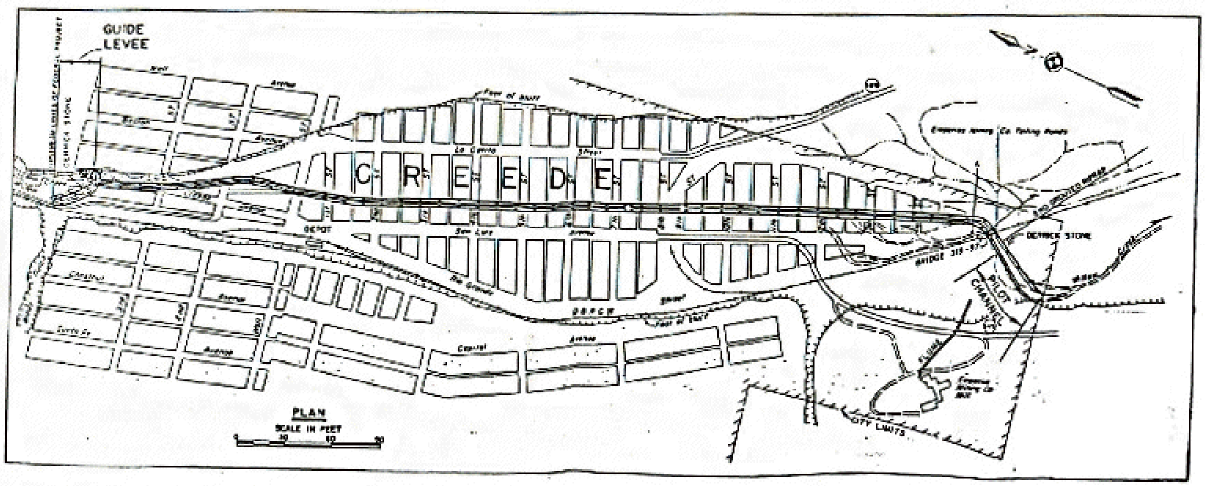


Figure 2. Creede Layout.

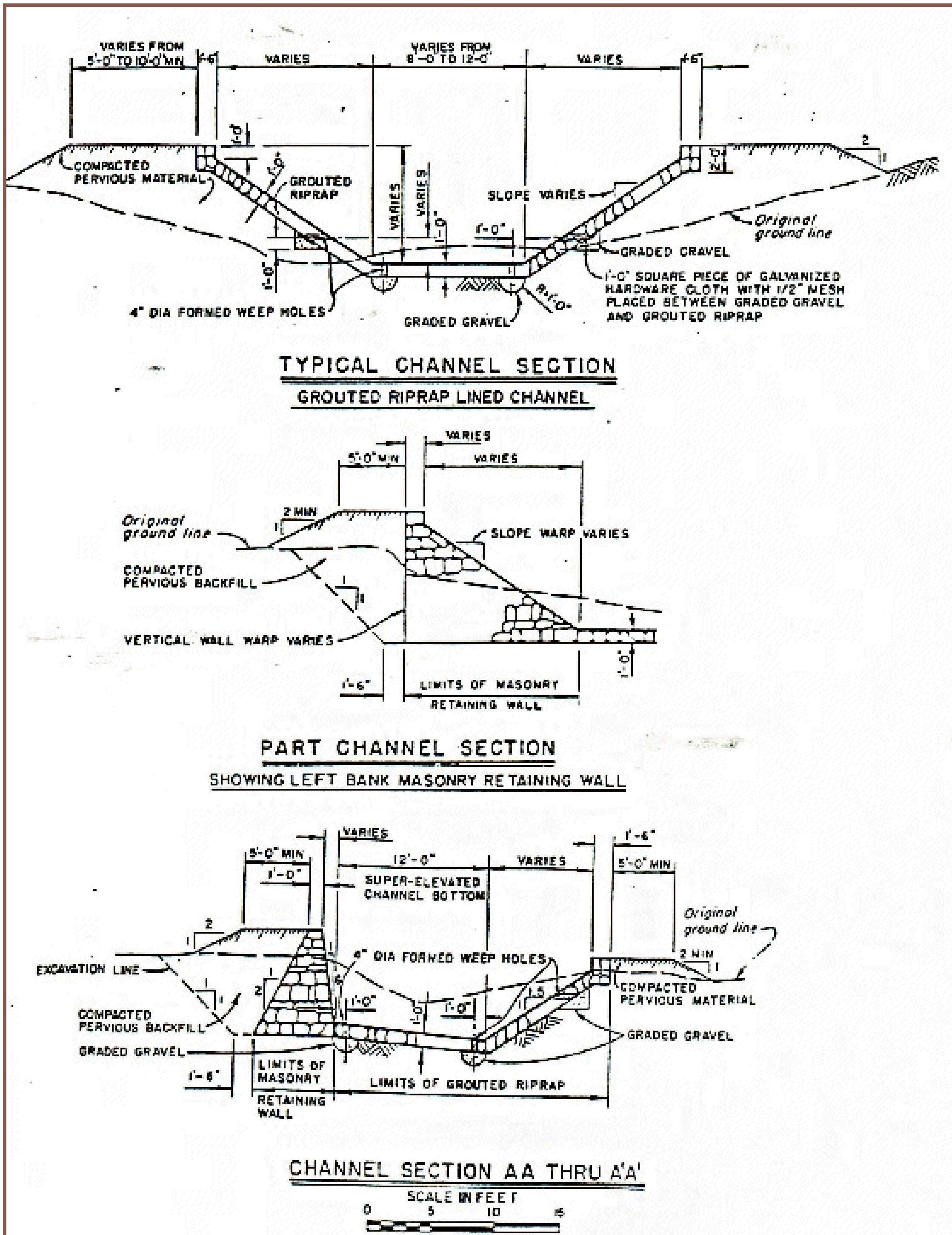
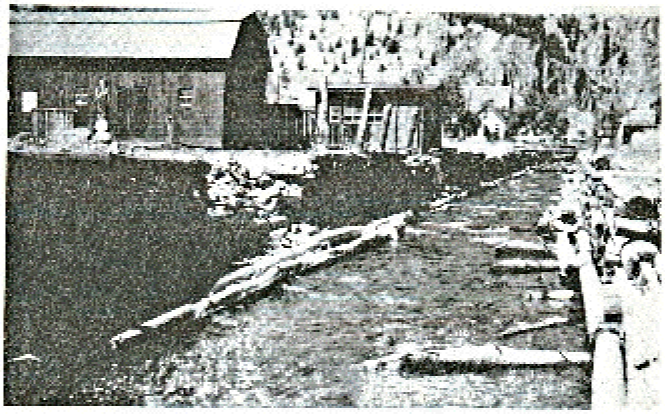


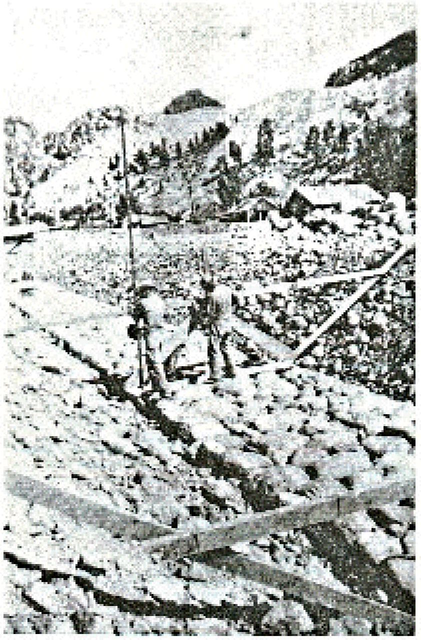
Figure 3. Typical Sections.

TIMBER CRIB CHANNEL



CREEDE, COLORADO, WILLOW CREEK

EXISTING CHANNEL DURING CONSTRUCTION



Photos C-1-4. Historical Photos.

Conveyance capacity becomes insufficient if the channel lining were to disintegrate (as it appears to be doing) or a tree were to jamb against a bridge and block the passage. Overflow will flood the City.

Cribs

Willow Creek transports extensive material from talus slopes and old mining operations upstream. Four log and rock cribs, approximately 3 feet deep, collect sediment and debris above the inlet. The County periodically excavates the cribs for road building and repair material. The cribs require continued vigilance during the spring runoff; the County has heavy equipment readily available for emergency work. The cribs also provide grade control for the channel. Virtually all inspections mention the structural tenuousness of the cribs. Photos C-6 and C-7 show the crib immediately upstream of the channel inlet. The 1998 photo is approximately 10 years after the last reconstruction.

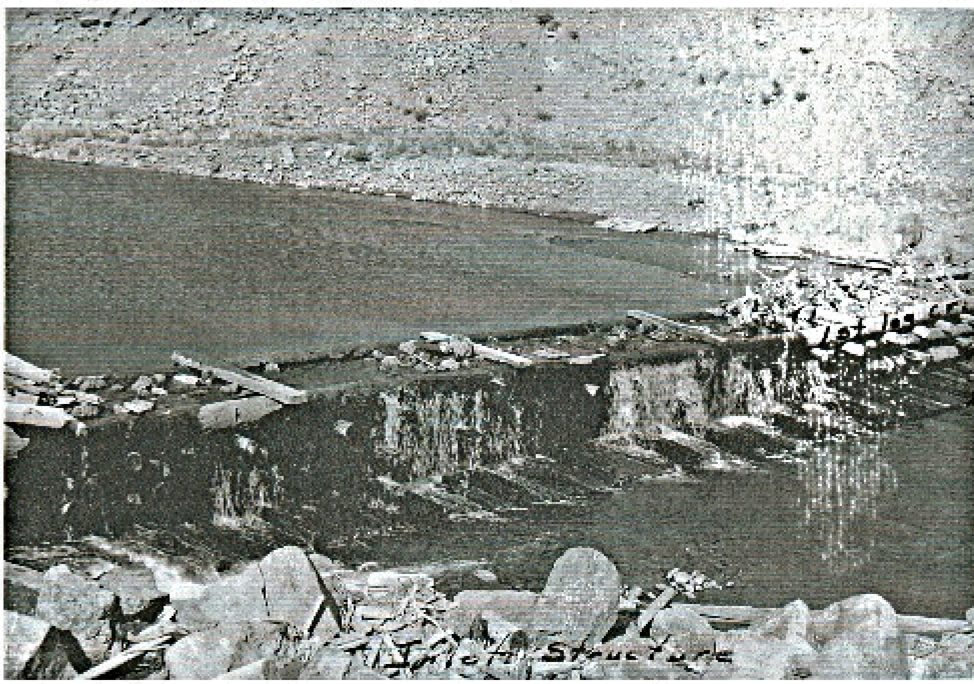


Photo C-6. Bottom Crib, 1957

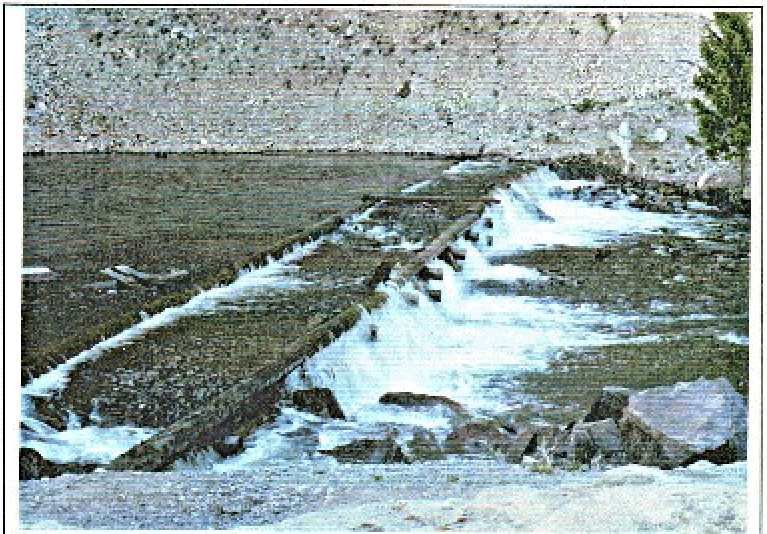


Photo C-7. Bottom Crib, 1998

Photo C-8 shows an upper crib in deteriorated condition. Flow has migrated to the left.

Weepholes

Seeps into the channel are common, both from natural near-surface flows and human change. (One long-noted inflow was eventually traced to a septic tank.) The channel has 4-inch weepholes which require regular cleaning. As the rock wall is relatively porous in any manner, the structure is not in great danger from hydrostatic loading.

Photo C-8. Upper Crib, 1998

Backfill

The City has frequently supplemented backfill behind the channel walls. The City concrete backfilled a 2-cubic yard void discovered in excavation for a new bridge abutment in 1989. That void might have been due to settlement, indicative of insufficient compaction at construction, or might have been washed out through the porous wall. Other backfilling needs may simply be the result of naturally low topography, areas in flood danger if the channel were to overtop.

Material Failures

The upper portions of the channel walls and the channel bottom are generally in good condition, save a few minor cracks in the upper walls and a few pieces of missing riprap in the bottom. Spalled mortar on top of the parapet walls needs occasional maintenance, but it is not critical to the project.

The channel is severely deteriorated along the waterline. Photos C-9-14 document the persistence of the problem.

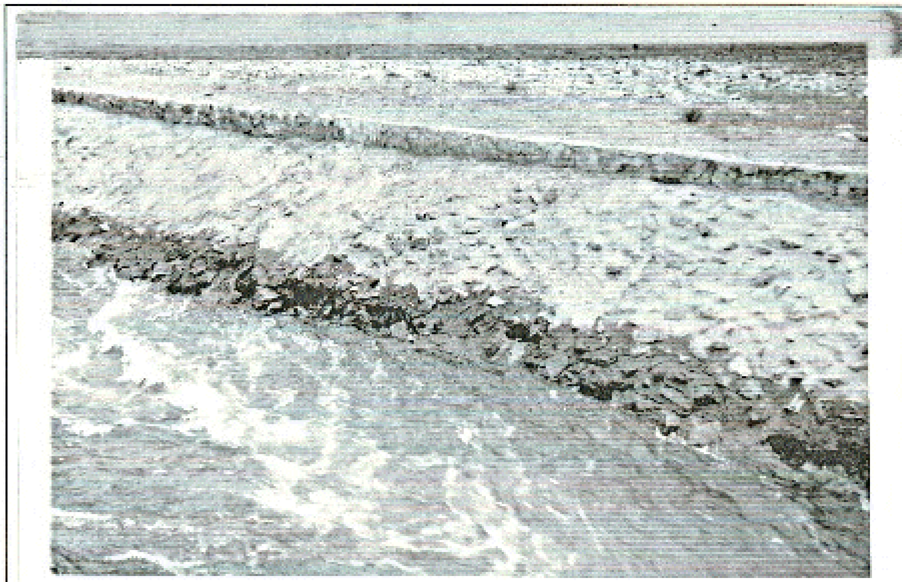


Photo C-9. Spalling at Waterline, 1965

Page 4

Photo C-10. Spalling at Waterline, 1974

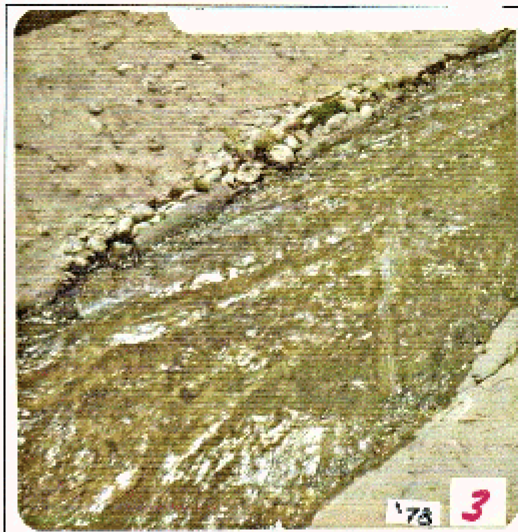


Photo C-11. Spalling at Waterline, 1978

Photo C-12. Spalling at Waterline, 1989

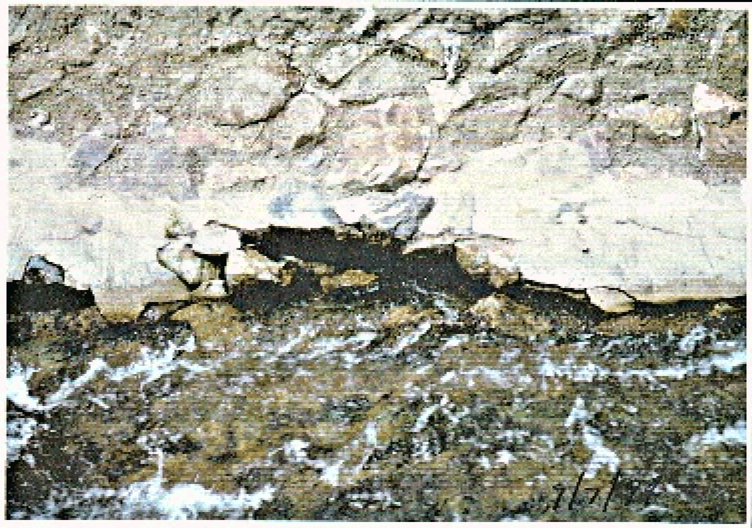


Photo C-13. Spalling at Waterline, 1994

Photo C-14. Spalling at Waterline, 1998

Factors which may contribute to the problem include:

(1) Freeze-thaw action where splash occurs. The waterline freezes and thaws with regularity. Creede has over 300 frost days per year. Not only are stones loosened and lost, but the entire channel wall has heaved 1-3 inches in one location.

(2) Mortar and riprap removed by the swift current. Channel velocity is 15 feet per second and greater. Attack is enhanced on the outside of the curve. Analysis indicates that a 12-year event will pull unsupported free stones from the channel bottom.

(3) Sediment impact.

(4) Destructive chemical reaction between acidic volcanic aggregate and mortar. Photo C-15 shows concrete disintegration caused by high acid aggregate.

Photo C-15. Concrete Disintegration

Repairs

The City has regrouted channel portions along the waterline on many occasions. About 20 feet of channel can be patched in one day. The work area is sealed off from streamflow by sandbags. Repair is limited to the low-water months, August to October.

Photos C-16-18 illustrate the sandbagging.

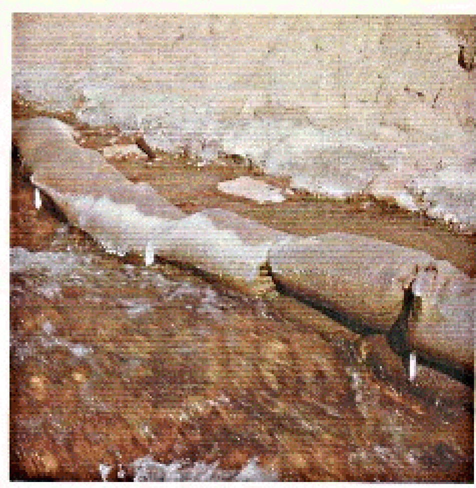


Photo C-16. Sandbagging, 1976

Photo C-17. Sandbagging, 1992

Photo C-18. Ready for Sandbagging, 1998

Noticeable in the center of Photo C-18 is a wave caused by a hole in the bottom of the channel. Sandbagging this area is more difficult than sandbagging along the sideslope.

Page 8

Patching technologies have included:

Hand-placed mortar, typically a 1-3 inch overlay. Grouting holds up for 5-7 years.

Shotcrete, which lasts only a few years.

Grouting. As it is not possible to remove and replace the stone during this process, grout is merely forced into the joints from the surface. The Cold Regions Research Engineering Laboratory was consulted to determine if any new grouting technology has been developed for cold regions. The answer was negative.

Suggestions include:

Avoiding grout in areas subjected to frequent freeze thaw cycles.

Sandblasting, water jetting or etching the surface to remove loose mortar, algae and other aquatic growth.

Epoxy paint.

Fiber-reinforced concrete.

Air-entrained concrete.

Latex concrete additive.

Removing 8-12 inches of wall face to allow a more-substantial patch.

The chance for the City to discover an affordable, achievable and lasting repair seems to be remote.

Photos C-19 and C-20 show a patch and its fate.

Photo C-19. Fix

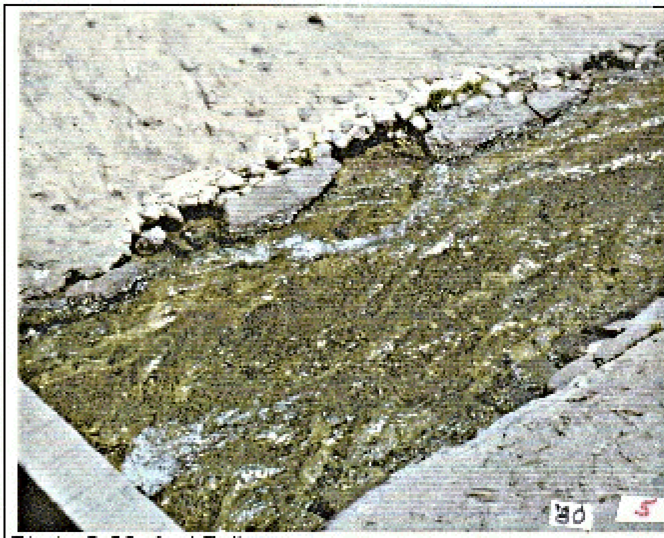


Photo C-20. And Fail

Right of Way

The project suffers the attack of encroachment. Photo C-21 shows the problem. The City has moved against violators, but the problem persists.

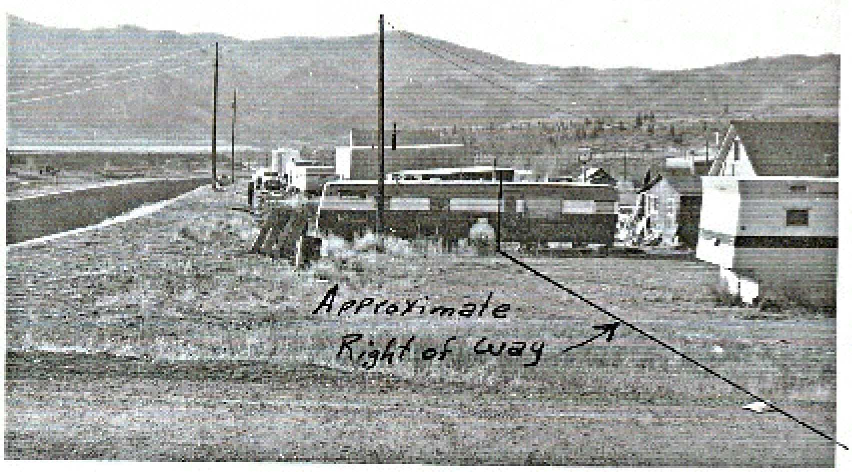


Photo C-21. Encroachment

Page 10

Safety

The project poses a substantial safety challenge. Photo C-22 shows a possibility of self-rescue, but as flow is fast and cold and the rocks are rough, the victim will be injured.

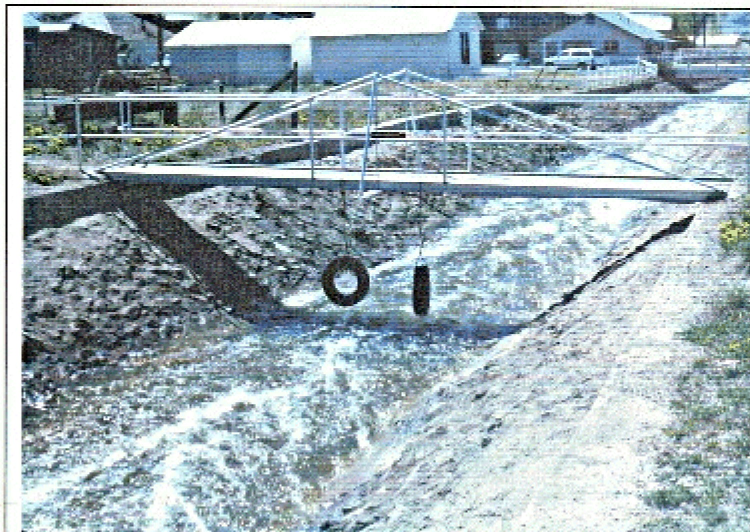


Photo C-22. Grab on if you can.

Reconstruction

In *Section 205 Detailed Project Report and Environmental Assessment, Creede Colorado*, 1989, the Corps investigated project rehabilitation. Reassessed hydrology and hydraulics lead to little change in project sizing. The existing channel was simply near the end of its functional life, primarily as a result of ice action along the waterline.

The preferred rehabilitation alternative was concrete lining. Alignment would be that of the existing channel. The channel would be sandblasted. A section of the channel lip would be removed to allow for a seamless pour. Eight inches of reinforced concrete would be placed along the bottom and six inches along the sides of the existing channel. The channel geometry is suited for slip-forming the lining if projecting rocks do not interfere with the slip-forming machine. An energy dissipater would be constructed at the downstream end. Bypassing the streamflow would be a formidable task.

Economic justification presumed that the existing channel would fail within five years (1994). It hasn't. The economics also showed that 1989 rehabilitation was unjustified if the existing channel could last another 16 years (to 2005). Sooner or later, Creede must have a new channel.

Page 11

The Sponsor

Channel maintenance is a perpetual challenge for a community perched on two sides of a mountain river. Creed's capital projects are funded from sales tax, $24,000 in 1989. Approximately $200,000 of channel repairs were needed that year. In good years, the City allocated $6000 for repairs, but even that is no longer a line item. What the City lacks in financial resources, it addresses with willingness and effort. Immediate maintenance needs noted in annual inspections are generally addressed by the subsequent visit. The mining heritage is obvious; City forces can fix broken things.

Lessons Learned:

Cold regions call for special materials consideration.

The best of projects can wear out. Patching patches becomes ineffective.

(1) Creede Date	Local Drainage	Backfill	Vegetation	Inlet	Log Cribs	Wire Fences	Channel	Concrete	Encroachment
21-Sep-54	Undesirable ditch through riprap.	Settled.		Good. Boulders at toe	One good. One with 20 ft missing.	Washed through.			
11-Oct-55	Same.	Sellted 6-12 inches.	Against riprap.	same.	Improved.	Not effective.			
8-Oct-56	Same.	Same.	Same.	Same.	Good shape.	Washed out.	Upflow through 10 inch hole in bed.		
17-Sep-57	Same.	Minor.	Enlarged.		Same.	Same.			
24-Nov-58	Same.	Improved	Trees, bush.	Very good.	Same.	Same.	Debris.		
28-Sep-59	Same.	Fill needed.	Willows, bush.	Good.	Good.	Not too successful.			
10-Oct-60	Same.	Added. More planned.		Good.	Fair.	Same.			
10-Oct-61	Same.	Improvements. Some work needed.	Bushes.	Good.	Fair. Flow through end of one crib.	Some dozer work, but problems remain.	Clean.	Minor spalling of concrete cap.	
12-Aug-63		Inadequate. Shrunk.		Good.	Same.	Same.	Clean. 2-ft hole developing.		
9-Jun-65	Above drainage is from old septic tank.	Need restoring. Hole needs filling.	Bush. Tree.	Good.			Clean. Weep holes filling in.	Spalling.	Construction close to channel.
3-May-66	Same.		Bushes. Tree.	Good.	Good.	Poor to fair.	Clean. Parched.	Cack from weep hole. Spalling. Weep holes filling.	Increasing encroachment into R/W. Dumping.

Inspection Summary

(1) Creede									
14-Nov-67	Should be extended.		Trees.	Good.	Good.		Crack worse.	Spalling.	Consderable trash and debris. Encroachment.
9-Jun-69		Needed.	Bush. Tree.	Good.			Cracking. Spalling. Weep holes covered by grading.		Timber may wash in. Encroachments.
8-Jun-70		Same.	Brush. Williws.				Cracking. Spalling. Popouts. Plugged weepholes.		Timber may wash in. Cesspool filled. Encroachments.
2-May-72		Poor backfill after sewer construction through parject.	Minor.	Good					High degree of encroachment.
25-Apr-73				Flow could spill into town before reaching inlet.			Problems with tunnels under channel.	Many cracks.	Emergency acces could be difficult.
27-Aug-74			Large trees gone.	Good.	Rotting.		Deteriating masonry walls at water line. Patches loosening. Floor fine, since always covered.	Cracks and spalling.	Encroachments remain.
8-Jul-75				Inflow could bypass into town.			Deteriated walls.		Numerous encroachments.

Inspection Summary

(1) Creede									
28-Oct-76				Same.			Inadequately repaired walls.		Same.
19-Jul-78		Need to raise road grade.		Same.			Good repairs. Springs through side.	Concrete breakdown.	
Jun-79									
18-Aug-80				OK			Cavitation at water line. Patches OK. Cavity.		Restricted R/W.
11-Aug-82				OK			Cavities on bank.		
18-Oct-83				Satisfactory.			Cavities. Some repairs. Serious masonry failures.		Numerous encroachments.
23-Aug-84								Cracks and spalls. Disintegration.	Not worse.
24-Sep-85		Road raised to proper elevation.					Lower end breaking down.	Cracks and spalls.	
6-Oct-87			Cleaned.	Crunbling wall.			Solid and smooth bottom. Wall deteriating.		
12-Jul-89				Crumbling wall.			New bridges OK. Debris and cavities in channel.		
20-Jun-90					Rotted away. Sediment washed in.		Accelarated breakdown.		

Inspection Summary

(1) Creede									
14-Aug-91									
29-Jul-92					Repaired		Some repairs. Deteriated masonry.		
21-Sep-93							Repairs. Deteriating splash zone.		
7-Sep-94							Same.		

Inspection Summary

+++++++++++++++ **The End** ++++++++++++++

Any questions, please contact info@pdhnow.com

QUIZ for Floodwater Lessons Learned: Creed, CO

1. The four cribs constructed above the channel are made up of

a. Concrete and rock

b. Wood timber and rock

c. Concrete weir and rock

2. The purpose of the cribs is

a. To trap sediment upstream before it reaches the channel

b. To trap water behind the cribs

c. Furnish grade control above the lined channel

d. “a” and “c”

3. The purpose of the four-inch weep holes in the grouted-riprap channel walls is to

a. Allow air to enter behind the channel lining

b. Allow water from the channel to enter behind the lining

c. Allow water that has accumulated behind the channel wall to drain into the channel

d. Provide an anchor hole to tie pedestrian bridges to the channel

4. The grouted-riprap channel has

a. Severe spalling at the bottom of the side slopes

b. Severe abrasion on the middle of the side slopes

c. A danger of floating like a large concrete canoe

5. A challenge to the channel wall integrity is

a. Creede has 300 frost days per year

b. High flood water velocity of 15 ft/sec

c. Sediment impact

d. Destructive chemical reaction between volcanic aggregate and mortar

e. All of the above

6. Hand-placed mortar repairs

a. Will last the project's life

b. Last about 5 to 7 years

c. May be made during high water

7. Grout may be successfully used in freeze-thaw areas

a. True

b. False

8. Creede channel damage is noticed mostly at

a. The freeze-thaw line

b. Where pedestrian bridges are located

c. Areas of encroachment

d. "a" and "b"

9. The two tires hanging from a pedestrian bridge

a. Are provided for tourist amusement during the summer months

b. Are a self-rescue apparatus

c. Used by U.S. Geological technicians to measure annual peak flows

10. Channel rehabilitation is well within the budget of the small town of Creede

a. True

b. False