# WATER OPERATION AND MAINTENANCE

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September 1990

## IN THIS ISSUE



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**Bureau of Reclamation**

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water supply systems. Its principal purpose is to serve as a medium of exchanging information for use by Bureau personnel and water user groups for operating and maintaining project facilities.

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Cover photograph:

Riverside Diversion Dam,
Rio Grande Project,
New Mexico. 6/24/69



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CONTENTS

# WATER OPERATION AND MAINTENANCE BULLETIN
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## ELECTRONIC DATALOGGERS FAIL IN STEEL RECORDING WELLS[1]

During the summer of 1989, the staff of the irrigation branch of Alberta Agriculture noticed the repeated failure of their electronic dataloggers installed in corrugated metal pipe (CMP) and steel recording wells. Replacement instruments would record data for about 2 weeks and then fail again.

Brian Cook, an electronics technologist with the branch, believes "the problem occurred when the CMP or any other metal in contact with moist soil becomes a primitive battery or galvanic cell generating between 0.7 to 1.1 volts." This voltage, he says, along with the high humidity found in recording wells and manholes is enough to destroy most micro chip based instruments and computers. Where possible, he suggests electronic equipment should be installed in PVC, fiberglass, concrete, or other nonconductive recording wells and manholes.

If, however, electronic equipment must be installed in a buried metal structure, he recommends using a desiccant product such as Silica-Gel in a tightly closed instrument box which is electrically insulated from all other metal.

For further information, please contact Brian Cook, Electronics Technologist, Irrigation Branch, Alberta Agriculture, Agriculture Centre, Lethbridge, Alberta T1J 4C7; telephone (403) 381-5879.

Alberta Agriculture has discontinued use of corrugated metal pipe and steel recording wells to house their electronic dataloggers.

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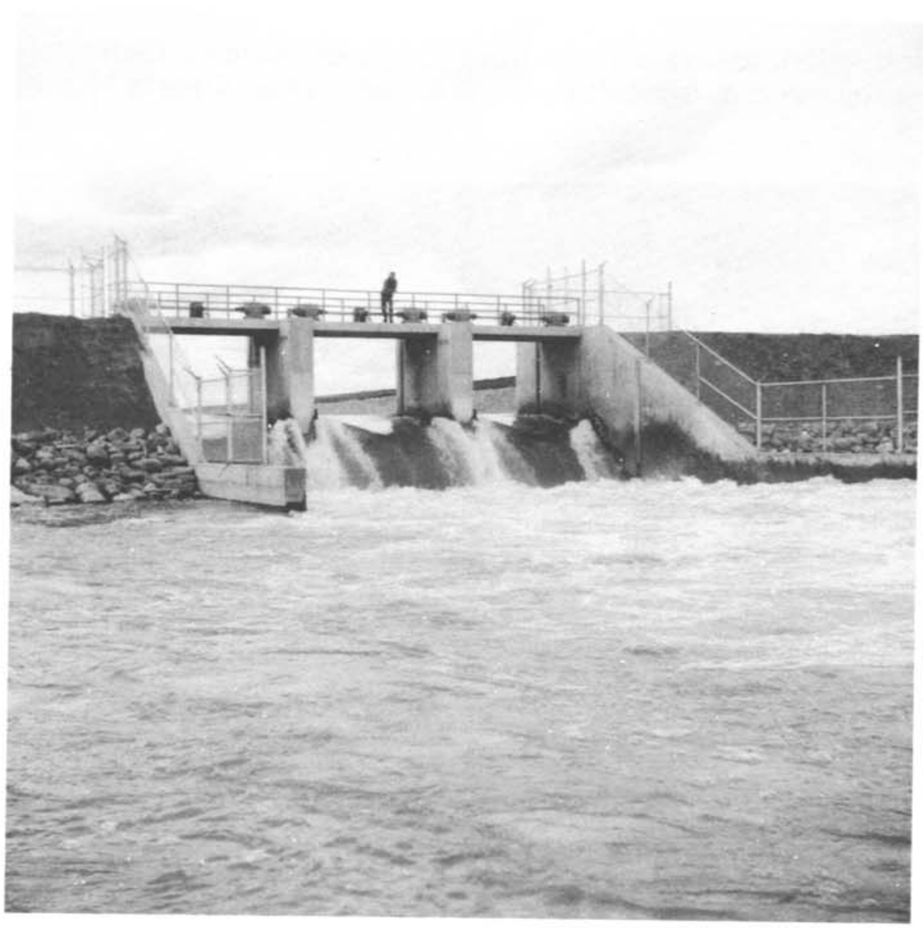
# A 1st FOR AN IRRIGATION STRUCTURE[1]

*Automated Overshot Gate Wins "Award of Excellence"*

UMA Engineering Ltd. (UMA) is changing the thinking of design engineers on how to control water in open channels (traditionally done with undershot gates) with the development of its award winning "Automated Overshot Gate." The automated overshot gate has not only won the "Award of Excellence," jointly sponsored by the Canadian Consulting Engineer Magazine and the Association of Consulting Engineers of Canada, but has been widely accepted by the "people who run the water."

UMA countered the trend of half a century of hydraulic design work in arriving at this innovative design. The overshot gate is simple! It can best be described as: a rectangular panel, hinged across the bottom, that is raised and lowered by two cables attached to the upper corners. Stationary sidewalls guide the flow of water up and over the gate panel. Liken it to a drawbridge placed in a canal.



Drop No. 18 on the St. Mary Main Canal is a check drop structure with three Overshot Gates.

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Hydraulically, the overshot gate is a moveable weir where flow over the gate varies as the three-halves power of the head, says UMA engineer Dale Miller. "This means that fluctuations in flow rate are reflected only as nominal fluctuations in water level. With water level held constant by the overshot gate, any diversions from the channel are assured of steady-state conditions. For a typical sluice gate diversion, the water manager needs to set his gate position only once with the knowledge that the flow through the gate will remain stable," says Miller.

How did the overshot gate come into being? Originally patented in 1890, the gate never did seem to catch on with design engineers. A quick review of modern day design manuals mentions no word about it. It was not until the SMRID (St. Mary River Irrigation District) needed a new inlet structure into Sauder Reservoir and manager Jim Brown's displeasure with existing structures that engineer Jozef Prozniak (then with UMA) began to develop the design. Only 2 years later, when trying to patent their product did UMA learn that 90 years previously someone had designed and patented a structure similar to theirs. No sooner was the gate designed than automation was pursued by UMA's Ian Daniluk to give the water manager around-the-clock control. All was not lost however, as UMA was able to copyright their automated controls and programs.

This smaller automated Overshot Gate is solar-powered, but these gates can also be connected to the local electrical grid system.

Financial assistance for further developing the automated overshot gate was received from the National Research Council of Canada, Farming For the Future and the Irrigation Council of Alberta. With financial assistance and the recent advances in computer and communications technology, UMA has reduced the size of the overshot gate and is now providing economical around-the-clock water level control on small canals as well.

"The overshot gate permits ease of operation by the water manager; a water level change of 10 cm (4 inches) is accomplished with a gate change of 10 cm (4 inches). The increment of control is very small; precise gate adjustments of as little as 5 mm (0.20 inch) are possible," adds Miller.

As simple as it may seem, the new design took many days to bring it from the idea stage to a fully functional irrigation structure.

For example, to prevent vibrations (both mechanical and auditory) and uneven flows over the gate, the nappe or overflow portion of the flow requires venting to atmosphere to prevent negative pressures from occurring underneath the gate panel. Venting is accomplished in two ways: by embedding vent pipes in the sidewalls of the larger structures; or by encasing one of the hoist cables with a vent hose on the smaller modular structures.

UMA enlisted the services of Armtec Inc. (a major gate and metal pipe manufacturer), to prototype the gate designs on a trial basis. Today Armtec has added the overshot gate to its product line and is selling them in both Canada and the United States.

Certainly it can be said the UMA development of the award winning automated overshot gate is one more tool in the design engineer's bag. With the control provided by this new structure, more efficient use can be made of a finite resource — water. When coupled with an automated control system, the overshot gate will contribute to improved conservation and management, at a time when the public is more aware of water issues and water managers are demanding more of their operating personnel and the tools they have at their command.

For more information please contact Dale Miller, P.Eng., UMA Engineering Ltd., Stafford Drive North, Lethbridge, Alberta T1H 2B2; telephone (403) 329-4822.

# PLUGGING OF AIR VENTS DOWNSTREAM OF OUTLET WORKS GUARD GATES

by Darrel E. Krause[1]

Generally, air vents are provided between the guard (also sometimes referred to as "emergency") gate and the regulating gate (or valve) of an outlet works configuration. The vent is normally connected to the downstream side of the guard gate body in a manifold to distribute the airflow. Without an adequate air supply, negative pressures can develop while the guard gate is being closed under "unbalanced head" conditions, which can cause cavitation damage or water column separation; or as discussed later, lack of an adequate air supply can result in collapse of the pipe downstream.

## Background

During normal operations, the guard gate is kept completely open while water is being released through the outlet works. The regulating gate (or valve) at the end of the pipe is used to control or stop the flow of water. With the regulating gate/valve closed, the guard gate can then be closed under "balanced head" conditions. Under these normal operating conditions, the air vent is needed only to release air from the pipe between the gates (or gate and valve) during the filling process or to supply air to the pipe during draining to perform maintenance or inspections within.

However, if the regulating gate/valve cannot be closed for some reason, the guard gate may need to be operated (under "unbalanced head" conditions) to stop the flow during an emergency situation. If an adequate air supply is not provided to the pipe downstream of the gate, negative pressures may cause the pipe to collapse.

The size of the air vent can vary and is determined from the diameter and length of the downstream pipeline, design flow, and design head. The vent is usually small for relatively close-coupled gates/valves and basically is used to vent air while filling or draining the pipe between them. Larger vents are normally required when the guard gate is located some distance upstream of the regulating gate/valve and there is the danger of high negative pressures developing and collapsing the pipe during an emergency closure of the guard gate. Where collapse of the pipe is not a concern, larger vents may be provided to reduce vibrations and noise which will occur during an emergency closure. Air vents are not normally sized to prevent minor and infrequent cavitation damage which will occur during the short period required for an emergency closure.

Most air vents are provided with a combination (air vacuum/air release) air valve assembly (see figure 1) to allow automatic operation, particularly during an emergency closure. Such a valve assembly allows the release of air from the pipe during the filling process and allows the admission of air during the draining or emergency closure process. In addition to the air valve assembly, most air vents consist of steel pipe embedded in concrete and terminating in a type of air manifold on the downstream side of the guard gate. The air manifold contains a number of holes or air passages across the width of the gate body to allow for equal air distribution (see figure 2). A properly operating

[1] Darrel E. Krause is a General Engineer employed by the Bureau of Reclamation, Facilities Engineering Branch, Denver, Colorado.

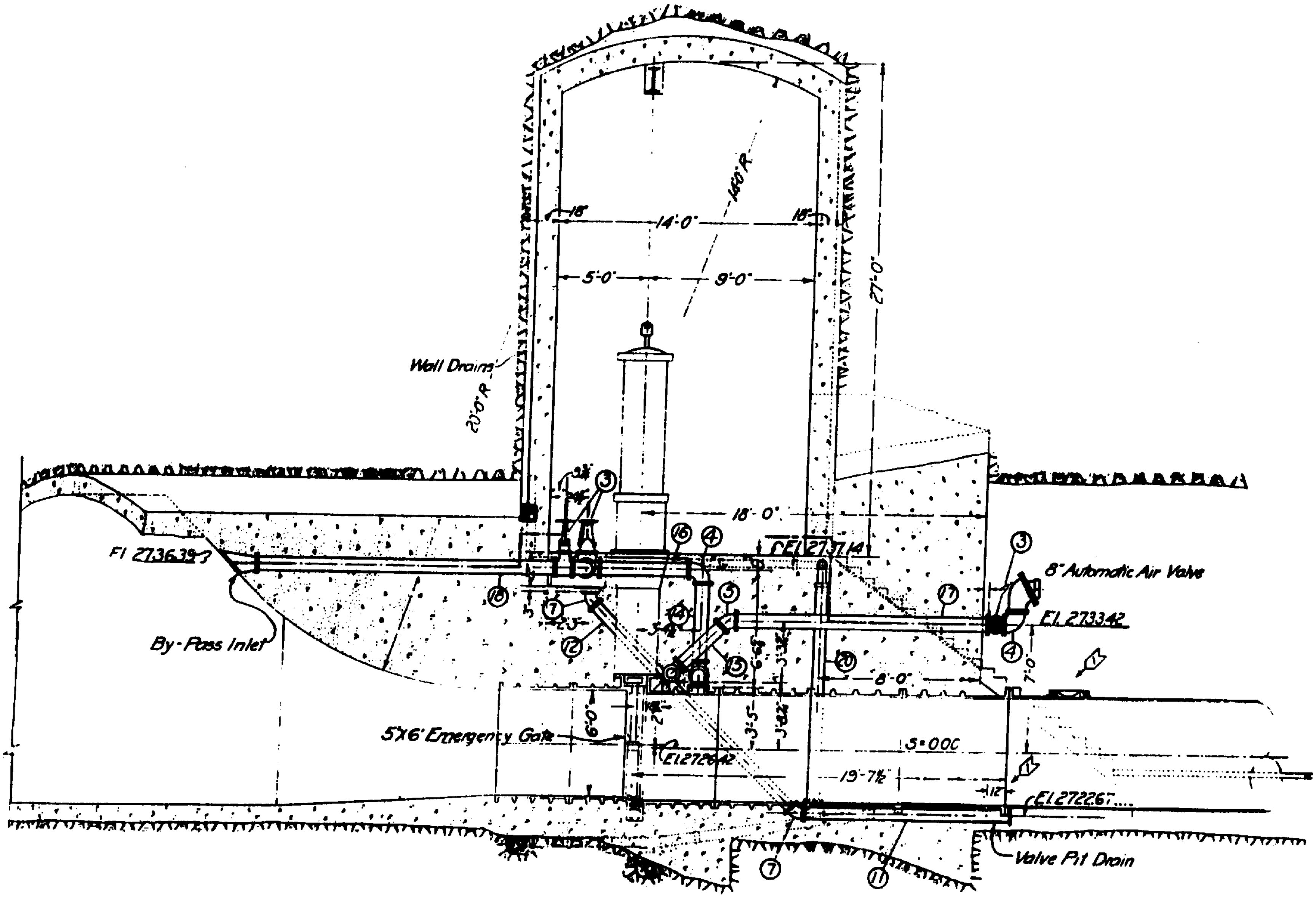



Figure 1. - Example of automatic air valve assembly provided on air vent downstream of emergency (guard) gate.

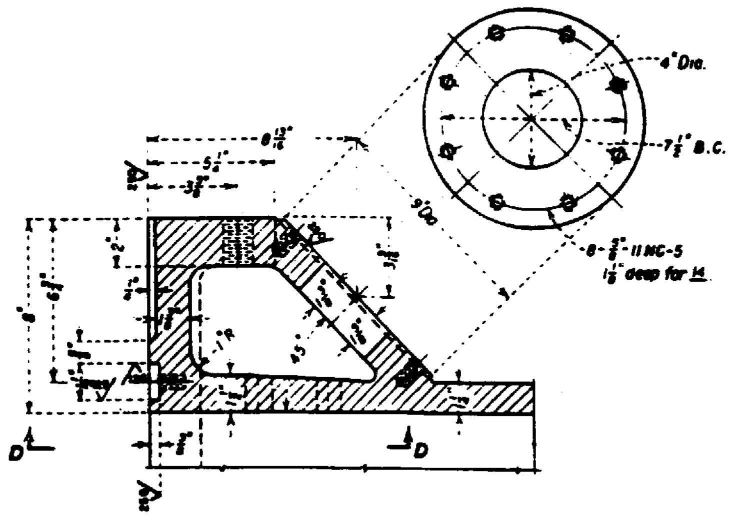
air valve assembly, as well as a clear and unobstructed air manifold and pipe, is essential to permit safe operation of the outlet works, particularly during an emergency closure.

## Plugging Incident

During the past several years, Reclamation research personnel have been conducting field tests to determine an appropriate standardized procedure to be used for ensuring reliable emergency closure capability of guard gates. One such field test was conducted at Silver Jack Dam in southwestern Colorado. During the course of the test, it was observed that the air manifold downstream of the guard gate was almost plugged with silt and debris, with the airflow area through the air passages/holes reduced by approximately 75 percent. This plugging caused a dramatic effect on air demand during the emergency closure process. A similar problem has been observed and corrected at other similar locations where the small vent holes in the manifold were obstructed with rust and silt.

## Precautions To Be Taken

Operating personnel at all Reclamation facilities having similar types of outlet works configurations and air vents should be made aware of this plugging possibility and its consequences. Silt, debris, and rust can accumulate through normal operations, as was observed at Silver Jack Dam. Thorough and frequent (at least annual) inspections of the air manifold and passages/holes, as well as the air valve assembly, should be included as part of the operating personnel's routine duties and responsibilities at the dam to ensure safe and proper functioning of the air vent and outlet works. This is particularly important in the event of an emergency closure when the pipe could collapse due to an inadequate air supply.

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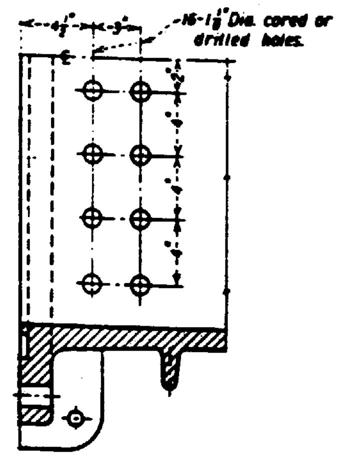


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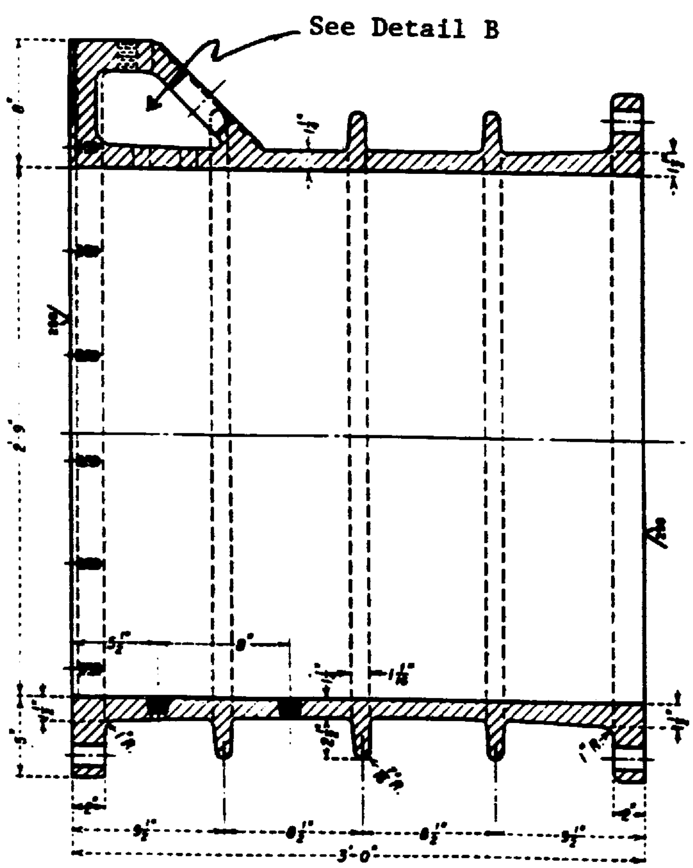


Downstream frame of gate

Figure 2. - Details of a typical air vent manifold.

# NEW METHOD OF STREAM BANK PROTECTION[1]

By Clifford Baber, P.E. [2]

With five creeks flowing through its residential and commercial developments, the property owners in Saint Charles, Missouri, are all too familiar with creek bank erosion. Over the years, a variety of methods have been employed by the city and private owners in an attempt to curb this erosion.

Cole Creek, having the largest drainage area of the five creeks, experiences the greatest fluctuation in flow. The serious degree of bank erosion at one residence along Cole Creek resulted in the city investigating and evaluating various erosion control methods.

Investigation began with a grid confinement system, but nearly vertical creek banks caused the manufacturer not to recommend its use. Interlocking sheetpiling was the next method to be researched. With an estimated cost of between $125,000 to $130,000, this method was not recommended. A concrete retaining wall that later could be incorporated into a vertical wall channel was a third alternative investigated. This 18-foot-high by 62-foot-long wall was estimated to cost $76,000 in 1987.

In the fall of 1987, it was decided to receive bids for a gabion basket wall. The low bid of $75,500 for the 80-foot-long by 18-foot-high wall caused the city to continue to search for a less costly alternative.

A new method of creek bank stabilization was introduced to the city in late 1987. The new method, the Waterloffel, is a variation of the Loffelstein wall system that originated in Europe. This retaining wall system consists of trough shaped concrete modules or units with interlocking wings. Each module is 18 inches wide, 26 inches long, 7 inches tall, and weighs approximately 176 pounds. The Waterloffel modules are produced by Seagren Industries, Saint Louis, Missouri. It was estimated this retaining wall could be constructed for approximately $54,000.

Construction of the Waterloffel retaining wall began with a 3-foot-thick footing located 1 foot below the creek bed. Poor soil conditions and sudden thunderstorms made construction of the footing difficult. During installation of the footing, the first layer of modules was embedded in the fresh concrete to ensure no slippage between the modules and the footing would occur. Construction of the wall progressed by setting the next layer of modules on the newly completed layer. Each layer of modules was set back approximately 8 inches to create a 40° slope from the vertical.

After completion of the first six or seven layers, a scour protection system was installed. This system, consisting of concrete-filled grid confinement system, was constructed at the toe of the retaining wall. The scour protection system was designed to help prevent scour along the footing.

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[2] Mr. Baber is Assistant City Engineer, Saint Charles, Missouri.

Creek bank stabilization system is built by placing layers of trough shaped modules on the steep slope. Interlocking wings tie units together, as shown in detail at left. Later a scour protection system was placed at the toe.

To ensure positive drainage through the wall, a 1-foot-thick layer of clean rock was placed behind the wall and the troughs of the modules were filled with clean rock. A filter fabric was placed between the rock layer and the excavated creek bank to reduce contamination of the clean rock.

The configuration of the modules will allow vegetation to grow along the wall eventually, blending the wall into its natural surroundings.

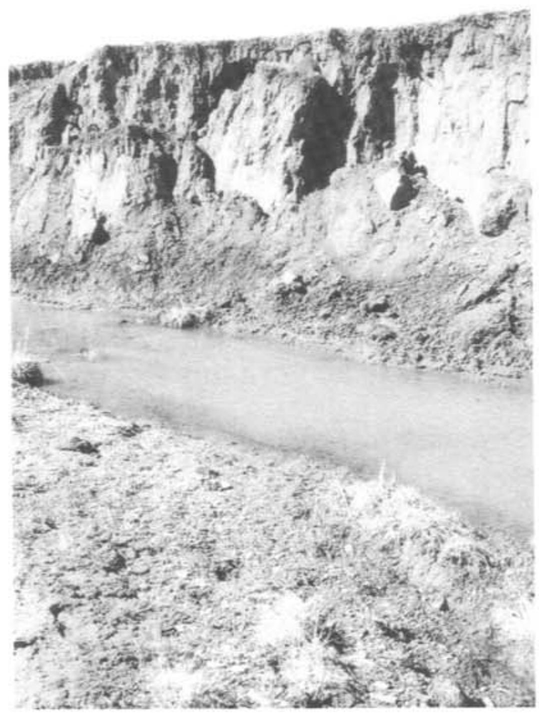
The completed Waterloffel wall is 85 feet long and 20 feet high, containing 1,210 modules. An average of 130 modules were placed per day with construction of the wall taking approximately 1 month. The bids for the wall ranged from $56,492 to $88,365 with the low bid representing a 34 percent saving over the gabion basket wall, the next least expensive option considered.

# NEW REVETMENT DESIGN CONTROLS STREAMBANK EROSION[1]

by Russell A. LaFayette and David W. Pawelek[2]

A watershed condition analysis of the Bluewater Creek watershed near Grants, New Mexico, showed that although most of the uplands were in at least satisfactory condition, stream channel meander cutting continued to provide excessive sediments to the fluvial system. An innovative revetment system eventually solved the problem.

The project site is located along the main channel of Bluewater Creek, one of two major streams contributing most of the flow into Bluewater Lake, a 2,350-acre impoundment in northwestern New Mexico. Located in the Zuni Mountains, the watershed contains 52,000 acres, 86 percent of which is managed by the Mt. Taylor Ranger District, Cibola National Forest, Southwestern Region, USDA Forest Service. Average annual precipitation varies from 14 inches at Bluewater Lake to 24 inches at the highest elevation. Precipitation falls predominantly in the summer in short-duration high-intensity thunderstorms.



Construction view of revetment shows main baffle segment parallel to flow, one perpendicular baffle, and posts in place for a second. At right, bank slumping along the main stem of Bluewater Creek prior to the project.

The watershed strongly reflects its land use over the last 200 years. Hispanic and anglo settlement, accompanied by extensive grazing and lumbering, reduced ground cover, decreased water infiltration, increased runoff and surface erosion, and initiated channel degradation.[1][3] Timber harvest took place over most of the watershed between 1890 and 1940. Grazing of cattle and sheep continued, and fire scars on remaining trees and stumps testify to extensive wildfires. Since the USDA Forest Service acquired the

[1] Reprinted with permission from the Editor, Public Works, December 1989 issue.

[2] Russell A. LaFayette is a Hydrologist, USDA Forest Service, Southwestern Region; and David W. Pawelek is a Hydrologist, Cibola National Forest, Albuquerque, New Mexico.

[3] Numbers in brackets pertain to References at end of article.

land in the early 1940's, better grazing and timber management have markedly improved the land.[2]

A hydrologic function analysis was begun in 1984.[3,4] Results were summarized in 1987 by Hanes and LaFayette.[5] Generally speaking, most subwatersheds were in at least satisfactory condition. Improved land use had allowed most land surfaces to regain sufficient cover to arrest surface erosion and moderate most normal rainfall and snowmelt runoff.

## Problems Remain

Problems persisted, however. Recovery of the drainage network has been slow. Headward gully erosion continues into broad meadows, lowering their water table, producing sediment, and decreasing productivity. Channel meandering causes very active streambank erosion, resulting in sedimentation of the stream and lake. Poorly located or unneeded roads channel water into drainages, as do livestock trails. Flood peaks remain unacceptably high while base flows remain small, limiting the extent of perennial streams in the watershed. Riparian vegetation remains far below potential, resulting in unstable streambanks, higher water temperatures, and low fish productivity.

Watershed study findings prompted a long-term program to improve hydrologic function and resultant benefits. Treatment goals include: moderate flood peaks, prolong base flows, and store water within the soil mantle; reduce sedimentation of the stream and lake; increase wildlife and fish productivity; boost timber and forage productivity; demonstrate watershed analysis and treatment methods; and preserve archeological resources.

Treatment methods include: gully headout control, road closures and improved channel crossings, livestock management, increasing riparian vegetation, better timber management, controlling channel base levels, increasing fish and wildlife management, and controlling excessive streambank erosion. The remainder of this article addresses a method to achieve this last objective.

## Streambank Erosion Control

Channel degradation and stream meandering had left several actively eroding streambanks along the main Bluewater Creek channel. Lateral water movement in the channel would undercut banks ranging from 10 to 20 feet high, causing a large prism of soil to fall directly into the active stream. Riparian vegetation was unable to become established on these banks and sediment production was substantial, particularly during high runoff years. Fourteen such banks and many smaller ones were measured in a 4-mile length of channel between private lands to the center of the watershed and a critical road crossing above the lake. Ways to control this excessive streambank erosion were analyzed and a preferred method chosen.

The method selected must stop streambank failures, thus limiting channel and lake sedimentation. It must work with the stream system rather than against it to preserve and promote maximum stream length and maintain channel gradient. The system should promote onsite sediment storage and development of riparian vegetation and overall ground cover.

Excellent cover was established less than a year after revetment installation.

Various streambank erosion control measures were evaluated for their advantages and disadvantages:

**Livestock control in riparian areas**.–This would provide a cure only in the very long term. Water flowing along the base of high cut walls could continue to undermine vertical banks.

**Riparian planting**.–Planting alone without livestock control would be inexpensive but ineffective. Progress would require many years and may not control water at the base of existing cut banks.

**Bank shaping**.–Although shaping would reduce the prism of soil available to enter the stream as well as provide a site for plant growth, problems included where to dispose the cut slope soil and erosion of the exposed surface before plant growth. It would not prevent water from running along raw banks or arrest meandering.

**Gabions**.–Although effective in preventing bank erosion, problems include high cost, complex construction, and failure to promote sediment deposition onsite and riparian plant establishment.

**Kellner jacks or tetrahedrons**.–These methods come close to meeting project goals since they follow stream contours, promote sediment deposition and riparian plant establishment. Negatives include relatively high cost, complex construction, and little esthetic appeal. Also, most jack systems are designed for larger stream systems.

**Porous fence revetment**.–This alternative was chosen for several reasons. Fence materials allow water to pass through the system, thus reducing water velocity and promoting sediment deposition. Sediments provide a growth medium for riparian vegetation. Plant growth, particularly woody species, strengthen the total system while making it less visible to the public. The system largely preserves the meander length and gradient. Temporary livestock exclosure is needed to speed recovery, but controlled grazing can be resumed after several years

Two streams meanders were chosen to apply the porous fence revetment system. Designated in an earlier examination of meanders as sites G and H, the two locations had a combined streambank length of 1,400 feet. Eroding meander scarps measured up to 18 feet vertically. Based on three USGS streamflow gauges around the Zuni Mountains, design flows for the 100- and 50-year recurrence interval floods were 1,420 $ft^3/s$ and 890 $ft^3/s$, respectively, from the 39,000-acre watershed above the sites (figure 1).

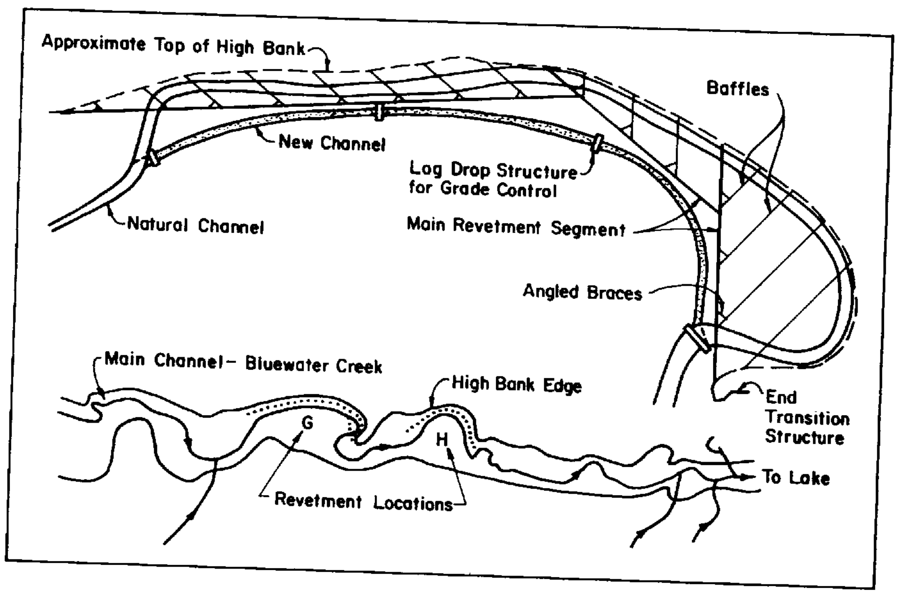



Figure 1. – Revetment locations on the creek and details of revetment G design.

Soils are a deep alluvium, with the streambed entrenched into this material. Plants dominating high benches are rabbitbrush and snakeweed. Kentucky blue grass is found on lower terraces next to the stream course. Many old terraces and meander scars are evident, depicting a history of channel degradation and meandering. Before the arrival of European settlers, we theorize that Bluewater Creek flowed in a wide and shallow alluvial valley growing significant riparian vegetation and providing home to numerous beaver and other wildlife.

Project Design and Materials

Materials are the key to this design. Other designs we had studied used posts of treated telephone pole, various diameter piping, old railroad rails, and similar materials.[6] All were difficult to handle and required drilling or other means to attach fencing materials. Fence materials typically were galvanized chain link fence or welded wire.

The design at Bluewater Creek uses pre-drilled galvanized steel U-channel sign posts commonly used to erect highway signs (figure 2). Posts can be bought in various lengths in 2-foot increments, in weights from 2-1/2 to 4 lb/ft. Two or more posts can be bolted together for added strength if desired. These posts are easy to handle, can be driven by hand or machine, and pre-drilling provides handy places to attach bolts, cable, and wire.

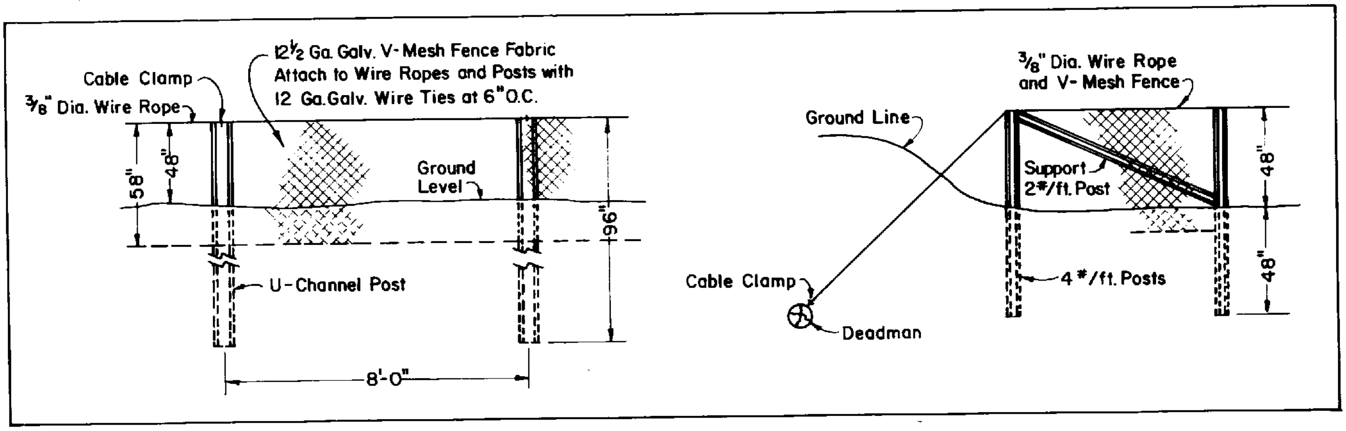



Figure 2. – Details of main revetment and baffle sections and the deadman and support assembly.

We chose fence material of 12-1/2-gauge galvanized V-mesh woven wire. Horizontal strands are twisted double wire. Woven V-mesh verticals are wrapped around horizontals rather than welded, a stronger and more flexible system since spotwelds can break. Wire rope used for top support and deadmen are galvanized, as are all fasteners.

Each revetment section consists of several components. A new permanent channel is dug to keep water away from the eroding bank, provide work space for construction, and a site for sediment deposition and plant growth. The new channel must be maximized to maintain overall stream length and gradient.

The revetment section consists of two elements: one or more main segments aligned parallel to flow, and a series of baffles oriented perpendicular to flow, extending from the main segments back into the streambank. Main segments and baffles are faced with the fence material, attached so that water and debris will force the fence material against the posts. Galvanized wire rope extends along the top of the main segments, held at tension and secured in the ground via deadmen made of post segments. Wire rope is similarly attached along the top of the baffle posts and secured in the banks. Fence material is secured to the posts and wire rope by 12-gauge galvanized tie wire and galvanized U-bolts.

In this design, 8-foot posts were driven 4 feet into the ground, leaving 4 feet exposed. Posts for the main segments and baffles were on 8-foot centers. Fence material 58 inches high was used, with 10 inches being buried and the remaining 48 inches above ground. Burying was done to provide below-ground protection should the channel meander or widen against the revetment.

At several locations, 24-inch-diameter Ponderosa pine logs were buried across the new channel with the top edge of the log level with the stream bottom. This feature was designed to provide temporary grade control while the revetments became firmly established.

To enhance the revetments' effectiveness, several features were added to the project. All disturbed soil was seeded to promote ground cover and reduce erosion. Local willow cuttings were planted along banks of the new channel to provide bank strength and eventual shade. Cottonwood poles were planted to provide a future over-story component and seed source. Livestock grazing was eliminated for at least 5 years to give all vegetation a chance to become established, after which well-managed grazing will be allowed.

Project Results

The revetments were installed by a contractor at sites G and H in late fall 1986. An above-average snowfall provided significant snowmelt runoff in spring 1987 before any vegetation could become established. The structures functioned flawlessly, however, capturing significant sediment deposits and small woody debris. The new channel widened considerably, but not enough to endanger the structures.

Vegetation growth in and around the structures did well during 1987, providing additional flow roughness to enhance sediment capture and provide ground and bank cover. Willow cuttings were planted on several occasions by various volunteer groups and cottonwood poles were also put in place. The second winter saw little snow and little spring flow but significant summer thunderstorm runoff. Plant growth in and around the revetments was excellent. Willow plantings were partially successful. Most cottonwood poles lost their top vegetation but sprouted from the root collar in summer 1988.

Due to improper installation and channel widening beyond expectations, several log grade-control structures were unsuccessful. Those logs properly installed continue to work well and remain submerged except during the lowest flows.

Project costs for materials, labor, and equipment totaled $27,700. With a bank length of 1,400 feet, cost averaged $19.79 per foot of protected bank. As plant growth continues, maintenance costs should prove minimal, since each passing season provides additional root strength and bank cover.

The project designers feel confident the project will continue to succeed. It has survived both high spring runoff and summer runoff events. Bank erosion is reduced, sediment deposition is occurring as planned, and plant growth is excellent. High-intensity storms in summer 1989 put the revetments to the test, and they did their job as designed.

Based upon the success of these first two structures, the forest service has installed six additional revetment segments. Several design advances aided project success. The basic design is simple, easy to install, and requires minimal equipment. Materials are readily available in various sizes and strengths to meet anticipated stream forces. It provides an integrated solution, combining revetment fencing, planting, seeding, and livestock management.

The designers feel several adjustments in design will make future projects more successful. Fences will be buried deeper, with only 1-1/2 to 2 feet of fence exposed. This will be less obtrusive above ground yet provide necessary control above and below the surface. The constructed channel will be further from the main revetment segments, providing additional insurance against undercutting. Grade control logs may be eliminated since change in grade along the stream profile is minimal. Cottonwood cuttings will be grown in a nursery for 1 year before planting since rooted stock survive better than bare poles sunk to ground-water level. Willows will be cut from local stock and planted as early as possible. These adjustments should strengthen the success of the initial design.

It is encouraging to note that local private landowners, previously skeptical of the forest service work along Bluewater Creek, are making inquiries about the project and considering similar work on their own adjacent lands.

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