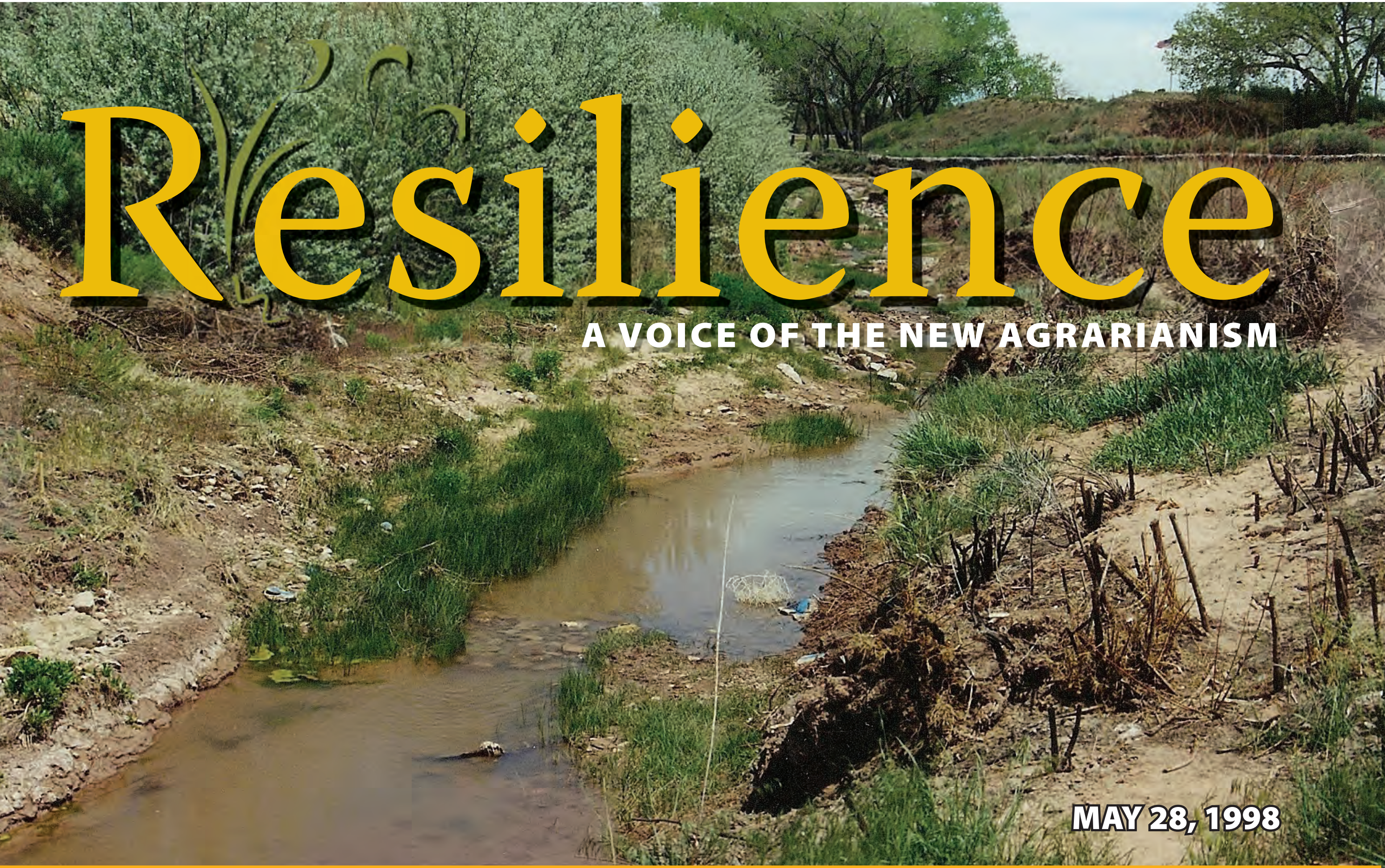
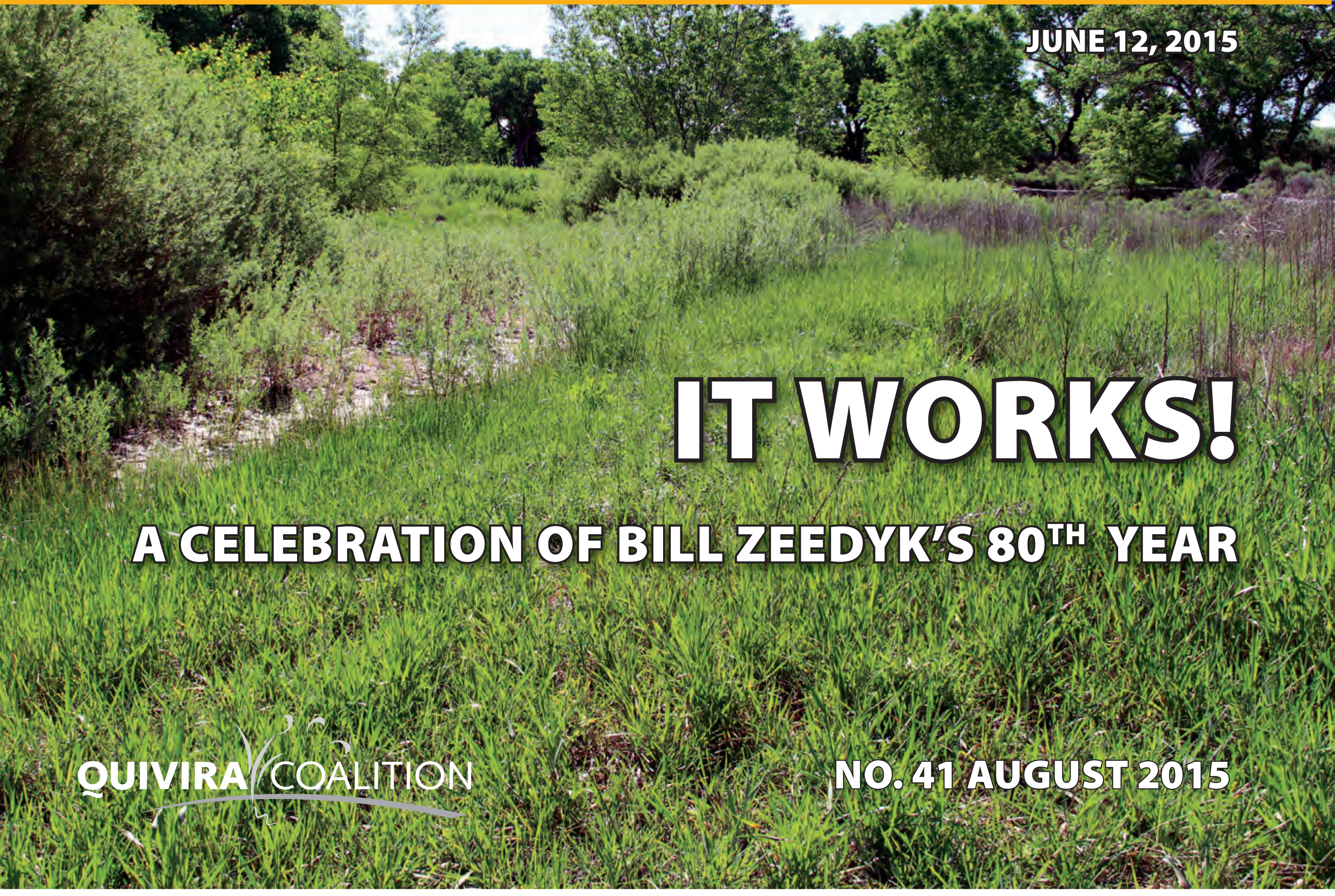
Resilience

A VOICE OF THE NEW AGRARIANISM



MAY 28, 1998



JUNE 12, 2015

IT WORKS!

A CELEBRATION OF BILL ZEEDYK'S 80TH YEAR

QUIVIRA COALITION

NO. 41 AUGUST 2015

From the Editor

It is our great pleasure to bring you this 41st edition of the Quivira journal. Not only is it a small token of our appreciation for the many ways that Bill Zeedyk has enriched our lives and work here at the Quivira Coalition, it is an honor to publish these original essays, each of which represents countless hours of fieldwork, documentation and analysis. We are especially pleased to present Bill's in-depth summary of his pioneering restoration project at Hubbell Trading Post in eastern Arizona, where he tested early ideas for Induced Meandering—to great success! We are honored that Bill chose *Resilience* to debut this important analysis.

I want to thank all the contributors for taking the time to write their essays and, by extension, thank the many, many volunteers, contractors, agency personnel, nonprofit staff, landowners and others who worked on the projects found on these pages. Success can't be measured just in linear feet of creek restored, cubic meters of rock moved or the number of biological species counted. Success also means teamwork—or it doesn't happen. Many hands make light work, as the saying goes, and in the case of ecological restoration, many hands make the radical center work!

As Editor of Resilience, I want to take this opportunity to sincerely and repeatedly thank Tamara Gadzia for her brilliant work over the years, designing and producing not only *Resilience* but every Quivira publication. Her creativity, patience and attention to detail shines in everything we produce. From all of us here at Quivira, including every reader, thanks Tamara!

Thanks again to all involved—and happy reading!

Courtney

Courtney White
Cofounder and Creative Director

Quivira Coalition Board of Directors*

Cover photo by ©Bill Zeedyk (1999) and ©Tamara Gadzia (2015). This issue of *Resilience* is funded by Quivira Coalition membership donations. Printing by Paper Tiger, Santa Fe, New Mexico.

Honoring Bill Zeedyk – Creek Whisperer Extraordinaire

In March, many of us at the Quivira Coalition had the pleasure of attending a daylong workshop organized by the New Mexico Environment Department to celebrate Bill Zeedyk's 80th birthday and to honor all that he has accomplished over the past two decades on behalf of wetlands, riparian areas and all of the animals, wild and domestic, that depend on them. It was an extraordinary event, filled with restoration success stories, history lessons and heartfelt accolades for Bill and his inspiring vision, leadership and good humor. By the end of the day, we realized that two words neatly summed up what we heard from the presenters: It works!

There's simply no question about it. Bill's ideas and methods have stood the test of time, evidenced by legions of monitoring data, stacks of photos and countless testimonials by restoration experts, agency personnel, landowners and others. Not that any of us ever harbored any doubt, of course! Still, it was both impressive and gratifying to see so much corroborating evidence from so many different projects. In fact, following the conclusion of the workshop, we decided to dedicate this issue of our Journal to spreading the news. It is also our way of honoring Bill during his 80th birthday year and thanking him for enriching our lives and work here at the Quivira Coalition.

For those of you who may not know Bill, his innovation and leadership in wetlands and riparian restoration has earned him the distinction as the Southwestern restoration "guru." Over the course of the last 20 years, he has been directly responsible for working with 71 different federal, state, NGO, tribal and private land owners in the U.S. and Mexico on over 150 restoration projects to improve more than 400 wetland acres and 65 miles of degraded riparian channels. That's a substantial undertaking when you consider the rarity, and therefore the exceptional significance, of wetland ecosystems in the desert Southwest, especially since most wetlands in our region are less than a quarter acre in size.

Beyond his ecological contribution, Bill has imparted his wisdom to more than 3,000 volunteers, students, apprentices, contractors and cooperators who have flocked to his public workshops and presentations to learn about how to care for our region's most valuable ecosystems. Bill has also contributed tremendously to the body of knowledge about wetlands and riparian restoration by publishing eight books and field guides.

Bill Zeedyk

©T. Gadzia, 2011

Bill holds a B.S. degree in Forestry (Wildlife Management) from the University of New Hampshire, and served in the U.S. Forest Service for 34 years in a variety of assignments, including Research Forester, Assistant District Ranger, Forest Wildlife Biologist, Staff Officer for Wildlife and Watershed Management, Endangered Species Biologist, and finally as Staff Director for Wildlife and Fisheries Management, Southwestern Region. Bill's career with the Forest Service epitomizes the truest meaning of "civil service."

When he retired in 1990, Bill traveled the world for a year and then went straight to work developing a second career focusing on simple techniques for stabilizing and restoring incised stream channels and gullied wetlands on public and private lands in the Southwest and Mexico. Today he and his wife, Mary Maulsby, own and operate a small consulting business specializing in the restoration of wetland and riparian habitats using "low tech," hands-on methods and native materials. Bill has developed an important set of low-cost techniques designed to "heal nature with nature," as he puts it. His wetlands toolbox includes about a dozen different log, rock and wetland sod structures (one-rock dams, "Zuni" rock bowls, log and fabric step falls, worm ditches, log flow splitters, plug and spread structures, etc.) that function to slow runoff and trap sediment and seeds so that new wetland vegetation is recruited and thrives. The brilliance of Bill's methodology lies in its simplicity. The raw materials are often on-site; the basic techniques can be taught and mastered in an afternoon; and the results are quickly gratifying—water is diverted from a down-cutting channel and spread back over a thirsty wetland, or a pool refills only to be discovered moments later by a resident trout.

Bill's devotion to meaningful partnerships is the keystone to his success as a leader in this important work. He serves as the innovative "idea guy," but relies heavily on partnerships and volunteerism to get his ideas implemented. The organizations that he has inspired represent the full gamut of western land stewardship, from big international conservation leaders like The Nature Conservancy to small watershed groups like the Hermits Peak Watershed Association, federal agencies like the Bureau of Land Management to sovereign Tribal governments, and all the way down to local Soil and Water Conservation Districts. Bill has also engaged deeply with many private landowners/managers and influenced the management of countless ranches and farms in New Mexico, Arizona, Texas, Colorado and beyond.

The reason for all this goodwill and collaboration is simple: Bill's ideas work. The results speak for themselves, and if there's one thing we can all agree on in these challenging times, it's the need for accomplishing on-the-ground results. Whether it's bringing a degraded wetland back to life, restoring a stretch of incised riparian area to health, repairing an eroded ranch road or just "thinking like a creek" generally, Bill's ideas and methods get substantial, long-lasting results. We'd like to share some of the success stories with you.

~Quivira Coalition Staff

BILL ZEEDYK IN HIS ELEMENT

©T. Gadzia, Pueblo Colorado Wash, 2015

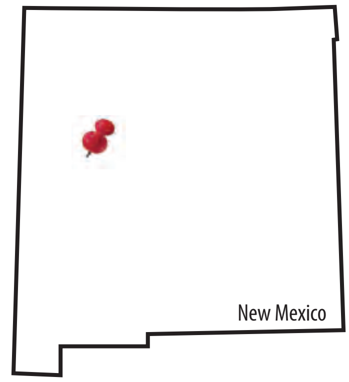
©K.G. Fisher, Cebolla Canyon, 2013

©T. Gadzia, CS Ranch, 2004

©T. Gadzia, Dry Cimarron, 2005

The Transformation of Cebolla Canyon

By Kristina G. Fisher and Michael Scialdone



It takes an impressive sense of time and vision to see the possibility of a wetland in a landscape that consists of a mud pit around an old spring and miles of gully downcut 40 feet or more.

But realizing this sort of vision is Bill Zeedyk's specialty. Over the past 15 years, he has led an effort to restore the degraded wetlands of Cebolla Canyon in the El Malpais National Conservation Area near Grants, New Mexico. The results achieved so far have been remarkable—particularly considering that much of the work has been completed by volunteers.

Ruins of homesteads from the 1930s still dot Cebolla Canyon.

M. Schultz, NMED, 2009

THE STORY OF CEBOLLA CANYON

Cebolla Canyon lies in the southeast section of the El Malpais National Conservation Area. Approximately five miles up the canyon sits Cebolla Spring, a perennial spring that, along with the summer monsoon rains, created a substantial slope wetland in an otherwise extremely arid area. The wetland fed a series of wet meadows that extended down the broad valley floor of Cebolla Canyon.

M. Schultz, NMED, 2009

Gullies throughout Cebolla Canyon have downcut rapidly, leaving this culvert high above the valley bottom.

Archeological evidence indicates that the canyon was used as a campsite as far back as 10,000 B.C., and it was periodically inhabited and farmed since at least 400 A.D. Due to climate change, early pueblo farms were abandoned by the mid-1300s.

In many places, roads captured streamflows and began to downcut into gullies.

M. Schultz, NMED, 2009

During the 1930s, another shift in climate led to big changes in Cebolla Canyon: homesteaders fleeing the Dust Bowl settled there, building houses and a school and growing truck crops, including potatoes, radishes, carrots, cabbages and beets. They also raised chickens for eggs and cut and sold firewood in Grants. The homesteaders chose Cebolla Canyon because of the perennial spring, from which they hauled water and built diversion ditches to irrigate fields.

©K.G. Fisher, 2012

Perennial Cebolla Spring once supported extensive wetlands and wet meadows.

Not long after it was settled, the community was abandoned. With the onset of World War II, most of the men left to join the military and the women took jobs in factories. Unfortunately, some of the changes the homesteaders had made continued to impact the canyon for decades.

Aerial photos taken by Charles Lindbergh during his surveys of New Mexico in the late 1930s show the roads the homesteaders carved into Cebolla Canyon. In the years that followed, these roads captured the annual monsoon flows and began to downcut. As the gullies cut through the wet meadow vegetation, the water table sank to follow them; soon the roots of the vegetation dried out and wetland plants were replaced by upland species. The fine silt and sandy soil eroded easily and the gullies continued to cut, dropping as much as 40 feet below the valley floor by the late 1990s. These impacts were exacerbated by the abandoned irrigation ditches, which continued to steadily drain the wetland, and unmanaged grazing, which saw cattle trailing up the gully bottom and wallowing in the small mud pit that had replaced the wetland around the spring.

In 1987, the El Malpais National Monument was created and much of the area around Cebolla Canyon was designated as wilderness. However, part of Cebolla Canyon itself remained privately held until 1995, when it was acquired by the federal government and placed in the hands of the Bureau of Land Management (BLM). Within a few years, Bill Zeedyk began arranging partnerships between the BLM, the New Mexico Environment Department and several nonprofits, with the goal of restoring Cebolla's historic wetlands.

ALBUQUERQUE WILDLIFE FEDERATION'S INVOLVEMENT

One of those nonprofit groups was the Albuquerque Wildlife Federation (AWF), an all-volunteer organization founded by Aldo Leopold in 1914 and dedicated to protecting and restoring wildlife habitat in New Mexico.

Bill Zeedyk has been an AWF board member for over three decades, serving as past president and leader of the restoration projects committee. He was one of a handful of key figures who shifted AWF's focus toward ecological restoration in the late 1970s. The group now organizes about eight volunteer restoration projects a year at locations across New Mexico, from the Valles Caldera to the Zuni Mountains to the Rio Mora National Wildlife Refuge.

A key part of getting volunteers to come out (and come back) to restoration projects is visionary leadership, and in this AWF has benefitted tremendously from Bill Zeedyk. Not only has he mentored AWF volunteers in a wide variety of induced meandering riparian restoration techniques, but he also brings an uncanny ability to read the landscape, imagine what it can become and communicate that to others.

Bill first brought AWF volunteers out to Cebolla Canyon in the year 2000. Both authors remember our first impressions of the canyon, feeling overwhelmed by the extent of the damage and pretty hopeless about the prospect of turning this landscape of dusty gramma grass and rabbit brush into a thriving wetland. However, in fairly

©D. Muirhead, 2007

Looking down the main gully cutting through the heart of Cebolla Canyon.

©D. Muirhead, 2006

AWF volunteers build Induced Meandering structures in the gully bottom.

short order, the changes we saw on the land surpassed our expectations, and we began to share in Bill's vision and excitement about how this place might recover. AWF volunteers have eagerly returned to Cebolla Canyon just about every year for the past decade and a half.

RESTORATION TECHNIQUES**

The restoration work at Cebolla Canyon focused on three goals: halt the downcutting of the gullies, expand the wetland habitat, and increase water infiltration and storage in the meadows.

The first restoration project involved constructing a seven-acre fence exclosure around Cebolla Spring, which at that time emptied into a stock pond and lacked any wetland vegetation. This project took place in 1997 and was led by three AWF members: Gene Tatum, BLM range conservationist, Andy Iskra, BLM biologist, and Dale Hall, Habitat Specialist for the New Mexico Department of Game and Fish, who arranged to fund the project with Habitat Stamp funds. Bill assisted in an advisory role.

In 2000, AWF volunteers came out for our first work weekend at Cebolla Canyon, which focused on plugging some of the old irrigation ditches that were draining water from the spring into the main Cebolla Canyon gully. Volunteers also filled in other ditches, gullies and cattle trails downstream from the spring and built restoration structures designed to hold water on the landscape and keep the meadows wetter.

The following year, seeing how well the wetland was recovering inside the original exclosure, Bill and Gene designed a diagonal fence across the valley to give the wetland more room to grow. AWF volunteers built this fence and the BLM installed a cattle guard.

From 2002-2004, AWF volunteers continued to focus on the upper meadows where the gullies were shallow, building numerous one-rock dams, Zuni bowls and media lunas, as well as several "burrito dams" in areas that lacked rocks.

To build a burrito dam, volunteers brought sandbags, filled them with dirt on-site, and lined them up one layer deep, just as we would do with rocks in a one-rock dam. The sandbags were then wrapped in a layer of UV-resistant cloth (the tortilla of the "burrito") to hold them together and keep them from falling apart in the sunlight. To keep elk from damaging the structures, they were topped with downed tree branches. The burrito dams were so successful at capturing sediment and growing vegetation that after a year or two these branches became the only signs of the structures.

From 2005-2008, AWF volunteers worked to arrest the downcutting of the gully in some of its deepest sections, in a reach stretching about a mile and a quarter upstream from the riparian exclosure fence. In this reach, AWF volunteers built dozens of one-rock dams and wicker weirs across the bottom of the channel to slow down the water and capture silt. Volunteers also built a series of picket baffles and vanes to push the water from one side of the gully to the other, creating meanders and knocking down huge piles of sediment to be captured

** For more information about these structures and how to build them, see Bill Zeedyk and Van Clothier's excellent book, *Let the Water Do the Work*, Chelsea Green Publishing, 2014.

©G. Muirhead, 2008

AWF volunteers constructing a burrito dam.

©K.G. Fisher, 2014

Working on a media luna.

©K.G. Fisher, 2010

Picket baffle in the gully bottom.

©D. Muirhead, 2010

Weaving juniper branches into a picket baffle.

by the one-rock dams. As we knocked down the side embankments of the gully, we were also widening the bottom of the channel, giving the water more room to spread out, slow down and seep in. This widening created space for stands of willows and bulrushes, which colonized the area on their own as conditions improved. Harvesting from these pioneers, we planted more of them in and around some of our structures.

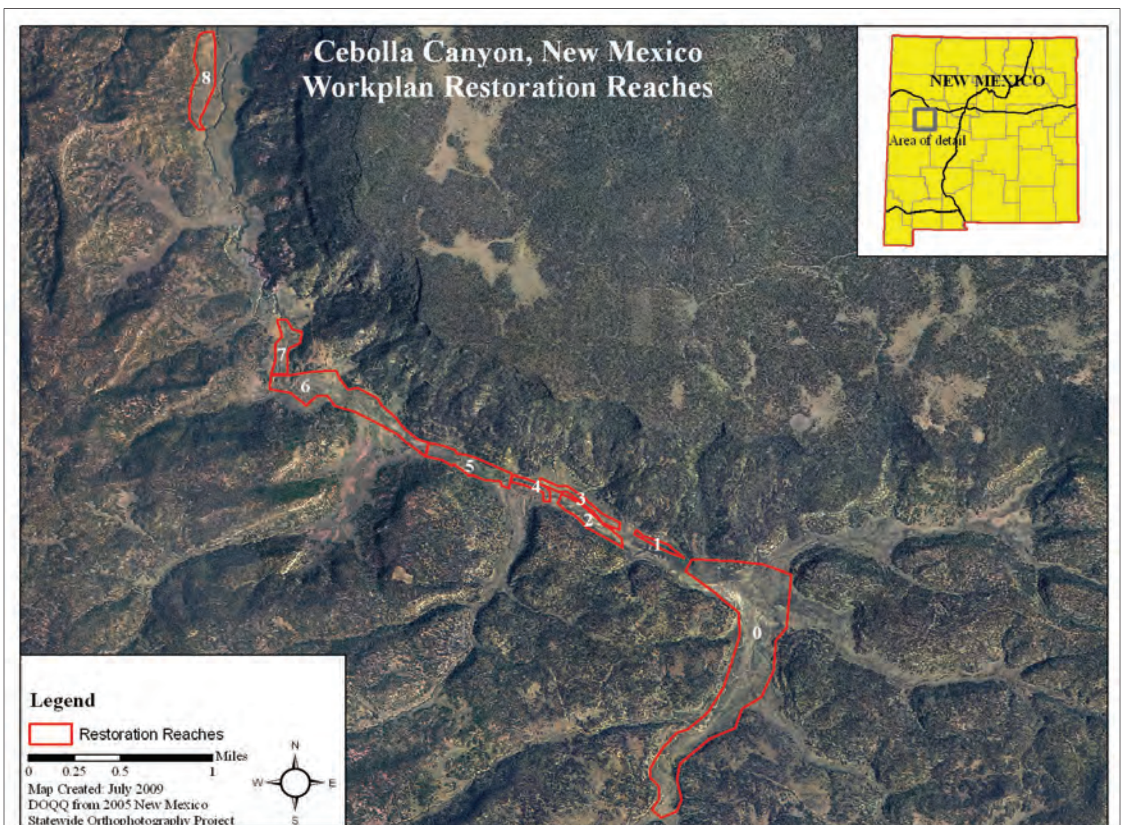
Around 2009, the Rio Puerco Alliance, led by Barbara Johnson, worked with the BLM and the New Mexico Environment Department (NMED) to plan, fund and construct several major restoration projects that built on what the volunteers had accomplished.

Bill divided seven miles of the canyon and its tributaries into nine stream reaches, designing different treatment prescriptions for each reach. He then oversaw the implementation of these treatments, while Matt Schultz of NMED assisted with planning, design, and pretreatment photos; Steve Vrooman performed pretreatment monitoring; Steve Carson of Rangeland Hands, Inc. implemented the treatments; and Craig Sponholtz built many of the restoration structures.

One major project involved realigning sections of the road through the canyon in order to promote wetland recovery, reduce wildlife disturbance and improve access. Bill and Gene aligned the road to remove it from sensitive wetland areas, and the BLM designed and constructed it with federal stimulus funding. In one place, a large rolling dip was installed to return flows that had been captured by the road to their original channel, rewetting about four acres of former wetland.

Bill also designed and oversaw a project to plug a large abandoned irrigation ditch above Cebolla Spring and return about 2,500 feet of Cebolla Creek to its original channel. This filled in a depression that had been nicknamed "Lake Cebolla" because it captured water during the monsoons, and it also raised the bed of the channel about two feet and enabled riparian recovery in that reach.

Finally, Bill designed and supervised the construction of a "Plug and Spread" treatment in a major tributary canyon that successfully rewetted another 12 acres of former wetland that had been drained by an old irrigation ditch.



NMED, 2009

Bill Zeedyk designed different restoration treatments for each of nine reaches in Cebolla Canyon, beginning with the area around the spring in Reach 0.

Although these large projects were built by professional contractors working with machines, volunteer labor played a critical role in making them possible. They were funded by more than $400,000 in state (NMED) and federal (EPA Region 6 Wetland Program Development Grant) grants. Volunteer labor from groups including AWF, Talking Talons and the National Wild Turkey Federation provided the required match for all of these grants.

In addition, because much of Cebolla Canyon is designated as wilderness, there are areas where machines are not permitted and the only option for implementing restoration treatments is to have volunteers build the structures by hand.

THE TRANSFORMATION BEGINS

Since AWF began working at Cebolla Canyon, we have seen the wetland around Cebolla Spring grow from 7 acres to over 40 acres and scattered wetlands return upstream and downstream of the spring. With the wetland vegetation has come a noticeable increase in wetland animal species, particularly migratory birds like the Sora Rail.

The one-rock dams and burrito dams have filled in the shallow gullies in the uppermost meadows, and as of 2014, water flows across the entire meadow during storm events, just as it did a century ago. Through one quarter-mile section of the canyon, the channel has been reconnected with its former floodplain, stretching about 350 feet wide. The juniper trees that had invaded the meadows are beginning to die off as the water table rises, and sedges and bulrushes are returning to the wettest areas.

Downstream there are many more perennial pools, areas where rock restoration structures are keeping the streambed wet most of the year. We have found salamanders in some of those pools, and there are thriving patches of willows and bulrushes in the wettest corners of the canyon.

Throughout Cebolla Canyon, the gully downcutting and headcuts have nearly all been halted, and some are beginning to reverse themselves, collecting sediment and raising channel beds rather than lowering them with each major flow event.

As Bill explains, an ecological system tends to be either degrading or aggrading—either unzipping, as water and soil and species are pulled away, or zipping back up again, as the system returns to health and species diversity improves. Throughout much of Cebolla Canyon, we can see that we have flipped the switch, and a system that was degrading and downcutting is now collecting sediment, holding water and nurturing wetland plant species that were formerly missing or scarce.

LOOKING AHEAD

This year, the BLM is significantly expanding the pipe exclosure fence around the Cebolla Spring wetland and has constructed several more large headcut control structures to protect the upstream meadows. With the wetlands recovering well within the nine treated reaches, we are beginning to plan how to expand our efforts upstream and downstream of those sections, where much work remains to be done in both the main channel and many tributaries.

M. Schultz, NMED, 2011

A cluster of headcuts were moving up the canyon. September 16, 2011.

M. Schultz, NMED, 2011

A large, machine-built Zuni bowl arrests the headcuts and helps retain moisture in the upper meadow. October 6, 2011.

As the wetland continues to expand, one hope is that we might be able to slowly reintroduce some of the animal species that died out when the wetlands vanished. (AWF assisted with the relocation of two nuisance beavers from Zuni Pueblo to Cebolla Canyon in 2007, but unfortunately they only survived a few years.) Animal species that might someday return to Cebolla include muskrats (which create open ponds for waterfowl), voles and meadow mice (which dig tunnels that disperse water, as well as becoming food for raptors), the Townsend's big-eared bat, leopard and western chorus frogs, and even small fish for the perennial pools that are beginning to reappear. Adding these species would amplify the restoration work that has already been done and bring Cebolla Canyon closer to the species diversity it once supported.

The great work of restoring Cebolla Canyon is only beginning. Bill has remarked that it took 70 years for Cebolla Canyon to degrade to the state it was in when we found it in 2000, and it will take another 70 years before it fully returns to a healthy, resilient diverse state. Yet the changes are beginning to happen before our eyes, and in our lifetimes we expect to see many more acres of wetland and wet meadows return to life, creating habitat for animal species once native to this landscape.

AWF volunteers will be returning to Cebolla Canyon in 2016, and we welcome anyone interested in helping us realize this inspiring vision to join us.

Kristina Fisher is vice-president and Michael Scialdone is president of the Albuquerque Wildlife Federation. To see the yearly schedule of volunteer restoration projects and sign up to participate, please visit abq.nmwildlife.org.

©K. G. Fisher, 2010

The gully bottom is widening and grasses and willow stands are thriving.

©G. Muirhead, 2010

Healthy wetland vegetation is returning below Cebolla Spring.

McGraw, NMED, 2014

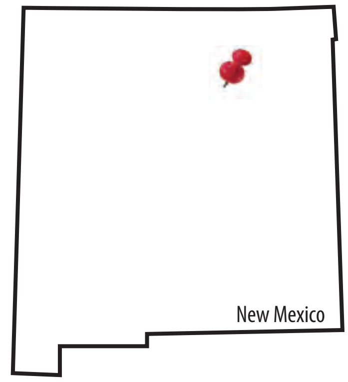
Year by year, the wetland is expanding down Cebolla Canyon.

©B. Nordstrum, 2007

Bill releases beavers from Zuni Pueblo into Cebolla Canyon.

Making Roads Work

by Julia Davis Stafford, CS Ranch, Cimarron, New Mexico



I can say from experience that Bill Zeedyk's innovative approach to ranch road repair, redesign and maintenance works.

Our family ranch, the CS, is located near Cimarron in northeast New Mexico, on terrain that varies from shortgrass prairies through piñon-juniper foothills up to high mountain elevations over 10,000 feet. The main roads into our headquarters are graveled and fairly well maintained, but we also have many miles of dirt and two-track roads that connect more remote areas of the ranch. The rule was that you never drove on roads after a rain. Upkeep of these secondary roads was usually undertaken after a stretch had gotten so bad that some work was essential to keep from getting stuck or damaging a vehicle.

Roads and trails, both vehicle and animal made, are a frequent source of aggravation and expense for anybody who manages land, and we had plenty of "problem spots" to keep us busy—bog holes that formed after every rain, arroyos that fanned out below culverts and multiple side-by-side tracks across a pasture caused by poor drainage. The thing that frustrated me most was that usually the work didn't really solve the problems and we had to keep dealing with the same bad stretches.

Fortunately, in 2004 I attended a Quivira Coalition riparian restoration workshop taught by Bill Zeedyk and learned a new way of thinking about road design, location and maintenance. At the workshop, volunteers pounded in cedar posts to direct the force of a creek away from steep cut banks, planted willow poles, built Zuni bowls and one-rock dams, and reworked a road crossing that had been dumping silt into the stream. All of these were low-tech, low-cost techniques that made good use of human labor and on-site materials.

I loved Bill's approach to restoration: take the time to look at the whole situation and figure out what's causing the problem, and then work with Mother Nature to heal it. Concentrated, fast moving water builds tremendous force that can carve gashes in landscapes, rivers and roads. Bill advised looking upstream and up-gradient. The most efficient way to protect banks, roads and bare ground is to grow a healthy cover of grass and forbs. If you focus on slowing it down, spreading it out and dissipating the gathered energy, water will soak in rather than run off. I left the workshop with a great appreciation for the power of moving water.

Later, at a Quivira Conference, Bill made a presentation on low-maintenance roads, with the intriguing title, "Harvesting Water from Ranch Roads." Again, he began with the need for careful observation before firing up the dozer and hauling in riprap. You want to address the cause, he said, not continue to apply band aids—or tourniquets! His methods focused on working with the lay of the land to locate a road so that it drains properly, preventing channeling and erosion while supporting

Running water is the primary force affecting road condition and generating the need for maintenance (Zeedyk 2006). To make good road design, maintenance and repair decisions, it's important to know "where your water is coming from".... "where the water is going"...."where it should be going"... and "what the water is doing." Photos ©T. Gadzia, 2004

Steve Carson spreading seeds on a disturbed area during the October 2004 workshop.

©T. Gadzia, 2004

Bill discussing the layout of a rolling dip to workshop participants. October 2004.

plant growth, and minimizing the machinery and dollars necessary to maintain the road. I returned home with a new "tool chest" of ideas, along with several of his excellent field manuals on road maintenance to study.

In October 2004, Courtney White and Tamara Gadzia of the Quivira Coalition organized a ranch road workshop on our ranch. Bill arrived several days before the class, accompanied by Steve Carson and his dozer, to locate good teaching sites. We decided on a section of road in the piñon-juniper foothills that was fairly steep with some serious channeling and erosion issues. It was remarkable to watch Bill in action. Driving or walking along the road for the first time, he would identify and mark locations and the treatment needed to address the particular problem. His "eyeball" assessments were invariably borne out by subsequent readings with a level. Steve, a talented equipment operator and fellow water enthusiast, sculpted numerous rolling dips to drain tracks, closed out and relocated a stretch that had cut through the center of a meadow, plugged arroyos and fanned the flow of water into grassy areas to slow it down.

The first questions Bill asked were, "Do you need the road? If yes, is it in the right location?" He went on to say, if possible, locate the road on a slight slope to facilitate drainage. Get the water off the road as often as you can and drain it in places where the water will do some good, growing grass rather than causing erosion. Don't put a road up the middle of a meadow; that breaks the natural flow of water, creates mud holes and channels, and starves the neighboring grasslands of water. His clear principles and the work on the land, once understood and observed, made excellent sense. The ranchers, equipment operators and land managers who attended the workshop considered it a day well spent. The road improvements completed during the workshop are still doing their job, and access to that area of the ranch is greatly improved.

We have continued to work with Steve Carson to improve our ranch roads, applying principles and using techniques he learned through many years of work with Bill. We budget an annual amount for roads and prioritize stretches that need attention. Steve brings up his camper and little dozer and works "till we run out of money," covering miles of road every day. He has put in

©T. Gadzia, 2004

Using a dozer to build a rolling dip. October 2004 workshop.

©J. Davis Stafford

A rolling dip on a CS Ranch road.

©J. Davis Stafford

A sign on the CS Ranch showing the location of a closed road and its new location.

hundreds of rolling dips, closed out several redundant or rarely used roads and relocated stretches that were in difficult places to maintain.

Hilly areas are often easier to work with because slopes provide opportunities to drain water off the road. The most challenging areas are relatively flat prairies; when there is little slope to drain away water, it tends to get caught in the tracks and stay in the road bed. If the drainage is not addressed, over time the road gets "wallowed out" and cut deeper than the surrounding pasture. Then traffic goes around the boggy area, a parallel road is started and the cycle starts over.

We have had good luck taking advantage of any slight slope and extending cut-out ditches far enough that water can be carried away from the road. At first the ditches look a bit rough, but they quickly grow a protective cover of grass. In places where a road is just too deep to fix, we have relocated it, put in rolling dips and cut-out ditches, and plugged and closed the old section.

Colfax County has miles of dirt roads to maintain to the standard of public, higher speed traffic. We have worked with the excellent county maintenance crew to drain public roads through the ranch into grassy areas, taking down stretches of fence while adequate cut–out ditches are bladed in, then repairing the fence. This helps get water off the roads and out of the barrow ditches, and it provides supplemental moisture to grass in the area.

Of course, even the best sited, drained and designed ranch road needs observation and periodic maintenance. Cloudbursts, animal trailing and general vehicle traffic take a toll on rolling dips, and cut-out ditches can silt in overtime and lose their effectiveness. We continue to observe the "don't drive on wet roads" rule and try to keep up with needed maintenance before a road is compromised.

Over the years, our overall network of ranch roads has improved, though we still have miles to go. Thanks to Bill, it is now impossible for me to travel along a ranch road without noticing and obsessing over all the work that needs to be done! We have drained many stretches, relocated some roads and closed others, stabilized stream crossings and reduced erosion. All this has been good for our land and rivers, and has made traveling around the ranch more of a pleasure to boot. We have learned ways to locate and maintain ranch roads that alleviate most recurring maintenance problems and turn them into assets rather than necessary evils. Bill's methods work with the lay of the land and nearby natural materials, leaving roads that, in large part, take care of themselves.

I appreciate this chance to credit Bill for the insight he has given me on roads,


©J. Davis Stafford

A fence that was removed and then replaced so an adequate cut-out ditch could be bladed by county road crews. This helped get water off the road while supplying supplemental moisture to grass on the ranch.

water courses and resource management strategies. His advice to "take time to look at the whole situation, figure out what's causing the problem, stop contributing to the problem and let Nature do the work of healing" has turned out to be sound advice indeed! Our ranch has benefitted and I, along with many others, am a better steward of the land due to his teachings.

Many thanks Bill, for sharing and spreading your knowledge and your experience.

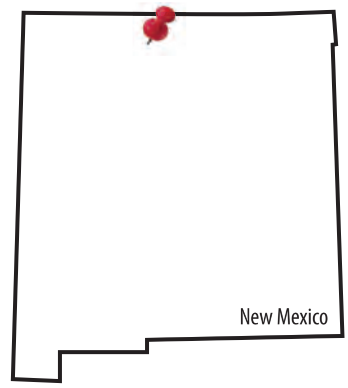
RESOURCES

- LaFayette, R. A., Pruitt, J. R. and Zeedyk, W. D. (1993). *Riparian Area Enhancement Through Road Management.* Proceedings of the International Erosion Control Assoc. 24th Conference. Indianapolis, Indiana.
- Terrene Institute (1994). *Riparian Road Guide: Managing Roads to Enhance Riparian Areas.* The Terrene Institute in cooperation with U.S. Environmental Protection Agency and U.S. Department of Agriculture Forest Service. Washington, D.C.
- Zeedyk, W. D. (1996). *Managing Roads for Wet Meadow Ecosystem Recovery*. US Department of Agriculture, Forest Service Southwestern Region. Tech. Report FHWA-FS=LP-96-016.
- Guenther, Keith (1999). *Low Maintenance Roads for Ranch, Fire & Utilities Access.* Wildland Solutions Field Guide Series. Clyde, CA. *www.wildlandsolutions.com*
- Water/Road Interaction Core Team (2000). *Water/Road Interaction Field Guide.* U.S.D.A Forest Service, San Dimas Technology and Development Center. San Dimas, CA.
- Rocky Mountain Research Station (2002). *Management and Techniques for Riparian Restorations: Roads Field Guide Volumes I and II.* U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. RMR5-CTR-102 Volumes I and II.
- Zeedyk, W. D. (2006). *A Good Road Lies Easy on the Land: Water Harvesting from Low Standard Rural Roads*. Quivira Coalition. Santa Fe, NM. *http://quiviracoalition.org/images/pdfs/1888-A_Good_Road_Lies_Easy_on_the_Land.pdf*

©T. Gadzia, 2004

At the end of the October 2004 workshop, participants gathered with Bill Zeedyk along a wetland drainage road intersection to discuss how and where a two-lane dirt road should cross a wetland to minimize impact while maximizing wetland vegetation growth.

Wetlands Waterfowl Habitat Improvement at Stewart Meadows on the Carson National Forest



by Maryann McGraw, Wetlands Program Coordinator,
New Mexico Environment Department
Surface Water Quality Bureau

The Stewart Meadows Waterfowl Habitat Improvement Project had an important goal: to provide resting and feeding habitat for migratory waterfowl as they make their spring journey along the Central Flyway. The western boundary of the Flyway closely follows the Rio Grande and the Rocky Mountains (Cornell Lab of Ornithology). The majority of birds that use it make direct journeys from winter habitat in the south to breeding grounds in the north. Birds that nest in the northern hemisphere migrate in the spring to find suitable nesting sites, take advantage of rapidly increasing insect populations, and access fish and emerging plants as the ice recedes from frozen waters. As winter approaches and the availability of insects and other food resources drops, the birds move south again. Some species follow customary migratory pathways and preferred stopover locations that provide food supplies critical to the birds' dietary needs and survival.

The overarching long-term plan for the region is to provide adequate sources of much-needed wetlands, with insects, suitable plants and resting habitat along a string of potential stopover sites along this western migratory route.

The Stewart Meadows Waterfowl Habitat Improvement Project is located on the historic floodplain on the Rio San Antonio near Los Pinos, Rio Arriba County. The Rio San Antonio is a tributary to the Rio de los Pinos and is within the Upper Rio Grande Watershed. The project lies within the midst of other important waterfowl wetlands including Lucero Lakes and Ursula Lake (ephemeral wet meadows and marshes), Laguna Larga and associated wetlands (lakes and ephemeral wetlands). Stewart Meadows lies less than forty miles from the Monte Vista National Wildlife Refuge that was created to enhance the survival and productivity of waterfowl within the Rio Grande Valley. Although the National Refuge provides protection for an important series of wetland habitats, there are potential disease hazards associated with relatively large concentrations of waterfowl. The development of a widely distributed system of wetland habitats effectively disperses waterfowl over a larger area, resulting in healthier waterfowl, shorebird and passerine populations, as well as decreased predation and improved nesting success.

Stewart Meadows was acquired by the Carson National Forest (CNF) with Land and Water Conservation Funds in 1973, and all property immediately adjoining the project area is National Forest System lands. The

M. McGraw, NMED, 2008

Bill Zeedyk standing in sheet flow on Stewart Meadows.

previous owners of the Stewart Meadows property drained and leveled the land for irrigated agriculture to grow hay for their ranching operation. In the vicinity of Stewart Meadows, the Rio San Antonio is incised and rarely overbanks onto the floodplain as it did in the past. In addition, eroding arroyos entering Stewart Meadows through adjacent culverts headcut through the floodplain lowering the local water table. Old meander scars across the floodplain were dry pasture and portions of the meadows were dominated by upland

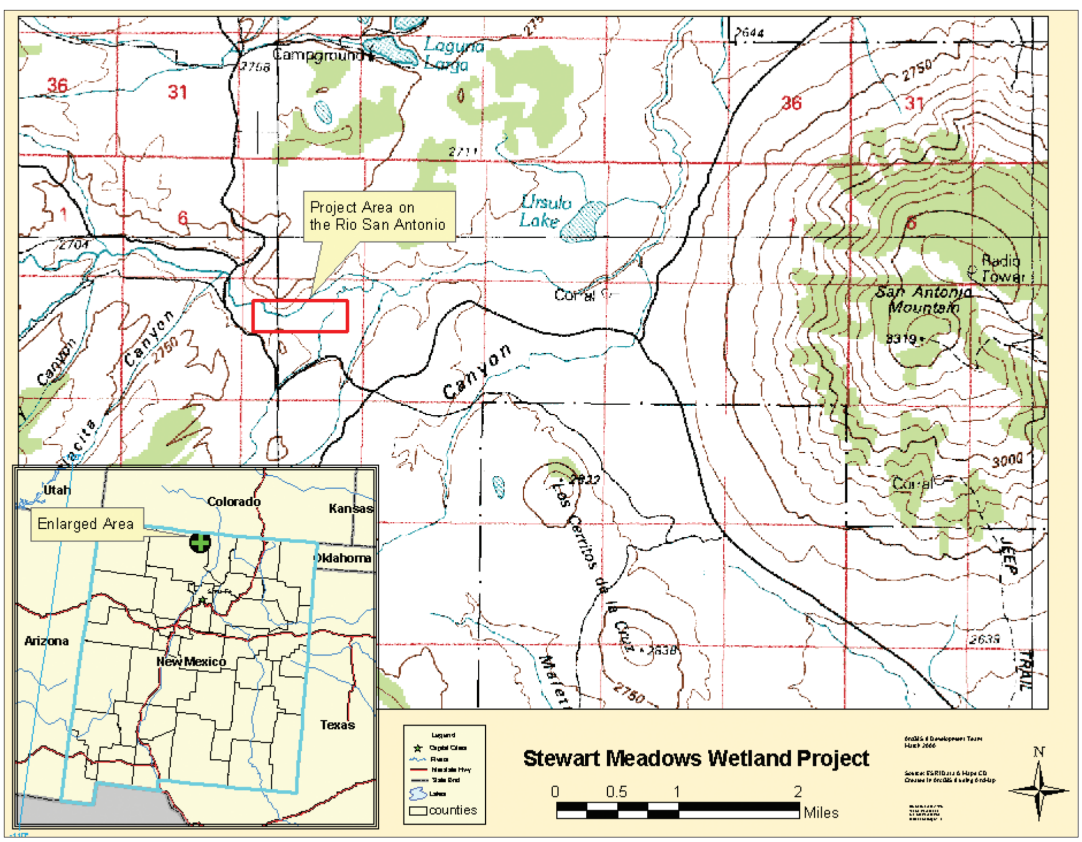
©S. Carson, 2009

A series of old meander scars were enhanced to restore meander flow in the middle meadow.

and cultivated plants rather than natural riparian and wetland species.

At the time of project planning, restoring the Rio San Antonio to access the floodplain was too costly for this relatively large river system. On the other hand, the nearly flat terrain and irrigation ditches presented an ideal opportunity for the development of shallow water wetlands, for restoring flow through side channels, sheet flow and old meander scars, and for creating a diverse habitat that fit the bill for waterfowl migration, feeding and breeding.

Originally, the goal of this project was to construct an impoundment dike to create a 25-acre pond for waterfowl. However after review of the project area with waterfowl habitat specialists, including the late John Taylor, USFWS's Bosque del Apache Wildlife Refuge Manager, and Dr. Leigh Frederickson of the University of Missouri, the goal was reformulated to develop much needed moist soil habitat within 300 available acres of the 350 total acres of the project site. The idea was that moist soil supports the macroinvertebrate and



©B. Skinner, 2003

Project location map.

plant community that provides the correct protein for waterfowl dietary needs.

In 2008, with the insight of Ben Romero, District Ranger at the time, the Carson National Forest hired Steve Carson, Bill Zeedyk and Van Clothier. This team came up with an inventive design to fulfill the goal of creating a moist soil regime. Bill commented that the light snow at the wetland site was a blessing and a curse. It was cold, but the snow highlighted the highs and lows of the terrain, which helped formulate the design to flow water across the floodplain and to fill small pothole wetlands. Numerous measurements across the landscape were made to confirm the ideas the team had for the movement of water to achieve the design goals. Highlights of the construction design included:

- Improve the ditch system so that water can be diverted to the whole area.
- Create shallow connected potholes to help water move around and wet the whole area. Potholes would also improve forage areas for waterfowl and allow for standing water further into the summer season.
- Re-contour arroyo outlets to the wetlands in order to direct run-off to the meadows and allow sediment to settle.

The final design, which includes approximately 300 acres of diverse moist soil foraging habitat, complements the already existing pond at the Stewart Meadows site, creating a diversity of habitat for waterfowl and other wildlife species to utilize. Thirty small wetland depressions were created that improved macro-topographic complexity and microhabitats. The delivery system of water to the Rio San Antonio floodplain was improved which also improved infiltration along the floodplain. Restoration of two culvert outlets more successfully re-wet Stewart Meadows and reduced downcutting and erosion within the floodplain. A system of flow splitters was installed to more successfully control water flow across the Stewart Meadows project area.

M. McGraw, NMED, 2009

Potentilla and Water Smartweek (*Persicaria amphibia*) in Stewart Meadows. Plant identification by Jim McGrath

M. McGraw, NMED, 2008

Bill Zeedyk and Van Clothier making measurements for a preliminary design at Stewart Meadows.

©S. Carson, 2009

Water is delivered to Stewart Meadows by an existing ditch system which was eroded, inefficient and threatened by recapture by the Rio San Antonio. The design included ditch cleaning and reshaping, and berm reinforcement so that water could be efficiently delivered to the upstream meadow.

The final construction included the removal of internal fences that created barriers for wildlife and the installation of a high water fence to keep cattle out of the project area. These improvements were completed by staff of the Tres Piedras Ranger District. As an educational activity and community service, plantings along the Rio San Antonio banks which help bank stability and Southwestern Willow flycatcher habitat, were installed by students from nearby schools at Ojo Caliente, Taos, Taos Pueblo and Questa.

In 2009, a volunteer work weekend was conducted at Stewart Meadows in honor of the 100th anniversary of Aldo Leopold's arrival in the Southwest as an employee of the new U.S. Forest Service. Over 40 volunteers organized by the CNF and Albuquerque Wildlife Federation helped with the completion of the installation of 25 structures that Bill designed to improve the drainage from culvert #4, which was downcutting and dewatering the Stewart Meadows area. The weekend's activities also included a tour of the nearby house where Aldo Leopold lived when he worked for the CNF, an evening of stories from the Sand County Almanac and a botanical walk lead by Jim McGrath (who conducted the botanical inventory for the project).

This project is an important demonstration of careful reading of the land to design a system to support a diversity of habitat needed by migrating waterfowl and other wildlife, including marsh, wet meadow, riparian shrublands, side channels and small pothole ponds. The re-creation of moist soil habitat on abandoned floodplain required consideration of flow over every part of the 300-acre site, which in turn required a keen sense of water movement and local hydrology to "let the water do the work."

Stewart Meadows is located in a sparsely populated part of the state surrounded by public land. The Stewart Meadows wetland site is a landmark for students from local communities to learn about wetland ecology and help with restoration measures so that they can become more connected with the region and the landscape that they call their home. The project was successful in completing one more bead in the necklace of wetlands that serve the thousands of waterfowl that winter in New Mexico and in regions further south.

This project was funded by an EPA Region 6 Wetland Program Development Grant, awarded to the New Mexico Environment Department Wetlands Program for the development and demonstration of innovative wetland restoration techniques.

©S. Carson, 2009

Flow splitters were sized, sited and carefully constructed to send flow from the upstream meadow to the middle meadow.

©S. Carson, 2009

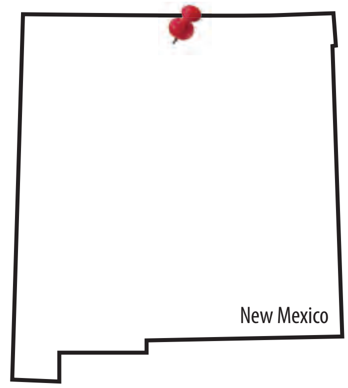
Boards indicate where 3 flow splitters distribute flow to fill pothole wetlands. Boards can be inserted to reduce flow in one splitter and send more flow to other open splitters.

M. McGraw, NMED, 2009

Rock Rundown constructed by volunteers at Arroyo #4. Steve Carson moved the rock materials to the sites for the work weekend. Bill provided on-site guidance to the volunteer crews.

The Miracle of Comanche Creek Sedges

by Bill Zeedyk



The following was written for the August 1994 edition of *New Mexico Fishing Monthly.* Below is a reprint of that article.

Some miracles happen in a moment. Others take longer. The miracle of Comanche Creek has been ongoing since 1982, and it's not over yet.

Sedges are the miracle workers of this creek. Sedges are robust, grass-like plants with stiff, three-cornered leaves that grow in moist soils along the edges of creeks and in wet meadows. Sedges have magical powers because they can heal wounded trout streams.

Comanche Creek is a cutthroat trout stream on the Valle Vidal Unit, Carson National Forest in northern New Mexico. It's a tributary of the Rio Costilla. Today, Comanche Creek teems with scrappy cutthroats, but only a few years ago trout were few and far between. The creek had been severely damaged by a century of overgrazing, subsistence farming, logging and too many roads.

Today it is recovering, thanks to the healing power of sedge and some tender loving care. By implementing a proper grazing system, obliterating roads and controlling off-road vehicles, resource managers have provided the right conditions for sedges to do their thing. The result is a living miracle.

When the Forest Service acquired the Valle Vidal by donation from the Pennzoil Corporation, the area's streams showed all the marks of long-sustained overgrazing, a pattern of use that began long before Pennzoil itself had acquired the land.

Typically, overgrazed meadow streams are wide, shallow and braided with many riffles and few pools.

©T. Gadzia, 2010

Sedges line the bank of Comanche Creek—the perfect place for Rio Grande cutthroat trout.

Stream banks are raw and eroded and lack undercut pockets where trout can hide. In-stream vegetation is scarce or absent. Water temperatures get too warm for trout in summer, too cold in winter. Anchor ice freezes from the bottom up. Gravel bars are clogged with mud.

In contrast, healthy meadow streams are deep and narrow, displaying a typical hour-glass shape wider at the bottom than at the surface. Stream banks are well vegetated and stable with numerous overhanging reaches. Riffles and pools are roughly equal in number, area, and distribution. Water temperatures stay cool in summer, warm in winter. Winter snows roof and insulate the creek. Anchor ice is rare. Stream gravel is clean, loose and free of mud.

Sedges can mend overgrazed meadow streams, given the chance. They can even do it in the presence of moderate livestock grazing, if the grazing use is properly managed and controlled.

The seeds of sedges sprout, take root and grow on sand bars at the water's edge in mountain streams. These plants grow rapidly and their roots spread quickly through the loose, moist sediments of the sand bar. While the sedges are growing, water levels rise and fall with each rainstorm. Particles of silt and sand, bits of grass, leaves and twigs wash downstream to become trapped among the still, upright leaves of the sedge plants.

These trapped sediments gradually get deeper, raising the surface of the sand bar higher and higher above the stream itself, and building the stream bank in the process. The stream narrows and deepens. Meander bends develop with a rhythmic pattern curving left to right, right to left, back and forth across the meadow. Braided stream sections disappear altogether.

Unlike upland plants, such as bluegrass, sedges have the power to grow up through accumulating layers of sediment, developing new layers of roots as the soil deepens. These new roots bind the soil particles together, holding the stream banks in place with sufficient strength to resist the erosive gouging of spring runoff.

Finally, as the banks rise higher, the deeper older layers of roots weaken and die. The force of flowing water cuts away at the base of the bank, eating out pockets where trout take cover from predators.

The key to successful stream recovery is in growing tall, dense and vigorous stands of sedge plants. If grazed too closely, sedges do not develop sufficient height to trap and hold sediments. Their roots don't develop enough strength to bind the soil together and resist storm flows.

So, the answer is in managing the grazing pressure correctly. The number of cows, when and how long they stay on site, and how much time passes before they return again are the key concerns. The objective is to leave the sedges tall, dense, and vigorous at the end of the summer's growing season.

One solution is to simply remove the cows altogether. Fence out the riparian zone and allow no grazing at all. Let the sedges grow undisturbed. Easy.

But cattle grazing is an important industry in Northern New Mexico. Cattle grazing keeps folks working, pays the bills, sends the kids to school and keeps the land in open space. Systems and methods of grazing are needed that can bring about habitat recovery in the presence of periodic livestock grazing. Under such a system everyone would benefit, including fishermen.

©T. Gadzia, 2010

Cattle grazing the uplands within the Comanche Creek watershed.

©A. C. Anderson Sponholtz, 2009

The confluence of Costilla and Comanche creeks.

A special grazing management plan was developed for the Valle Vidal with the goal of restoring its meadows and streams to good ecological health and vigor while sustaining some livestock use. Basically, where 2,000 head of cattle had grazed before, now just 600 were permitted. The land was fenced and cross-fenced into eight separate pastures, four east of the Rock Wall and four west.

When the cattle arrive each spring, they first graze east of the Wall, staying about 20 days in each of three pastures. Each year a different pasture is totally rested with no grazing at all that year.

In mid-July the cattle are moved to higher elevation lands west of the Rock Wall and the process is repeated. Three of the four pastures are grazed for 20-30 days each and a different one is rested each year. By mid-September the cattle are removed from the area altogether. There are other aspects to the system, but the pattern and frequency of moves is the basic principle permitting recovery of the sedges.

Under the system now used, the sedge plants are not hedged to ground level year after year. They regain much of their height and vigor after the cows are moved along to the next pasture.

The residual stubble of ungrazed grasses and sedges forms a thatch that covers the land through the winter. It slows the spring runoff during snowmelt. This cover mulches the soil, prevents frost heave, traps sediment particles and lets the water seep slowly into the soil where it restores the water table. Overhanging mats of sedge protect the stream banks from the spring torrent and prevent ice flows from gouging the banks.

Encroaching sedge plants sometimes pinch opposite sides of a stream channel through the riffle area. The riffle narrows and gradually becomes a run or a glide, with little turbulence. Eventually, some glides become pools, especially on the outside curve of a stream meander. Cutthroat trout move easily from the cover of such pools to feeding grounds in the runs and riffles.

There are many more trout in Comanche Creek now than there were in 1982. Because the range was recovered, the Forest Service has gradually increased the number of cows permitted to graze there each year. Eventually the upper limit will be reached where further increases would jeopardize the fishery.

©C. White, 2005

Sedges on river-left provide a nice place to hide for the Rio Grande cutthroat trout.

Comanche Creek has about 8 miles of fishable trout waters above its confluence with Rio Costilla. Four miles are easily accessible from Forest Road 1950; the rest is walk-in only.

I find it easy to fish a narrow, meadow stream, like Comanche Creek, by casting and moving slowly downstream. I let the current wash my fly under an overhanging bank. I don't need to worry much about natural drift. I just get the fly to the fish with as little commotion as possible. I walk softly and try to stay concealed.

Reading the water helps me catch fish. The pattern of pool, glide, riffle, pool is repetitive in a meadow stream like Comanche Creek. Reading the water is easy to do.

Usually, the biggest trout will be lurking next to the first overhanging sedge clump downstream from the turbulence at the head of the pool. That is about ten to twenty feet down. I cast my fly to the head of the pool and let it drift by the first big clump of sedge. Bang! He's on.

During late evening or early morning hours, cutthroats are quite active. At these times, the runs, glides and riffles may produce good fish if overhanging banks and pools provide nearby cover.

The Valle Vidal has set the stage for the recovery of not only Comanche Creek but also Middle Ponil Creek and Rio Costilla. That's part of the story. Concurrently with changes in land use, the New Mexico Department of Game and Fish changed the fishing regulations. That's the rest of the story. Creel limits went from eight per day to two per day, to catch and release. As a result, there has been an increase in the average size of fish as well as numbers of fish.

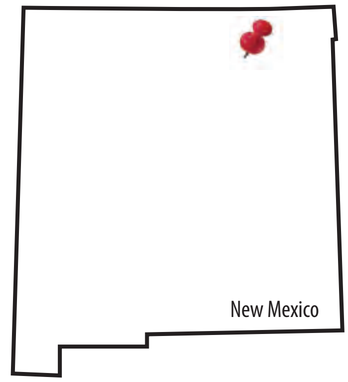
Comanche Creek really is a miracle. The miracle is the direct result of professional managers applying the best technology to on-the-ground practice, cooperation of conscientious livestock operators and the good will of the public.

Yes, the sedge, that tough little plant at the water's edge. Give it a little time. Let it do its thing. It heals wounded trout streams.

Catch and release fly fishing on Comanche Creek.

©D. Einspahr, 2010

A small Rio Grande cutthroat trout—caught and released!



Raising a River—
Restoration of the Dry Cimarron

Quivira Coalition Staff

"The difficulty lies not in new ideas, but in escaping the old ones." —John Maynard Keynes

Rivers like to meander—among other attributes it's their way of dissipating energy in a watershed. A river's natural meander pattern and functioning floodplain — its hydrology, morphology and ecology—are important indicators of a healthy riparian ecosystem. Intentionally cutting off meanders to protect or enhance the surrounding landscape (in order to save farmland from erosion, for example) leads to channelization, soil loss, dehydrated banks, and changes in the diversity and quantity of plants and animals supported by the system. This was the fate of a stretch (called a reach) of the perennial Dry Cimarron river that runs through the property of Rainbow Ranch, 35 miles east of Raton, New Mexico. Headwaters of the Dry Cimarron begin in Colfax County and flow east across the Oklahoma border as part of the Canadian River watershed.

A BRIEF HISTORY: WHY THE LAND BECAME DEGRADED

When trying to restore degrading systems on private land, more often than not, implementation is the easy part. Harder is the decision to try something new in the first place; even more difficult sometimes is getting family and interested parties to agree.

Rainbow Ranch is owned by the Williams family and during the summer of 2001, daughter Sunny Hill returned home to manage the property. But she faced a serious dilemma: in an attempt to save his farm from floods and erosion, her father, Jack Williams, had built an earthen dam across the river without permits or permission. The permitting agency for this type of activity, the U.S. Army Corps of Engineers (USACE), as well as various state agencies, had ordered the dam's removal. This upset Mr. Williams, who saw it as an affront. Sunny, however, saw it as an opportunity to begin restoring the four mile section of the Dry Cimarron that flows through their property to ecological health.

Sunny understood, as did her father, that the river was in trouble. The river had become entrenched along almost its entire length, up to 25 feet in places, and was threatening to go deeper. Its unstable condition threatened not only their farm operation but also the bridge that the family had built across the river in order to reach their homes. In fact, it was the concern for the bridge that had caused Jack to build the dam in the first place.

©C. White, 2007

Sunny Hill and Olivia White enjoying time exploring the Dry Cimarron, August 2007.

Mr. Williams had tried other mitigation strategies over the years, including straightening the river (by cutting off meanders with a backhoe) and installing tire dumps at key erosion sites. He had also unintentionally damaged the riparian zone with year-round grazing by domestic livestock, which contributed to the erosion situation.

Sunny did not blame her father; she knew that he was responding to the crisis with traditional remedies. Nevertheless, his actions had exacerbated the river's ills. Straightening the river, for example, caused it to become more

©S. Hill

Jack and Mildred Williams (circa 1980's).

deeply entrenched with each flood.

In a conversation with the Quivira Coalition's then executive director, Courtney White, she said, "He did his best with the knowledge he had at the time. He meant well, but I suspected there had to be another way."

Fortuitously, the New Mexico Environment Department, Surface Water Quality Bureau (NMED-SWQB) had recently analyzed several reaches of the Dry Cimarron east of Rainbow Ranch and listed the river under the Clean Water Act as impaired for temperature, pH, dissolved solids, stream bottom deposits and ammonia. As part of the 2000-2002 State of New Mexico 303(d) List for Assessed Stream and River Reaches it was given a priority 4 (top) rating.

Sunny had heard about the Quivira Coalition and the ideas of progressive grazing management and watershed restoration that Quivira advocated. She approached the organization, wanting to know if Quivira could help her save the ranch, which was struggling ecologically and economically. We eagerly agreed.

In 2002, in partnership with Rainbow Ranch, the Quivira Coalition submitted and received an Environmental Protection Agency (EPA) Clean Water Act Section 319 (h) Water Quality grant to implement riparian restoration treatments pioneered by Bill Zeedyk on the Dry Cimarron along the property's East-end and West-end reaches (divided by a bridge and low-water crossing). In 2009, Quivira received a New Mexico River Ecosystem Restoration Initative Grant to reinstate three cut-off meanders along a segment of the West-end reach. These grants were administered through the New Mexico Environment Department, Surface Water Quality Bureau and by Rainbow Ranch, Inc. Additional and matching funds were provided by the Quivira Coalition, Rainbow Ranch and workshop volunteers.

RESTORATION GOALS

The overarching restoration goal was to return the river's channel and its riparian ecosystem to a productive, stable and resilient state. Specific goals included:

- Reconnecting cut-off meanders with the river's natural channel alignment in order to increase channel length and sinuosity
- Stopping channel entrenchment and gully formation
- Raising the river's bed level
- Revegetating eroding banks

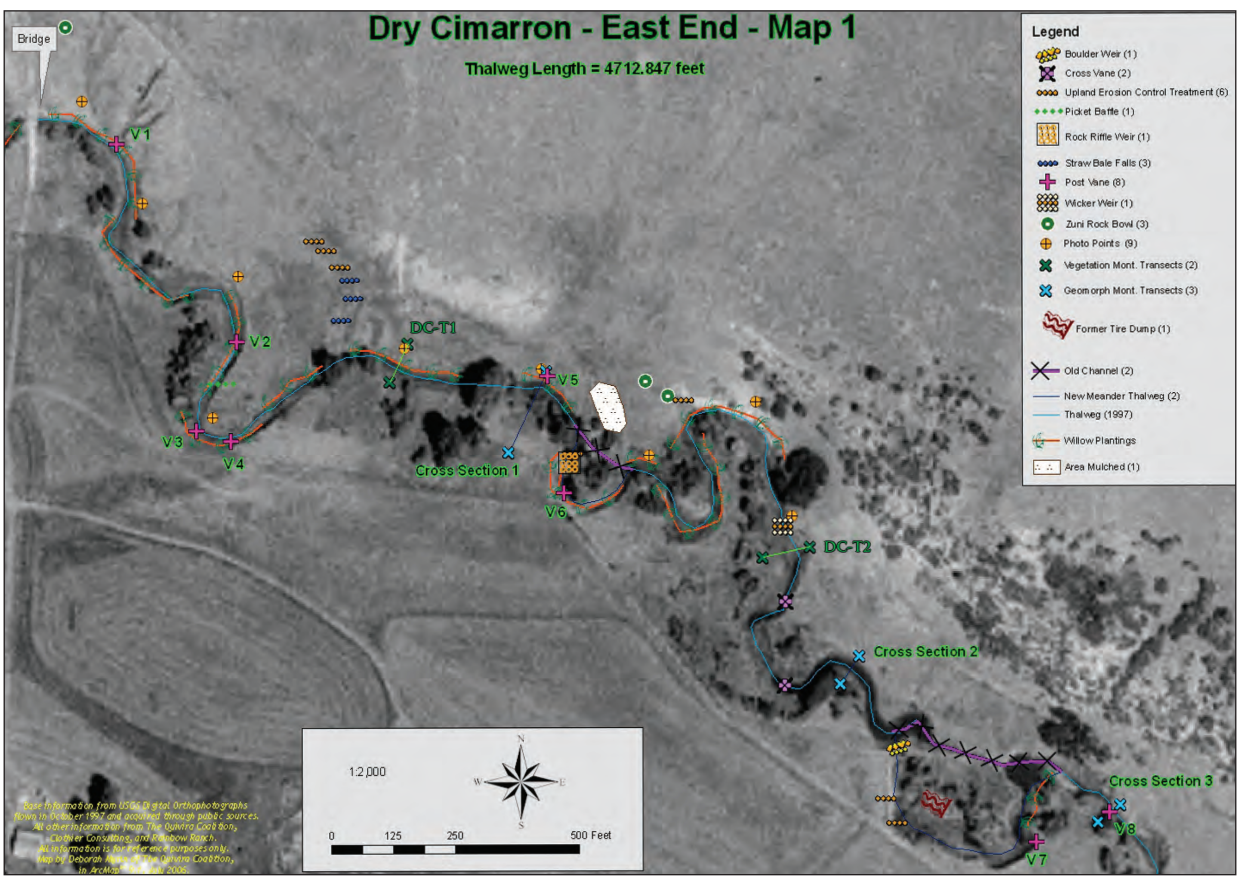
Photos show degrading features in the Dry Cimarron River—headcuts, channel incision, bank erosion and loss of riparian vegetation.

- Decreasing sediment inputs
- Improving water quality

The Quivira Coalition had recently met Bill Zeedyk on another project and began working to implement his innovative, low-cost treatments on Comanche Creek in the Valle Vidal Unit of the Carson National Forest. We realized that Induced Meandering and structures such as one-rock dams, wicker weirs, post vanes, baffles, Zuni bowls and porous-fill road crossings—which worked on Comanche Creek to heal incised stream channels, halt migrating headcuts and stabilize and restore degraded wetlands—would be a perfect fit for the Dry Cimarron restoration project.

The project began with riparian, rangeland and cultural assessments, followed by development of appropriate restoration treatments, designed by Bill Zeedyk, Steve Carson and Craig Sponholtz. Permits (404/401) were obtained from the U.S. Army Corps of Engineers and the New Mexico Environment Department. Archeological surveys were completed and clearances were approved by the State of New Mexico's Historic Preservation Division. Monitoring and survey activities included:

- A Project Quality Assurance Plan (PQAP), submitted in March 2003 and approved in August 2003; amended in November 2003
- Rangeland health assessment in 2003
- Nine photo points established in 2003 on the East-end reach and 26 in 2010 along the West-end reach; photo points retaken annually in most years, ending in 2014
- Rosgen Level I and II geomorphology baseline surveys (cross-section, longitudinal profil and pebble counts) on the East-end reach in 2003, level II repeated in 2005; baseline survey for the West-end reach in May 2010, level II partially repeated in October 2014
- Riparian vegetation baseline surveys on the East-end in 2004, repeated 2006; baseline West-end reach surveys in October 2009, with follow-up readings in May 2012



The Dry Cimarron East-end project map showing the location of treatments, structures, photo-monitoring points, vegetation and geomorphology cross sections, and beaver dams. Map produced by Deborah Myrin-Bertagnolli using ARC-GIS.

- Baseline fall/spring bird surveys in 2002 along the East-end reach, repeated twice annually 2003-2005; baseline surveys on the West-end 2010/2011, with follow-up 2011/2012
- Fishery assessment by the New Mexico Department of Game and Fish on June 11, 2008
- GPS coordinates for each treatment area, structure, photo point, geomorphology transect, vegetation transect and survey, recorded and data mapped using ARC GIS mapping software

TREATMENT IMPLEMENTATION

First, a new livestock grazing plan was developed and electric fencing installed that allowed for dormant season (winter) use in riparian pastures along the river. Over the course of the project, six original meanders were reinstated, one concrete irrigation plug was reconstructed as a filter weir, one low-water crossing was re-designed and lowered, and a tire dump was removed from a cut-off meander in the East-end. Volunteers implemented handbuilt treatments during public workshops. Eroding stream banks were revegetated with willow cuttings from a healthy stock located on the far eastern end of the ranch. Vane structures were installed in strategic locations to move the river's thalweg (the deepest part of the channel) away from eroding stream banks, and the channel bed was stabilized using one-rock dams and wicker weirs. Sediment sources from upland sites and eroding side gullies were controlled using one-rock dams, straw bale falls and rock bowls, and disturbed areas were reseeded. These treatments were implemented during five hands-on, volunteer workshops (approximately 100 volunteers totaling approximately 1,379 hours) and by five sub-contractors (approximately 308 hours).

This had been the easy part.

WORKING WITH THE FAMILY

During the course of the project, Sunny Hill struggled to get her father to understand that these ideas—and all this work—were not meant as a criticism of his management of the farm for so many years. However, despite his tacit approval of the project, Jack Williams never embraced the goals or methods. As a result, emotional tensions in the family remained taut.

GOALS – TREATMENTS – STRUCTURES

Reconnect historic meanders with the river's channel, stop channel incision and gully formation, raise the river's bed level

Treatments:
- 6 meander cut-offs reinstated
- 2 cross vanes
- 11 boulder/rock/wicker weirs
- 1 concrete crossing decommissioned
- Induced Meandering

Decrease sediment loading, improve water quality

Treatments for upland erosion sites:
- 3 rock bowls
- 2 one-rock dams
- 1 straw bale dam
- 1 sand bag dam
- 1 (3-tiered) straw bale falls
- 6 rock headcut control structures
- 1 tire dump removed
- 1 low-water crossing re-configured

Increase riparian vegetation, stabilize eroding banks

Treatment:
- 35,383 feet of riparian pasture electric fencing installed
- 5,000 willow cuttings planted along 4,338 feet. of streambank
- 16 post vanes
- 2 boulder vanes
- 3 picket baffles

In this way the Williams family represents a common dynamic in the West today, as the younger generation takes over from their parents with new ideas and goals. While the methodology, scientific underpinnings and implementation of riparian restoration are relatively straightforward, the inner workings of families and the tension that sometimes exists within them, often pose the greatest challenges to the long-term success of a project. Halfway through the Rainbow Ranch project, Jack Williams confided to Bill Zeedyk, "I know you're doing the right thing. I just can't go look at it."

In the end, through our combined efforts, a stretch of damaged river has been healed. It is our hope that this healing process has extended to the family that owns the land as well.

RESULTS

Of all the treatments implemented on the Dry Cimarron, reinstating the cut-off meanders provided the most resilient hydrologic and ecologic benefit to the river, with substantial economic benefits to the ranch. The following (pages 26-29) maps, graphics and photos of a West-end meander reinstatement provide an example of the complexity, work and dramatic result of returning meanders to a river and adding sinuosity to its pattern.

The cut-off channel for the meander was 138 feet long, and the reinstated channel is 393 feet long. The

©M. Bain, 2011

Installing bounder vanes on West-end reinstated meander #1. May 15, 2011.

© A.C. Anderson Sponholtz, 2009

Volunteers build a post vane during the June 2009 workshop.

© A.C. Anderson Sponholtz, 2009

Craig Sponholtz leads a discussion on the benefit and construction of rock erosion control structures during the June 2009 volunteer workshop.

©T. Gadzia, 2005

Bill Zeedyk standing in a sea of vegetation on the Dry Cimarron during the October 2005 workshop.

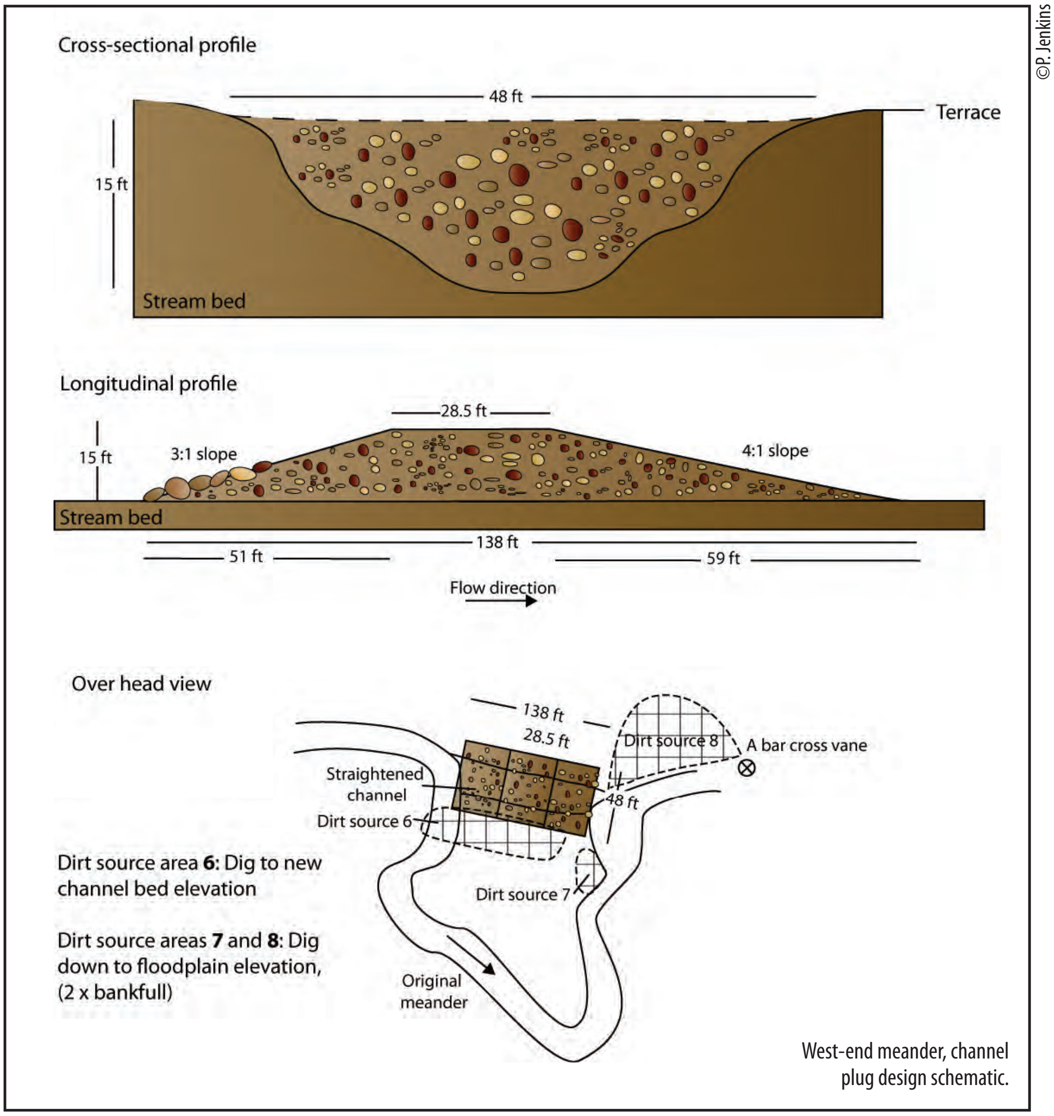
©T. Gadzia, 2005

October 2005 workshop volunteers admire the amount and diversity of riparian vegetation on the restored reach of the Dry Cimarron.

reinstatement produced a net gain of 255 feet of channel length, plus a small wetland/backwater area on the downstream side of the new plug in the cut-off channel.

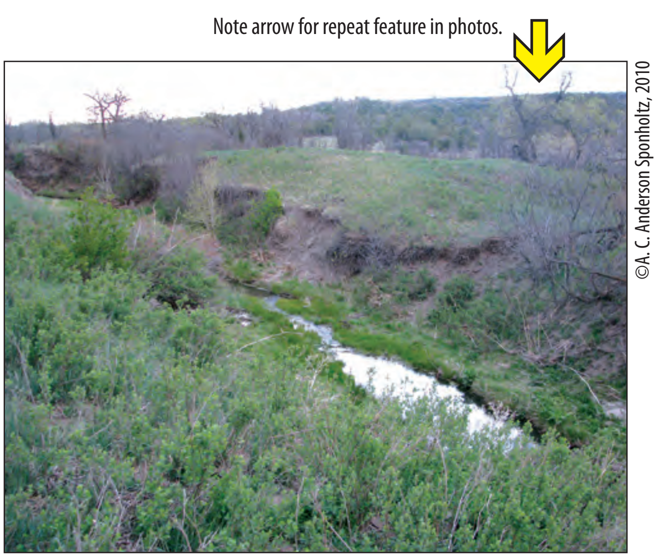
The overarching restoration goal was to return the river's channel and its riparian ecosystem to a productive, stable and resilient state—**GOAL ACHIEVED**. By the end of the project in 2013, 18,480 feet of river benefited from treatments that:

- Increased the channel length by 1,300 feet
- Reduced the river's sediment load caused by bank and upland erosion
- Increased riparian and aquatic vegetation, stabilizing eroding banks
- Created a net gain of 2 acres of wetland
- Narrowed the channel width
- Raised the river bed elevation in some locations while eliminating further downcutting throughout
- Increased the number of beaver dams from 1 to 26

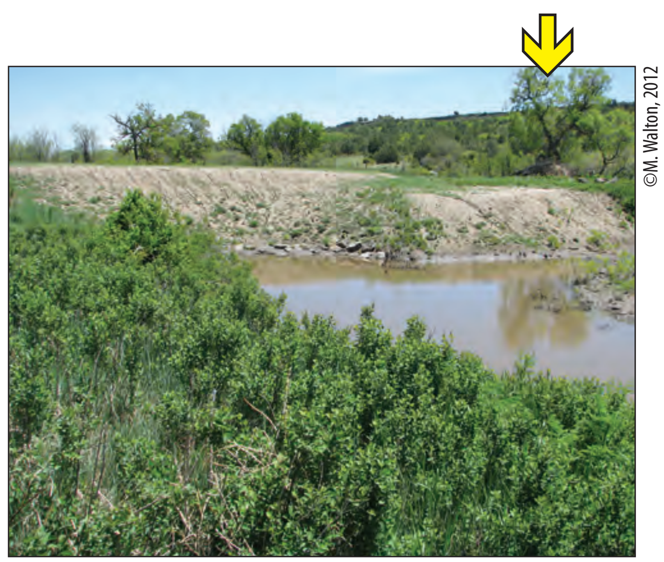


West-end meander, channel plug design schematic.

Note arrow for repeat feature in photos.

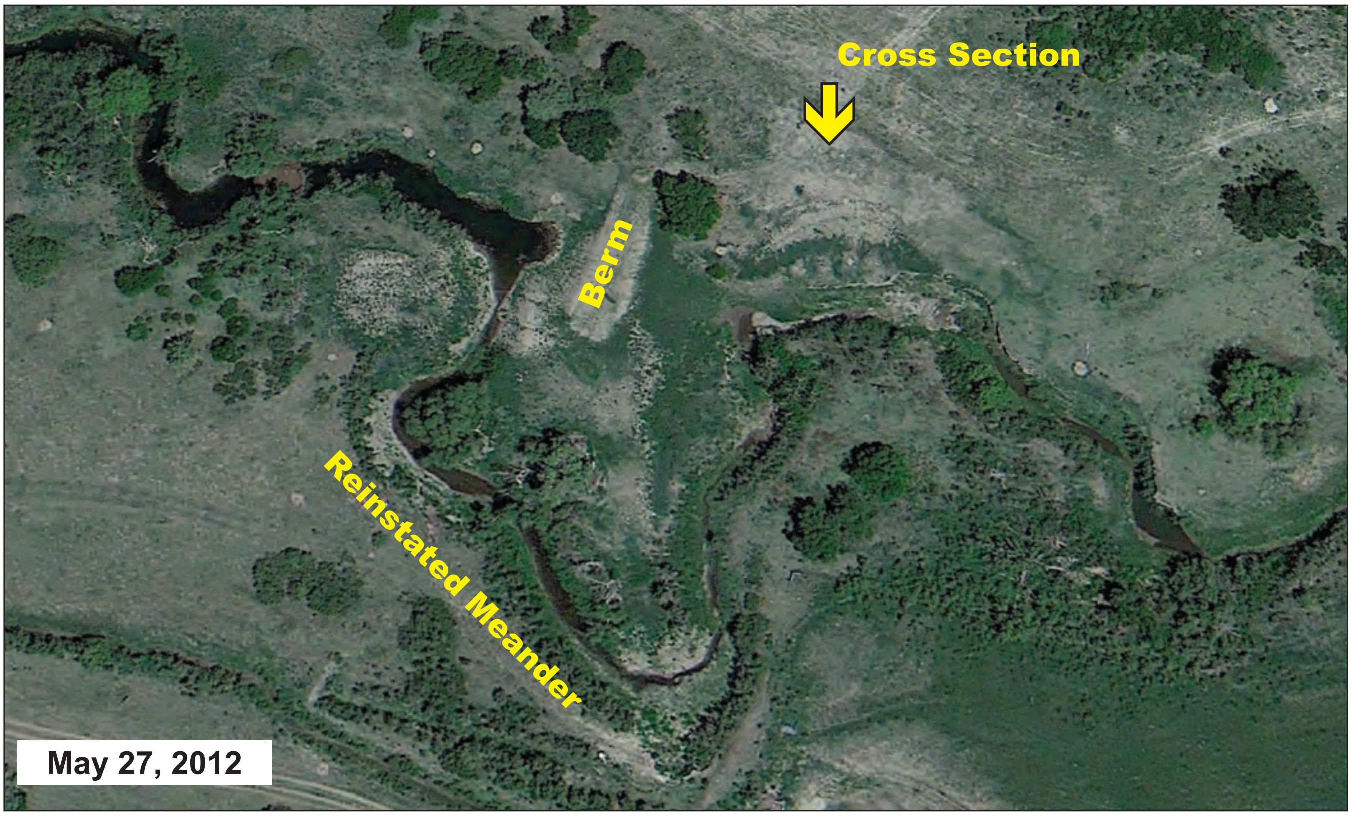


Channel plug, pre-treatment, May 13, 2010.

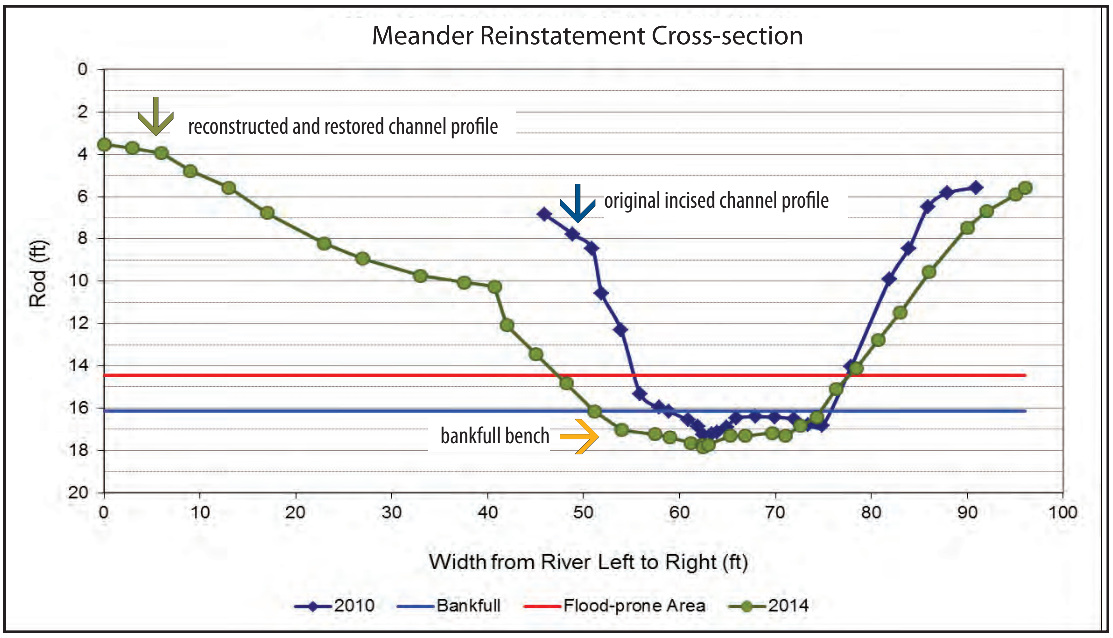


Channel plug, post-treatment, May 15, 2012.

West-end Meander Reinstatement Google™ Earth Documentation



Google™ Earth is an excellent tool for pre-project design and post-project assessment.



Example of a meander re-instatement on the Dry Cimarron River. Cross-section (left) and photos (below) show construction and re-vegetation of bankfull bench with improving channel geomorphology.

©A. C. Anderson Sponholtz, 2010

Pre-treatment, May 13, 2010.

©M. Bain, 2011

Post-treatment, June 3, 2011.

©T. Gadzia, 2014

Post-treatment, October 7, 2014.

All successful stream restoration projects have a monitoring component. Monitoring should address channel morphology, hydrology, ecology and structure performance. Project monitoring is not research; it is an essential step in assessing project success. It is how restorationists track progress toward reaching their goals. Monitoring also provides guidance for making adjustments in a timely fashion when the treated reach is not responding as planned. It is always wise to budget ahead and incorporate future monitoring and maintenance costs into project planning (Zeedyk and Clothier, 2009).

Also, projects often occur in too short a timeframe to detect significant long-term results. While some changes can be visually observed in the immediate time frame of a project, like increase in density and diversity of vegetation, it may take 10 years to observe geomorphologic and hydrologic changes in the channel. Baseline monitoring for data collection is often required by the grantee or by federal or state regulatory agencies and is included in funding, but post-project monitoring, which can be time-consuming and expensive, is usually not funded. Unless private landowners or public land agencies are willing to commit financially, post-project monitoring may not occur. Because post-project monitoring was not included in funding for the Rainbow Ranch project, this Dry Cimarron project is incomplete.

©T. Gadzia, 2008

Beaver dam on the East-end reach.

The following are excerpts from monitoring reports submitted as part of the 2002-2006 EPA-319 final report.

Bank protection structures resulted in well-vegetated banks, an expanding point bar and increased riparian vegetation diversity.

Rosgen Level II Survey

As reported by Abe Franklin, NMED-SWQB:

> *In November 2003 and again in October 2005, data were collected from 4 cross sections, longitudinal profiles and pebble counts. Three cross sections were purposefully located near post vanes. "The cross sections showed that two out of three post vanes surveyed (cross sections 1 and 3) had little effect on the stream channel between survey dates. Cross section 4 had a clearer, desirable effect; the thalweg (the deepest part of the channel) had moved about three feet and aggraded several inches. Several inches of new deposition had occurred on the point bar opposite a steep cut bank (which the vane was intended to protect) which is now not as steep and not as actively undercutting. Visual observations of other vanes indicated that the proportion of vanes that have had desirable effects is probably greater than shown by these three cross sections. The following was reported by The longitudinal profiles are prone to more error and are more difficult to register than the cross sections. They indicate that the overall grade of the reach surveyed (around cross section 1) has changed little (the stream has neither aggraded nor downcut here), and that there were more developed (deeper) pools in 2005. One of these pools is located immediately upstream of the restored meander.*
>
> *The pebble count data indicated a higher proportion of gravel (13% in 2005, up from 6% in 2003), which may indicate either a reduced sediment supply (which would logically result from the increase in vegetation thus far only qualitatively observed), increased sediment transport capacity due to changes in channel morphology (unlikely in the surveyed reach, based on cross section 1), or recent scouring events that removed a large amount of stored sediment from the system (a possibility, considering the large spring runoff event that occurred). In any case, the reduced percent of fines (particles less than 2 mm) constitutes an improvement in habitat for most aquatic species which may occur here.*

©C. White, 2007

Vegetation Surveys

Observed changes in plant communities as indicated by the transect data for each site are summarized below by Maryann McGraw of NMED, SWQB.

Cross Section 1. *Vegetation communities transition abruptly from wetland to upland species. In 2004 and in 2006 the cumulative distance along the cross section for wetland and upland is about the same, indicating that the wetland/riparian complex at this site has not shown significant expansion or change. In 2006, yellow sweet clover is missing as a dominant component of the upland plant community, which may be a response to drought conditions. A change in upland species composition, including grasses, may be in response to changed grazing practices, as this site was not grazed in 2005. Also, sweet clover is a colonizer and quickly invades disturbed soil conditions.*

Cross Section 2. *The percent upland to wetland plant communities is slightly reduced in 2006 compared to 2004. A significant change is the loss of Robinia (Locust) and a corresponding increase in Western Wheat. No explanation is evident. However, the right bank permanent marker may have been moved during installation of a filter dam on this section in March 2006.*

Cross Section 3. *The 2004 data does not show open water footage because the channel at that time was choked with aquatic plant species dominated by Water Speedwell. For this stream section, the decrease in wild Sweet Pea was due to the lack of spring moisture and the plant had not come up yet. Serviceberry was expanding into the monitoring site, and for this stream section, a decrease in Water Speedwell may be due to scouring events, consumption or trampling by animals, or nutrient input changes.*

Greenline. *Greenline data were also collected at each site and the observed changes in plant communities are summarized below.*

- *The wetland plant communities show Eleocharis decreased, Water Speedwell decreased and increased, and the Bulrush/Water Speedwell community increased.*
- *Coyote Willow shows an increase and Wood's Rose shows a decrease in mature specimens.*
- *Upland species Bromus and miscellaneous forbs increased.*
- *Bulrush is a highly competitive wetland species and increased because of favorable habitat conditions.*
- *Three high-water events and increased beaver activity changed the location of the greenline to higher up the bank into an existing willow stand and the structures may have increased bank storage creating more suitable moisture conditions for willow communities. This increases willow sprouting.*
- *An increase in Bromus and decrease in grasses may be due to the high snowfall during the winter of 2004-2005 and the drought conditions from October 2005 to July 2006.*

A combined list of 111 riparian and riverine vegetation species was compiled by Bruce Robinson in 2004 for the East-end project and in 2009 and 2012 by Steve Vrooman for the West-end vegetation surveys.

©T. Gadzia, 2004

Cross section 3, June 14, 2004.

M. MCgraw, NMED, 2004

Robust and diverse riparian vegetation.

Bird Surveys

A summer baseline bird survey was conducted by Hawks Aloft, Inc., in July 2002. A baseline winter survey was conducted on February 28, 2003, and the next summer survey on June 16, 2003. Surveys were conducted in March and June, 2004. Hawks Aloft provided a summary data report for surveys conducted 2002-2004. The executive summary by Gail Garber, Hawks Aloft states:

> *Livestock grazing can negatively affect birds in riparian areas by altering the vegetation they need for nesting and foraging. Excluding livestock from riparian areas during certain seasons might allow vegetation to regenerate, thereby reducing potential negative effects of grazing on birds.*
>
> *Hawks Aloft, Inc. conducted bird surveys along Dry Cimarron Creek, in northeast New Mexico, to evaluate abundance and species richness associated with a dormant season grazing regime. Surveys were conducted during the summer and winter from 2002 to 2004. For summer surveys, we recorded relatively high species richness (51 species), indicating that Dry Cimarron provides habitat suitable for a variety of breeding birds. Seasonal abundance and species richness were consistent among years, indicating that site quality did not change from 2002 to 2004. We recommend continued attempts to restore and protect riparian vegetation through cattle exclosures and dormant season grazing regimes.*

LESSONS LEARNED

Maybe one of the most important parts of a project of this scale is what is learned during the process and from its outcomes. A five-year period between the East-end and West-end work was beneficial. It provided time to watch how the river progressed and to make better decisions based on results from the 2003 meander re-instatements. Below are a few notable lessons learned from the 2002-2006 project.

Mother Nature Rules! Between 2004 and 2006, plenty of rain fell on Rainbow Ranch. Restoration work had to be postponed on several occasions due to very wet ground that did not allow for the use of heavy equipment. Five high-water events between June and August of 2004 pushed "yet to be fixed" headcuts further

Post vanes allow for revegetation of formerly eroding banks and development of new floodplain habitat.

©C. White, 2002

October 2002

©T. Gadzia, 2007

September 2007

©T. Gadzia, 2009

September 2009

upstream. In May of 2004, a late freeze damaged 2,000 willows that were planted in April, but luckily about 75 percent survived and re-sprouted from the roots.

Lesson: Projects need time and budget flexibility to allow for unexpected weather events.

Electric Fencing. Electric fencing works well in an open grassland situation but is more difficult to manage in a riparian area. The change to dormant-season only grazing in the riparian pasture caused a tremendous growth response in riparian vegetation. Vegetation growing next to the fence often caused it to short-out and therefore became a constant challenge to manage. Sunny commented that if she could do it over, she would not have installed electric fencing for the riparian pasture.

Lesson: Completely evaluate a treatment or task and ask questions of more than one entity to get a complete picture of the situation. Also, it may be better to use barbed wire fencing when creating a riparian pasture.

Restoration Materials or Livestock Food. The natural, biodegradable straw used in the three-tiered straw bale fall and straw bale plug fit well with project goals and functioned well for a short time, until livestock stomped on the structures to consume it. Then a heavy rain occurred. Despite damage by the cattle, the structures continued to function, but at a lower level.

Lesson: Straw bales work well, but not on a pasture grazed by domestic livestock!

FINAL THOUGHTS

Much has changed since the day Sunny Hill came to the Quivira Coalition's office in Santa Fe and asked us to help her family save their farm. Ecologically, the innovative ideas of Bill Zeedyk brilliantly implemented by an energetic crew of professionals and volunteers over many years went a long way toward restoring the river to health. This accomplished Sunny's dream while satisfying numerous regulatory concerns, all in the spirit of collaboration and shared goal making. After 13 years of grant writing, project organization and implementation, and extreme wet and dry weather, the river continues its path to healing. In other words, Bill Zeedyk's ideas and methods work, and they work well.

©T. Gadzia, 2004

©T. Gadzia, 2006

Top photo, June 2004 . Bottom photo, August 2006.

Whether the farm was saved economically and socially is not so obvious. Jack and Mildred Williams passed away. Sunny and her daughter have moved on to new agrarian adventures off the ranch. No one else in the family wanted to give it a go, so it is likely that the ranch will eventually be sold. Ecological stressors on nearby stretches of the river (overgrazing, drought and overpumping) remain persistent problems.

Despite these challenges and changes, the section of the Dry Cimarron that passes through Rainbow Ranch will continue to thrive and heal—nature will take it from here.

PROJECT PARTNER RECOGNITION

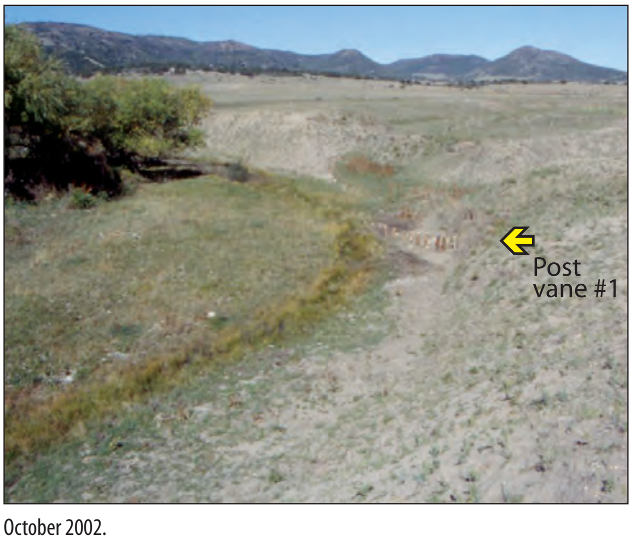
We commend the EPA and NMED for the way this project was handled, with special thanks to Tim Herfel (retired) at EPA-Region 6, and to Abe Franklin, Maryann McGraw and Karen Menetrey at the New Mexico Environment Department-Surface Water Quality Bureau.

Many thanks to:

- **Bill Zeedyk**, Zeedyk Ecological Consulting, LLC, **Steve Carson**, Rangeland Hands, Inc. and **Craig Sponholtz**, Watershed Artisans, Inc. for their expertise in design; volunteer workshop instruction; and restoration organization
- Implementation contractors, **Steve Carson** and **Wesley Kendrick**, Colfax Construction, for their mastery in moving large amounts of soil and building rock structures
- **Kirk Gadzia**, Resource Management Services, LLC, for upland assessment and livestock grazing plan
- **Steve Vrooman**, Keystone Restoration Ecology, for vegetation monitoring and geomorphology survey support
- **Gen Head** and **Steve Townsend** for archeological surveys
- **Bruce Robinson** for a vegetation survey
- **Hawks Aloft**, **Deanna Einspahr**, **Mary Ristow**, and **Rick Martinez** for bird surveys
- **Jim Wood** (retired) and **Deanna Cummings** at the U.S. Army Corps of Engineers, Albuquerque, New Mexico for assistance with two 404 permits
- **Eric Fry**, Northeast Area Fisheries Manager, New Mexico Department of Game and Fish for fish surveys
- All the great **volunteers** who helped make the hands-on restoration treatments so successful

We would especially like to thank Rainbow Ranch Family Members: **Sunny Hill, Jack and Mildred Williams, Kelly Hill, Seth Keele, Allan Hamilton, Sid Hamilton and Rochelle Williams**. Without their interest in having a functional watershed and a healthy productive riparian area, their dedication and hard work, and their generous and gracious hosting, this project would not have been possible.

Finally, we'd like to thank Quivira Coalition staff—**Courtney White, Tamara Gadzia, Deborah Myrin-Bertagnolli, Avery C. Anderson Sponholtz, Michael Bain, Mollie Walton and Deanna Einspahr**—for their dedication to this project and their diligent work in implementating and documenting it.



©C. White, 2002

October 2002.

©T. Gadzia, 2006

August 2006.

HUBBELL TRADING POST—BIRTHPLACE OF INDUCED MEANDERING: 18 YEARS LATER AND STILL LEARNING

by Bill Zeedyk

PREFACE

Eighteen years have passed since the pioneering experiment in Induced Meandering began at Pueblo Colorado Wash, Hubbell Trading Post National Historic Site. Principles, procedures, structures and treatments that were merely conceptual in 1997 are now proven and refined or have been discarded and forgotten. Concepts proven at Hubbell have been applied at numerous restoration sites across the American Southwest, as well as in Australia, Spain, China and elsewhere. Induced meandering is a viable method for restoring appropriate sinuosity, width-depth ratios, floodplain access and streamside vegetation to incised stream channels. Best of all, when necessary it can be successfully applied using handbuilt structures. Heavy machinery is helpful, but not essential.

After eighteen years, channel recovery is still ongoing at Hubbell. Channel evolution continues—the stream is longer, the upper reach (Phase I) is no longer incised and has a flood prone width of about 120 feet. Rabbit brush and upland grasses have been replaced by willow thickets, tall cottonwoods and a variety of wetland vegetation, including cattails and bulrush (Figure 1 and 2). There are perennial pools supporting fish, frogs and aquatic insects. The lower reach (Phase II) is longer, wider and more sinuous, and it supports several perennial pools where only one existed before. It, too, is lined with willows and cottonwood, in marked contrast with the untreated channel downstream. Upstream the Ganado Chapter, Navajo Nation, has begun a program to restore the wash through the community of Ganado, as per the Hubbell example.

Induced meandering at Hubbell changed the creek, changed attitudes about stream restoration, presented new treatments and changed my life as well. I am grateful for that. "If at first you don't succeed, try and try again."

INTRODUCTION

Induced Meandering was first applied on a project scale at Pueblo Colorado Wash on the Hubbell Trading Post National Historic Site, Apache County, Arizona. Hubbell Trading Post National Historic Site, owned by the National Park Service, is a small, 160-acre inholding within the Navajo Indian Reservation at Ganado, Arizona. Restoration of the wash was initiated by the Park Service to address several management concerns,

©W.D. Zeedyk, 1998

Figure 1. Phase I, Photo Point 2, downstream view, May 28, 1998.

©T. Gadzia, 2015

Figure 2. Same view, June 12, 2015.

including ecological diversity, historical integrity, wildfire prevention, flood prevention and education. I designed the project and, beginning in June, 1997, it was implemented by the Park Service using Park Service employees and volunteers.

In 1998, after a rather humble beginning, the project received a real boost with funding from the Arizona Water Protection Fund Commission (AWPF), Grant number 97-029. Funding was later extended under Grant 00-104, spanning a total period of six years, 1998 through 2003. The grants enabled full-scale implementation of the project and required that geomorphologic and photographic monitoring be conducted through 2003 and that any structures installed under the grants be maintained for a period of 20 years. Water quality monitoring was also required. Principal cooperators included the Navajo Nation Environmental Protection Agency (NNEPA), Water Quality Program (Tom Morris, retired) and Navajo Water Management Branch (Lynette Stevens). Other cooperators included the Youth Conservation Corps, Ganado Unified School District, and Navajo Game and Fish Department.

The following is excerpted from the initial grant application by Park Superintendent Nancy Stone (retired):

> *The archeological ruin along the Wash at the entrance to Hubbell is designated in Navajo as Wide Reed Ruins. However, it's been some time since any type of reeds flourished in this aquatic habitat. However, in attempting to manage this site as a cultural landscape, we now have an opportunity to restore integrity to a segment of the watercourse that is the Pueblo Colorado Wash.*
>
> *For over 100 years, the Pueblo Colorado Wash has been denuded, disturbed, diverted and dammed to benefit the human inhabitants of the region. Now, we have an opportunity as well as an awareness of our responsibility to enhance the Wash through restoration of self-sustaining processes and enlightened management concepts to provide benefit for more than 20 years to this riparian zone of the Little Colorado River Water Basin. Although this project is focused on a specific portion of this intermittent stream, the applicability to other areas within the state is unlimited. The need to conserve critical riparian areas, and to control the threats of unmanaged grazing, are similar throughout the Southwest. Because this project is located on public land and is a discrete, manageable unit with institutionalized stewardship, it will serve well as an ongoing, long term, feasible, cost effective demonstration area for protection, enhancement and restoration of riparian areas. The project's potential for land users/managers to utilize as a "learning center" may become its greatest value. The interpretive opportunities of the site will contribute to greater understanding of the restoration needs in the National Park Service as well as in the Navajo Nation.*

Pueblo Colorado Wash is a tributary to the Little Colorado River, draining southwesterly from the Fort Defiance Plateau on the Navajo Indian Reservation and joining the Little Colorado east of Holbrook, Arizona. Above the project site, the watershed is 80 square miles in size. Elevations range from near 5,000 feet at the Little Colorado to more than 7,000 feet on the Plateau.

Figure 3. Pueblo Colorado Wash, Phase 1 Reach, Google™ Earth, June 2014.

Figure 4. Park employees cutting and removing invasive Russian olive.

Runoff is diverted from the wash to fill Ganado Reservoir and then distributed for agricultural use. The impact of the diversion is substantial during years with little snowmelt runoff and may affect channel dimensions.

At Hubbell Trading Post, Pueblo Colorado Wash is an intermittent channel with a short, perennial subreach fed by a small, perennial spring (discharge ≤ 0.2 cfs) surfacing just below the pueblo site at Wide Reed Ruins.

Within the project area, the wash is approximately one-half mile long, in two reaches. It was grazed yearlong by trespass livestock and dominated by tamarisk and Russian olive, and in 1980, the upper reach had been dredged and straightened for flood control purposes. Dredging resulted in its downcutting as much as 12 feet in the upper reach. The lower reach downcut from three to six feet.

Treatments designed to address management concerns have included fencing and enforcement to exclude and remove trespass livestock; removal of exotic vegetation by cutting, burning and herbicidal treatments; channel stabilization and restoration using Induced Meandering techniques; and reintroduction of native woody and herbaceous plant species. Removal of exotic species began in 1996 and continued through 2000 (Figure 4).

The hydrologic condition of the watershed at the time of project inception was poor and declining due to the combined impacts of long-term overgrazing, the proliferation of primitive roads, urbanization, and the replacement of native grasslands by piñon-juniper woodlands. As a result, stream runoff was very flashy.

PROJECT DESIGN

A core principle in project planning and design is to formulate a vision of the restored reach. This being the first attempt at Induced Meandering, the vision was simple and straightforward: "a meandering Rosgen C channel with an accessible floodplain, a rising water table, perennial pools and a well-vegetated riparian zone dominated by native species." (For more information on river classifications see *http://wildlandhydrology.com*)

Pre-treatment Characteristics

Within the project area, the channel was divided into two reaches, upper and lower. The upper reach, which had been dredged and straightened, was identified as the Phase I Reach. It included the area first treated in 1997 by volunteers. The lower reach, or Phase II Reach, included that portion of the channel first treated in 1998, when funding by AWPF began.

Characteristics of the Phase I Reach were channel length, 1074 feet; valley length, 1,033 feet; channel width at bankfull, 9-12 feet; mean depth, approximately 2.5 feet; channel slope, 1.47 percent; sinuosity, 1.04, with no apparent meander. Bed materials were predominately sand, but the stream banks were composed of very cohesive clays. Rosgen channel type was G5 (Figure 5).

Characteristics of the Phase II Reach were channel length, 1,626 feet; bankfull channel width, 22 feet; mean depth, 1.5 feet; channel slope, 0.8 percent; apparent meander length, 232 feet and a sinuosity of 1.13. Bed and bank materials were more variable by subreach from gravely sand to very cohesive clay. Channel type was Rosgen F5 with subreaches of G5 (Figure 6). The combined channel length of the two reaches was 2,600 feet, with a valley length of 2,478 feet.

Figure 5. Phase I Project Reach.

A reference reach was selected on the Navajo Reservation about one-half mile upstream of the project reach. This site was selected as the only relatively stable reach between the project area and the Ganado Reservoir. There being no significant tributaries or diversions between the project area and the reference reach, it was assumed that the attributes of the reference reach would apply to the project reach. The following parameters were measured at the reference reach: channel length, 600 feet; bankfull channel width, 28 feet; mean depth, 1.5 feet; maximum depth, 2.5 feet; width/depth ratio, 18:1; entrenchment ratio, 2.20; sinuosity, 1.3; and meander length, 360 feet. The bank bed material was sand. Rosgen channel Type was C5.

Because the reference reach was incised into sandy banks, but the project channel was incised into highly cohesive clay banks, a dimensionless meander length (Lm) of 11 was chosen. Dimensionless meander length ranges from 10-14 with the lower multiplier applied to highly erosion-resistant banks and the higher to less cohesive banks. The factor of 11 was selected arbitrarily.

©W. D. Zeedyk, 1998

Figure 6. Phase II Project Reach.

Multiplying the channel width (28 feet) by 11 yielded an estimated meander length of 308, which was rounded to 310 (Figure 7). A goal for the total channel length in response to treatment was set at 3,200 feet by multiplying valley length of 2,478 feet by sinuosity of 1.3 (2478 x 1.3 = 3,221) rounded to 3,200 feet. Management objectives by reach are shown in Figure 8.

The overall project goal was to achieve the above listed objectives within three years, but with no prior

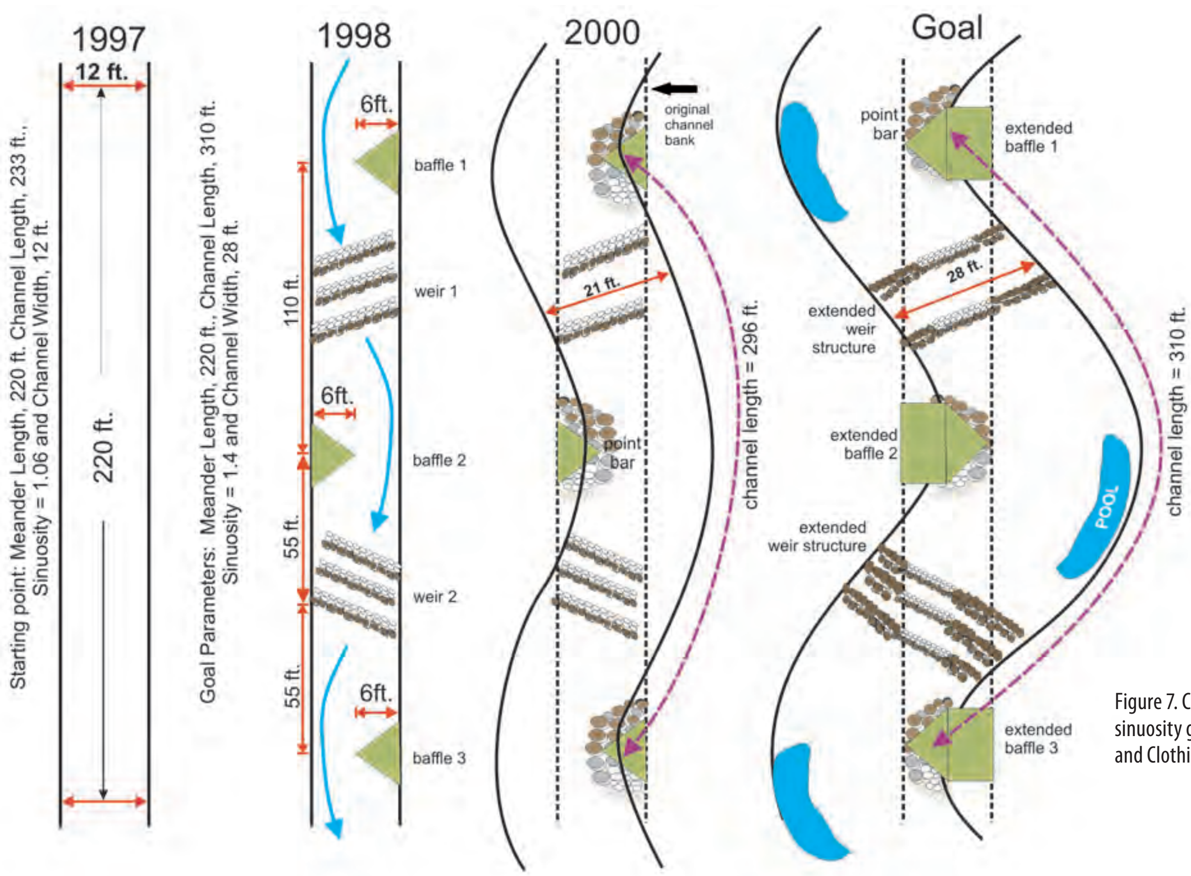


Figure 7. Channel sinuosity goals (Zeedyk and Clothier, 2009).

experience in the application of the Induced Meandering method, there was no real basis for the three-year time frame. As it turned out, that goal was wildly optimistic, but many of the design objectives have been reached.

STRUCTURES

Two kinds of structures were used in the initial 1997 design, baffles for deflectors and weirs for grade control. It was assumed that the weirs would spawn the development of riffles, and therefore, in anticipation of success, weirs were initially called "riffles." This nomenclature soon evolved to "riffle-weir" and eventually to weir. Three sorts of baffles (Figures 9 and 10) were eventually used: rock, picket, and rock and picket. Three sorts of weirs were used for grade control: one-rock dams, wicker weirs and a single Rosgen "W" weir. Only rock baffles and one-rock dams were used in the initial treatment of the Phase I Reach in 1997. Another principle that guided the Hubbell project was that all structures would be constructed by hand labor using hand tools with construction materials gathered locally from on-site sources (Figure 11).

Management Objectives

Parameter	Phase I Reach	Phase II Reach
Bankfull Width (ft)	28	28
Mean Depth (ft)	1.5	1.5
Width/Depth	18:1	18:1
Entrenchment Ratio	2.20	2.20
Valley Length	1,033	1,439
Channel Length (ft) (rounded)	1,340	1,870
Sinuosity	1.3	1.3
Average Channel Length per Meander (ft)	310	310
Meander Length	220	220
# of Meanders (rounded)	5	7
Channel Slope (%)	0.84	0.84
Particle Size (Bed/Bank)	sand/clay	sand/clay
Rosgen Channel Type	C5	C5

Figure 8. Phase I and II management objectives.

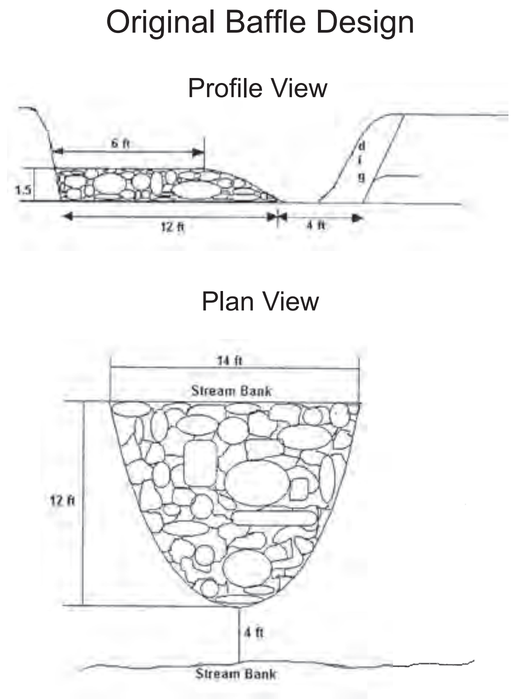


Figure 9. Typical baffles were 14 feet at base and extended 12 feet into the stream channel unless shown otherwise on the plan. Baffles were 1.5 feet high at the base and tapered down starting at about 6 feet from the base.

©W. D. Zeedyk, 1998

Figure 10. Original baffle design, but with added support from pickets and wicker. Phase I, Baffle 7, October 22, 1998.

©W. D. Zeedyk, 1997

Figure 11. Volunteers constructing Phase I, Baffle 6 by hand and using local materials.

MATERIALS

The channel and its immediate vicinity were littered with construction materials resulting from the original flood control project installed in 1980. This material included large and small boulders, concrete chunks and slabs, perhaps fifty cubic yards of cobble left over from gabion basket construction and talus rock from locally exposed bed rock outcrops. Damaged gabion baskets were dismantled and the cobble fill was salvaged. Although not used initially, there was an abundance of woody material (posts and pickets) ranging from two to eight inches in diameter (Russian olive and Siberian elm), resulting from the removal effort. An abundance of wicker-sized material (tamarisk) was also available.

The concrete slabs were broken into usable pieces by sledge hammer; concrete chunks and rocks were transported by wheelbarrow. Live plant materials—mainly willow cuttings, cottonwood poles and sod mats of common three-square (Scirpus pungens)—were collected locally from within the boundaries of the park. Beginning in 2002, other riparian species were imported, including New Mexico Olive, Wood's rose, skunkbush and others. A small cottonwood nursery was developed, using native sprouts to grow and harvest poles for planting material.

PERMITTING

Park Service policy required that an archeological survey be conducted. A direct quote from the field notes of the survey pretty well summed up the situation archeologically as well as ecologically, "Riparian area within project area has previously been disturbed when channel was straightened for flood control and gabion construction. Current condition is very unnatural." Only one archeological site was encountered. No threatened or endangered species would be affected. When the proposed project was submitted to the U.S. Army Corps of Engineers, Phoenix District, the 404 permit was approved without question. Navajo Nation EPA certified the 401 permit. The way was cleared for implementation of the first Induced Meandering project.

IMPLEMENTATION

Phase 1 Reach, Initial Treatment, 1997

Initial treatment of the Phase I Reach began in June 1997 and was completed in July of that year. Eighteen instream structures were installed consisting of nine rock baffles and nine rock weirs comprising four and a half meander lengths at 220 feet each (Figure 12). Baffles (Figure 13) were installed at one-half meander intervals or 110 feet. Weirs (Figure 14) or "riffle weirs" were installed halfway (55 feet) between baffle tips and skewed 15 degrees to the channel. Structures were numbered in a downstream direction with odd numbers on the left bank and even numbers on the right. No bankfull flow events occurred during the summer or fall of 1997 and structures were not seriously tested. Still, several lesser

Phase I Typical Dimensions

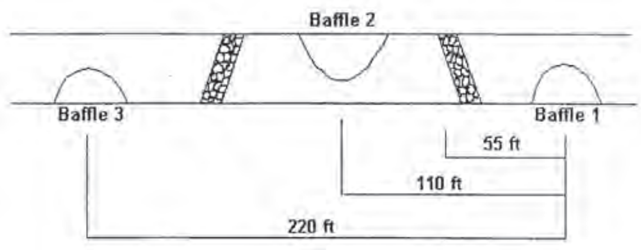


Figure 12. Schematic of structure layout.

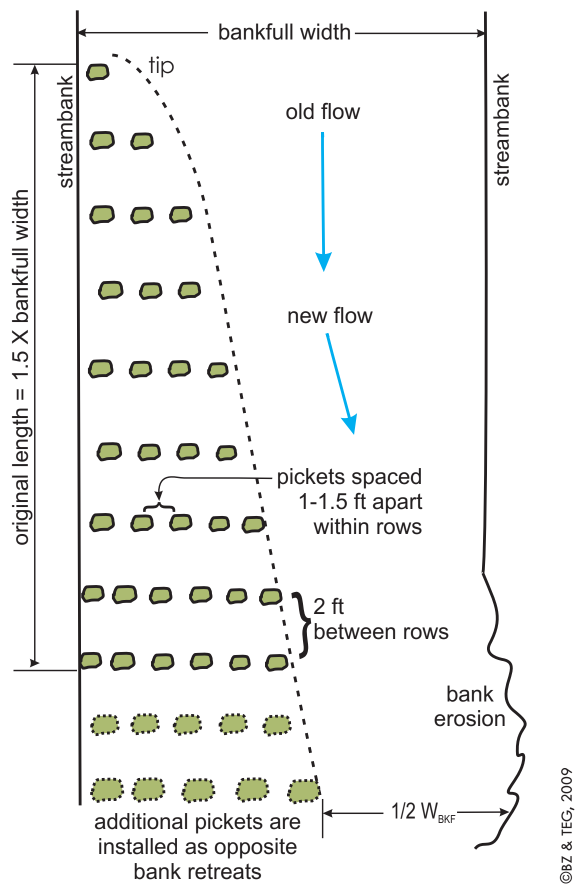


Figure 13. Picket baffle schematic (Zeedyk and Clothier, 2009).

events initiated channel response. The most significant response was a gradual wetting of the vertical clay banks due to their exposure to pooled water stored behind the weirs. As the wetting wicked upward, extensive cracks developed along the left bank opposite baffles 2 and 4 leading to bank collapse.

Some minor cave-ins occurred during a modest flow event in October 1997, widening the channel by one to two feet opposite some baffles. Simultaneously, small point bars began to form adjacent to and downstream of the baffles. The weirs collected sediment. By the end of 1997, the channel had slightly widened opposite all baffles. Induced Meandering was beginning to work. Unfortunately, unexpected problems lay ahead.

Snowpack in the watershed during the spring of 1998 exceeded 400 percent of normal. Snowmelt discharge on the order of 120 cfs began in February and continued through April. This rate was just slightly less than the estimated bankfull discharge of 150 cfs. Significant channel downcutting occurred and most of the rock weirs, which had been built without footers, were damaged or destroyed. The channel degraded as much as 2.5 feet along one third its length. The left-bank slumped and the channel widened an additional two feet opposite baffles 2 and 4. Fallen root wads that were too large to be moved

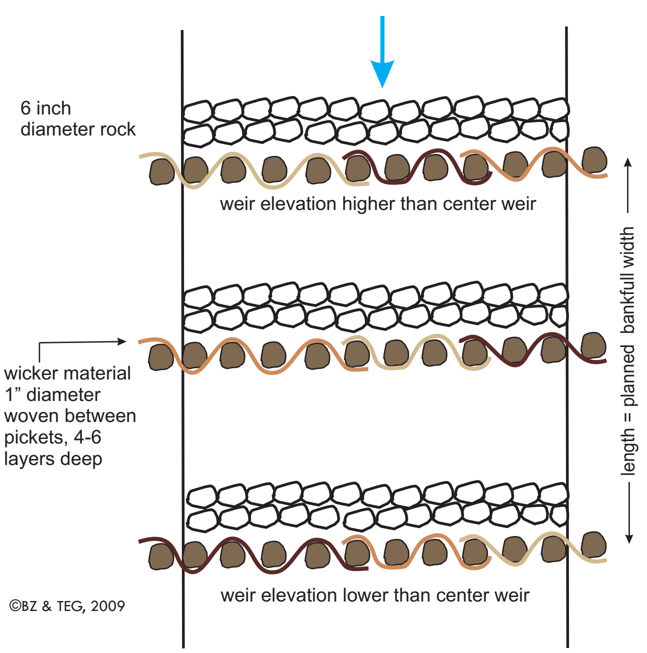


Figure 14. Wicker weir schematic (Zeedyk and Clothier, 2009).

by the current altered the direction of flow and damaged some baffles due to eddying effects (Figure 15). Yet overall the baffles were working and the channel continued to widen.

Initial monitoring, maintenance and modification of Phase I structures, under the auspices of AWPF Grant 97-029, began in May 1998 and was completed by June. Rocks and concrete rubble from local sources were added to the original structures. A Rosgen "W" weir was added to control a newly developed deep headcut, or bed scarp. To increase their resistance to shear stress, sod wads of common three-square were planted around the edges and across the surface of the baffles. All structures were measured and photographed as built.

On July 29, 1998, overbank flooding occurred damaging most structures (Figures 16, 17,18) . The "W" weir withstood the July 27 flood unscathed (Figure 19). Despite the damage, channel response was significant. Induced Meandering was working, but stronger structures were needed. The main problem, of course, was that rock structures built on sand-bedded channels must have substantial footers. But how could substantial footers installed to three times scour depth be realistically built entirely by hand? The future of the project seemed very much in jeopardy. The answer, after much deliberation, was to substitute pickets or posts for the rocks. Green sticks were abundant and could be easily sharpened and driven far below scour depth in the sand-bed channel and trimmed to the proper height after placement. It was necessary to experiment with baffle design. After some false starts, a wedge-shaped baffle, built on the scale of a 30-60° right triangle, proved most effective. One-rock dams were replaced with wicker weirs.

Phase II Reach

Design and construction of the Phase II Reach was done in May, June and July of 1998 under AWPF Grant 97-029. The differences between the two reaches were profound, most notably channel width, which was 22 feet in Phase II versus 12 feet in Phase I. Bank materials were sand and gravel over about half the length of the Phase II reach versus clay in Phase I. There were four partly developed meander bends in Phase II, the channel was less entrenched, and banks were more stable due to lower

Figure 15. After snowmelt runoff banks are beginning to collapse. March 1998.

Figure 16. Phase I Baffle 6. Note erosion opposite baffle. July 1, 1998.

Figure 17. Flood event looking upstream. Letting the water do the work! July 27, 1998.

Figure 18. Phase I Baffle 6, after July 27 overbank flood event. July 28, 1998.

Figure 19. Rosgen W weir for grade control. All photos ©W. D. Zeedyk, 1998.

height and vegetative armoring. Twenty three structures were installed including 11 baffles and 12 weirs. Several obstacles that were negatively impacting the meander pattern—including the wreckage from a failed gabion basket check dam, corrugated metal pipe, old bridge pilings and two large debris dams—were removed. Construction was no sooner completed than three rock baffles and four rock weirs were destroyed by the flood of July 27, 1998. These structures were replaced with picket baffles and wicker weirs. Channel width was measured at all structures. Permanent photo points were established and monumented following AWPF protocols. All structures were maintained during October in preparation for spring 1999 snowmelt.

FLOOD OF AUGUST 28, 1999

A huge flood struck the project on August 28, 1999, sweeping away the crest gauge. Maximum flood stage exceeded 11 feet in the Phase I Reach and seven feet in the Phase II Reach, eight and a half and five feet above bankfull respectively. The flood persisted above bankfull stage for more than a week, drowning more than 180 of 200 cottonwood poles that had been planted that spring by student volunteers (biology students led by Ellie Trotter of the University of New Mexico had assisted with planting, beginning in spring, 1999). More than 60 percent of the structures were seriously damaged or destroyed. Concave banks were scoured and sizable point bars and lateral bars were deposited. Some structures were buried. A basalt boulder more than three feet in diameter was transported more than 140 feet downstream and deposited in the slack water in the lee of Baffle 2.

An eight-inch thick concrete slab, four feet wide and seven feet long, was carried more than 300 feet to be deposited on the surface of Baffle 3. Cutoff chutes were scoured between several baffles and the banks in both reaches. Channel avulsions cut through two meander bends, shortening the channel length in the Phase II Reach.

The flood occurred August 28, 1999 as my beloved wife Gene lay dying of cancer. She died September 16. My sorrow at her dying, coupled with my reaction to the flood's appalling devastation, completely demoralized me. I could not concentrate nor think creatively. I was about to give up on Induced Meandering altogether.

However, it was also obvious that the flood had widened the belt width and flood prone area. The newly deposited bars and floodplain soils would provide excellent planting sites in 2000. After carefully deliberating the effects of the flood, it was determined that the flood had actually hastened the channel evolutionary process. Furthermore, much was learned regarding structure design and installation, what worked and what did not. After allowing my emotional health to heal, I decided to try again.

All baffles that had not already been modified were modified or replaced by picket baffles or post vanes. Two post vanes (Figure 20) that had been installed in June 1999 in the Phase I Reach had withstood the large flood undamaged (Figures 20-21). All structures were repaired or replaced by October 1999 in preparation for the 2000 spring snowmelt. We copied what worked, abandoned what did not.

MONITORING, MAINTENANCE AND MODIFICATION

Visual Inspection

All structures were inspected after each flood event and promptly repaired during the first three years (1998-2000). Beyond that, all structures were inspected in May following spring snowmelt and repaired before monsoon season, inspected again in October and repaired before winter. New photos were taken from thirty feet upstream and thirty feet downstream to document changes to each structure.

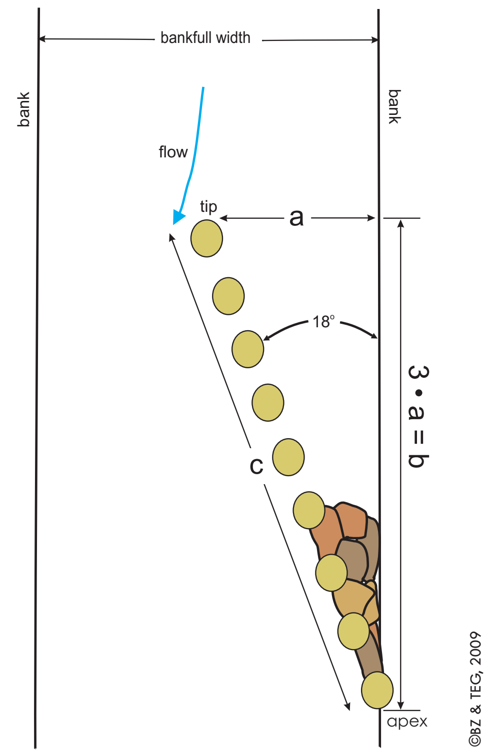


Figure 20. Post vane schematic (Zeedyk and Clothier, 2009).

Figure 21. Post vane, November 2, 2000.

Figure 22. Post vane, June 12, 2015.

Geomorphological Monitoring

Geomorphological monitoring of the channel, including a longitudinal profile and three cross sections per reach, were conducted each October from 1998 through 2003. Fred Johnson, (NNEPA) used GPS mapping techniques on an annual basis to track subtle changes in the channel alignment. Channel response at each structure was measured every October. The combined data were used to track channel response to treatment and analyzed to determine what modifications to structures or structure placement might be needed.

For example, Baffle 6 in the Phase I Reach was washed away each time the stream flooded. The channel width at that site was only nine feet and shear stress was too great for the baffle to endure. The site was shifted downstream and the structure was replaced by a post vane, which had more resistance to shear stress . As a result, the opposite bank quickly eroded and no further structural repairs were needed. Similarly, Baffle 1 and Weir 1 were destroyed by the 1999 flood. The Baffle 1 site was abandoned and the weir location was shifted slightly downstream with no further problems. At another location, a weir was replaced by a post vane in order to increase the meander radius at a natural meander apex. While doing the longitudinal profile, the invert elevation of all weirs was routinely checked to maintain channel slope as planned; weirs were raised or lowered accordingly. All cross sections were installed at riffles, in accordance with accepted protocol. However, since riffles are located at the meander crossover, considerable channel widening occurred first at the meander apices (baffles) before any widening was detected by the cross sections installed at the meander crossovers.

Since 2003, geomorphological monitoring of longitudinal profile and cross sections has been conducted under the auspices of the National Park Service, Southern Colorado Plateau Network, by Stephen Monroe, hydrologist. The channel has aggraded throughout its length but aggradation is most apparent in the Phase I reach, where bed elevation had risen 1 meter or 3.3 feet during the period of 2003-2007.

Ground Water

Two ground water monitoring wells were installed in October 1998 by the Navajo Water Management Branch (Lynette Stevens) and re-measured sporadically though 2003 when monitoring was assumed by the Park Service. Well #1 was installed in a clay bank and Well #2 in alluvial sand and gravel in a preexisting meander bend. For the first two years, Well #1 was dry, even though the bottom of the well was 1.5 feet below the elevation of the channel bed. However, since that time, as the streambed has aggraded, there has been a steady rise in the water table. Maximum rise has been a little more than 3 meters or 11 feet. Well #2 has fluctuated over time in direct response to stream stage because it is sited at a point where the banks are gravel rather than clay, as they are at Well #1 Figures 25-28, page 46).

©W. D. Zeedyk, 1998

Figure 23. May 1998.

©T. Gadzia, 2015

Figure 24. Same view. Note change in channel geomorphology. June 12, 2015.

Photo Monitoring

Photo monitoring was implemented and repeated twice annually, spring and fall, using photo monitoring protocols required by the Arizona Water Protection Fund, which was the principal funder. Representative, permanent photo points were selected, mapped and staked using five eighths inch rebar stakes, painted blue.

Repeat photographs were taken twice annually during the last week of May and the last week of October. Photos were taken at the same time of day to normalize shadow lengths and highlighted areas. The same camera was used, using the same focal lengths, and the camera height was standardized at five feet above ground. The film used had an ASA of 200. These protocols were care-

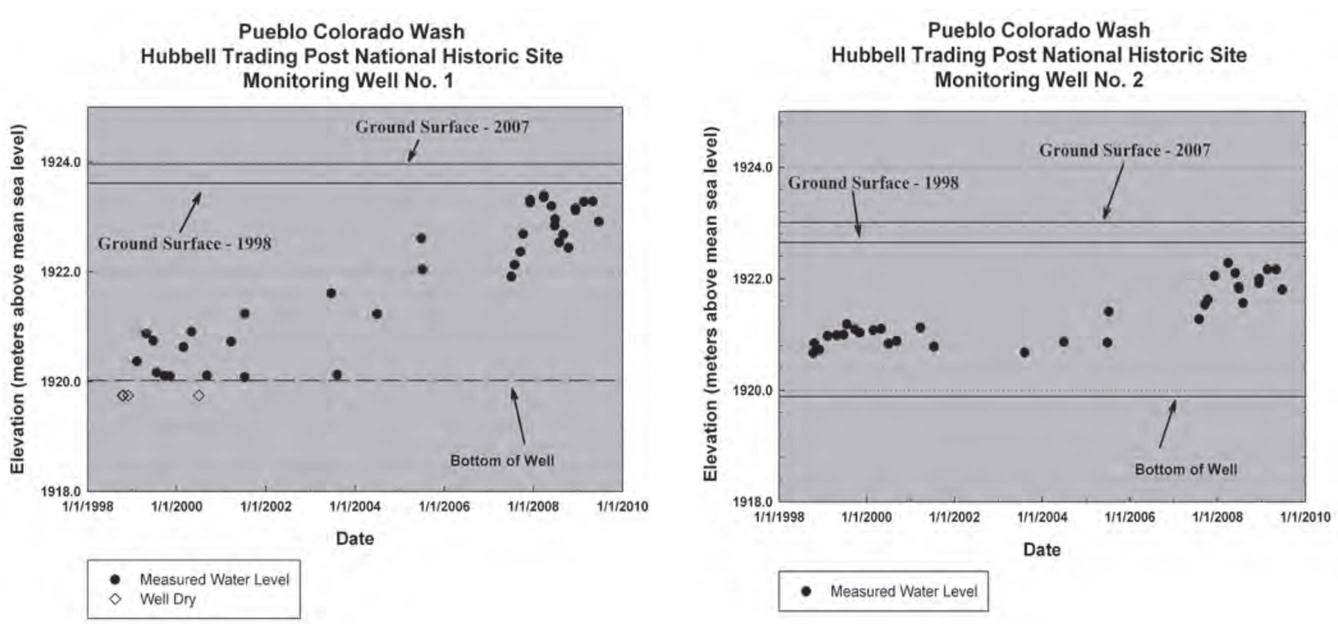


Figure 25. Rise in water table at both wells due to rise in streambed elevation. Data provided by Steve Monroe.

©C. White, 2012

Figure 26. Collecting well data on Pueblo Colorado Wash at Hubbell Trading Post, Apache County, Arizona.

©V. Clothier, 2008

Figure 27. Piezometer tube.

©V. Clothie, 2008

Figure 28. Close-up of piezometer data logger.

fully followed to help ensure that any changes portrayed from year to year were real and not just apparent due to sloppy camera work.

After the six years, repeat photos were taken each spring through 2010 and then not again until 2015. As time went on, some of the initial photo points were lost due to channel meandering(!), debris accumulation, plant growth blocking the view and miscellaneous other reasons. Perhaps we should have "GPSed" all the photo point locations or used T-posts instead of rebar stakes.

Digital cameras are now used instead of a film based camera, introducing even more variability. All monitoring photos have been catalogued and carefully retained. Who knows, we may wish to take new photos again someday... Let's say in 2018 or in 2023—25 years after initial treatment.

The take-home lesson is that to be most meaningful over time, photo monitoring techniques must be standardized as much as possible and trees should not grow up to block the view (Figures 29 and 30).

VEGETATION MONITORING AND MANAGEMENT

Vegetation management consisted of removing exotic woody species, planting native herbaceous and woody species, and conducting periodic surveys. All invasive tamarisk and Russian olive vegetation was removed by cutting and burning, followed by herbicide treatment of individual stumps to prevent re-sprouting. Two shrubby species of willow and one species of tree willow were collected from local sources and replanted along stream banks. Willow shrubs were planted only on inside banks at meander apices in order to promote meandering. Cottonwood poles were also cut locally and planted either on inside banks to promote further meandering or on outside banks to prevent meandering as appropriate to point-specific treatment objectives.

Later in the project and at the urging of Harley Shaw, additional woody species were added, including New Mexico olive, Wood's rose, skunk brush and others. Sod wads of the locally abundant common three-square were dug from stream banks and sand bars to revegetate newly developing point bars and stream banks after each significant flood event. Bulrush was transplanted by students from the one surviving clone in the Phase II reach. Now it has spread the length of the project within the park boundary (Figure 31, page 48).

Vegetation data were collected and analyzed by Marc Baker from 1998-2005 and reported in *Analysis of the Streamside Vegetation within the Hubbell Trading Post, Apache County, Arizona.*

SUMMARY AND CONCLUSIONS

Eighteen years have come and gone since the experiment in Induced Meandering began at Hubbell. Good friends have moved on or passed away. Formerly barren streambanks support lush stands of cottonwoods and willows. Wetland vegetation prevails on all suitable sites.

Induced Meandering has failed in the Phase I Reach, but has succeeded in Phase II. Pueblo Colorado Wash looks far different than it did 18 years ago.

©W. D. Zeedyk, 1998

Figure 29. Photo point 7-1. Phase II reach. View from photo point as originally established. Photo taken with SA 200 film, May 28, 1998.

©T. Gadzia, 2015

Figure 30. View from the relocated photo point following loss of the site original due to outside bank erosion. Inside bed height has risen 3 feet. Digital photo, June 12, 2015.

©T. Gadzia, 2015

Figure 31. A healthy vigorous stand of bulrush (wide reed).

LESSONS LEARNED

- Induced Meandering works. It is a viable treatment for restoring incised (gullied) stream channels.
- Structures first used at Hubbell have had far broader application, especially post vanes, wicker weirs and baffles.
- If the streambed and banks are fine-textured sediment, sand or clay, use posts for structures; if gravel or cobble, use rock or boulders.
- Given a chance, vegetation eventually stabilizes all structures and shapes the stream banks.
- Monitor, maintain, modify for several years. Adaptive management is essential.
- Long-term commitment to maintenance by dedicated volunteers is vital to any restoration project. Funding seldom carries forward for the time needed to monitor sufficiently.

The Phase I Reach is now a wide, lush wetland (Wide Reeds) rich in bulrushes, cattails, three-square and other emergent wetland plants. But it does not meander (Figures 32 page 49; and, 34–35 page 50). The channel, which initially responded to treatment and had begun to meander, has become braided. The initial meanders have disappeared, swallowed by deep deposits of sand. The highly cohesive clay banks resisted erosion once the yearly maintenance and modification of baffles and vanes ceased. Silt and sand originating from the eroding upstream watershed have buried the evolving channel under tons and tons of sediment forming a braided, not a sinuous, channel as intended. Lovely to look at, but not the project goal. Yet the treatments helped make recovery happen.

The Phase II Reach, wider and more sinuous to begin with, has responded differently and now displays sinuous meanders as intended (Figure 33). Its more sandy banks continue to erode and reshape themselves in response to the baffles and post vanes installed at least nine years ago. Here the structures have worked even without maintenance since 2003.

Induced Meandering remains a viable and legitimate tool for the restoration of incised (gullied) stream channels where conditions are appropriate (bed and bank composition, sediment supply, volume of discharge, vegetation, land management and other factors). The structures first used and tested at Hubbell have had far wider application at many project locations.

Because of Hubbell, I moved on to a new and more diversified career in stream, wetland and riparian restoration. Two young Navajo students, who worked on the project in 1998, went on to become hydrologists. Methods learned have been applied on four continents. A cottonwood pole that Richard Becker cut and planted back in the year 2000 now towers over the wash. He named the tree "Aldo Leopold" in honor of our leader and mentor in all things ecologic.

Hopefully lessons learned at Hubbell, as related to the science of geomorphology, hydrology and ecology will help guide stream and wetland restoration long into the future.

Figure 32. Phase I Reach no longer meanders but displays channel braiding due to heavy sedimentation from upstream sources. ©T. Gadzia, June 2015

Figure 33. The Phase II Reach, with less cohesive banks and less sedimentation, meanders as planned. Note relict picket baffle in left foreground. ©T. Gadzia, June 2015

Figure 34. Photo Point 1 Phase 1 Reach. Russian olive, right bank, not yet removed. May 28, 1998.

Figure 35. Photo Point 1 Phase 1 Reach. Stream bed has risen 8 feet. Dominate vegetation is bulrush, cattails, cottonwood and willows. June 12, 2015.

PROJECT PARTNER RECOGNITION

- **Nancy Stone** (retired), Superintendent of Hubbell Trading Post National Historic Site, helped conceive the initial project and obtained financial support and long-term commitment to the project.
- **Tom Morris** (retired), Navajo Nation EPA, provided long-term inspiration and support of the project. He expanded the application of Induced Meandering to numerous other locations on the Navajo Nation.
- **Richard Becker, PhD** (deceased), a past President of the New Mexico Riparian Council (NMRC), organized volunteer support by NMRC members to assist planting cottonwoods and willows. He assisted with monitoring and construction activities.
- **Ellie Trotter** (deceased), Biology Teacher, University of New Mexico (UNM). Organized student volunteer groups for five years, providing 12-15 students each spring to assist with revegetation and structure maintenance.
- **Steve Monroe**, Hydrologist, National Park Service, adapted and expanded long-term geomorphology and hydrology monitoring activities at the project.
- **Lynette Stevens**, Hydrologist, Navajo Nation, now with the NMED. Established initial water monitoring wells and flow estimates.
- **Michael Baker**, President and Executive Director of Volunteers for Outdoor Arizona. Organized and led volunteer workshops at Hubbell.
- **Harley Shaw and Pattie Woodruff** conducted vertebrate seasonal population surveys of amphibians and birds. Harley is the author of *Natural History of a Small Place* (about Hubbell Trading Post).
- **Tamara Gadzia**, Quivira Coalition, assisted long-term repeat photo monitoring of AWPF permanent photo points after initial grant expired.

RESOURCES:

Zeedyk, W. D. (1998). *Rescate y Restauración de los Rios*. U.S. Department of Agriculture, Albuquerque, NM and Sociedad Audubón de Mexico, San Miguel de Allende, Gto., Mexico.

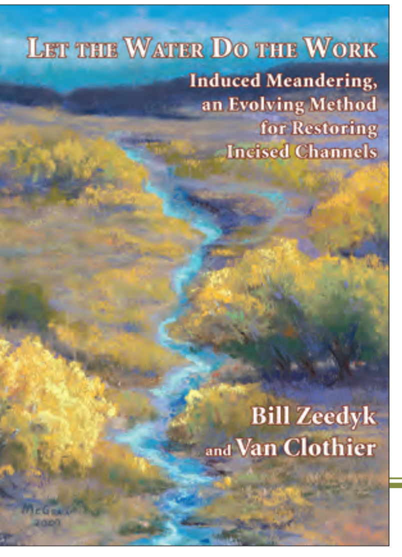
Zeedyk, W. D. (2001). *Induced Meandering. Success Stories in Riparian, Wetland and Watershed Habitats.* Proceedings, New Mexico Riparian Council, 33-38.

Zeedyk, W. D. (2003). *An Introduction to Induced Meandering: A Method for Restoring Stability to Incised Stream* Channels. Santa Fe, N.M.: Quivira Coalition. 4th edition, 2009. *http://quiviracoalition.org/images/pdfs/1905-An_Introduction_to_Induced_Meandering.pdf*

Shaw, H. G., P. M. Woodruff and W. D. Zeedyk (2005). *Natural History of a Small Place: An Ecological History of Pueblo Colorado Wash at Hubbell Trading Post National Historic Site, Ganado, Arizona*.

Baker, M. (2005). "Analysis of the Streamside Vegetation within the Hubbell Trading Post Historic Site, Apache County, Arizona." Interim Reports available for 1998, 2002, 2003, 2004 and 2005.

Zeedyk, W. D. and V. Clothier (2009). *Let the Water Do The Work: Induced Meandering, an Evolving Method for Restoring Incised Channels.* Second edition, 2014. White River Junction, VT: Chelsea Green Publishing. *http://www.chelseagreen.com/let-the-water-do-the-work*



QUIVIRA COALITION

Membership and Donation Form

Quivira annual membership levels:

1. individual
2. household
3. organization (agency, business, school, nonprofit)
4. lifetime

Membership includes discounted registration fees for the Quivira Conference (for households, all family members; for organizations, up to 10 employees). That's a real savings! Each membership will also receive one copy per issue of Quivira's Journal, *Resilience,* and our monthly eNewsletter.

I support the Quivira Coalition with the following tax-deductible annual membership and/or donation:

- ❑ $30/ individual
- ❑ $50/ household
- ❑ $100/ organization
- ❑ $1,000/ lifetime
- ❑ Donation of $____________________

Name /Contact Person____

Affiliation ____

Mailing address____

City ____________________State ______________________Zip_____________

Email ____________________________________Phone____________________

Additional Email Addresses (for eNews) _____________________________

____

____

PAYMENT:

- ❑ Check *(made payable to Quivira Coalition)*
- ❑ Visa ❑ Mastercard
- ❑ Monthly charge of $ _____________ to my credit card

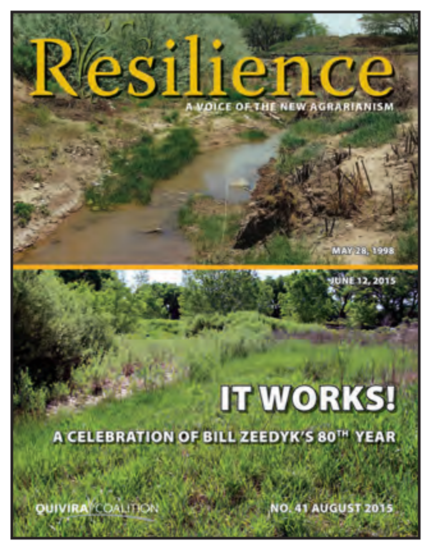
Account number ____

Exp. date ____________________Security code (3 digits) ______________

Signature ____

You can also join Quivira or make donations online at www.quiviracoalition.org.

Purchase gift memberships by calling the number below.



THANK YOU FOR YOUR SUPPORT!

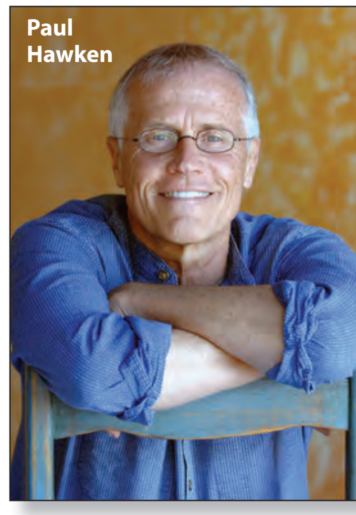
email ***admin@quiviracoalition.org*** phone **505.820.2544 *#** web ***www.quiviracoalition.org***

QUIVIRA CONFERENCE

Plentiful, ample, bountiful, generous, fertile, rich, replete—these are words that describe both the attitude and the goals of the next wave of agrarians. A social movement is like an ocean wave. It arises at a certain time, gathers strength, grows and works toward a defined goal, becoming an effective agent of change for a while. Eventually, a new wave with fresh ideas and energy heads toward shore, building on the earlier wave's success. Today, the goal is to put the now large and diverse regenerative toolbox to work cultivating abundance for all. In this conference, we will hear from ranchers, farmers, scientists, activists and others who are leading this next wave. We'll look down the road with them and share their thoughts on how to flourish amidst the emerging conditions and challenges of the twenty-first century.

WEDNESDAY, NOVEMBER 11 – FRIDAY, NOVEMBER 13, 2015 – ALBUQUERQUE, NEW MEXICO

SPECIAL EVENT – WEDNESDAY EVENING FUNDRAISER



The Quivira Conference is proud to announce that **PAUL HAWKEN**, staunch advocate for sustainable agriculture, will be the featured speaker at this year's fundraiser. Internationally renowned and New York Times Bestsellers, Hawkens books have been published in more than 50 countries and 28 languages. Titles include *The Next Economy, Growing a Business, The Ecology of Commerce and Blessed Unrest*. His talk will focus on **Project Drawdown**, how one hundred solutions deployed at scale will alter the composition of our atmosphere and forge a path toward carbon decline. Please join us for an exciting evening! This event is open to the public. Bring your friends!

WEDNESDAY – DAY 1, TWO WORKSHOPS

All Day

Fundamentals of Soil

2015 is the International Year of Soils. We will kick off the conference with a full-day workshop centered on the work of soil scientist **Christine Jones.** Dr. Jones, an Australian groundcover and soils ecologist who has made soil restoration her specialty, is in high demand as a speaker at educational events around the world.

Afternoon

Capturing Every Drop: Using Keyline Design and Plug-and-Spread to Regenerate Degraded Landscapes

Keyline Design techniques will be discussed to address drought by maximizing beneficial use of water resources across the landscape. Hear from Keyline designers **Owen Habluztel** and **Gordon Tooley**, as well as rancher **Christopher Gill** and Yeoman's plow specialist, **Noah Small**—all of whom have hands-on experience to share! In addition, restoration guru **Bill Zeedyk** will contribute to the workshop by talking about "Plug and Spread" treatments that utilize the Keyline principles for managing water on western rangelands and degraded wetlands. Come and learn the basics in this dynamic, practice-based workshop!

THURSDAY AND FRIDAY – DAYS 2 & 3, PLENARY TALKS

Thursday Speakers

Andre Leu, Rebecca Burgess, Ivan Aguirre and Son, Chris Gill, Dave Johnson, Richard Teague and Owen Hablutzel

Friday Speakers

Arturo and Oriana Sandoval, Hasbídító, Scott Black, Betsy Neeley and Breece Robertson

Register online at www.quiviracoalition.org

QUIVIRA COALITION

1413 2nd Street, Suite 1
Santa Fe, NM 87505
www.quiviracoalition.org

Return Service Requested