Muddy Creek Task Force
Water Resources Research Laboratory

PAP-753

Muddy Creek Demonstration Stream Restoration Research Project

Progress Report

Fall, 1996

by
Dr. Rodney J. Wittler

Progress Report

CRDA-96-1

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INTRODUCTION

This report summarizes progress on the part of the Reclamation Water Resources Research Laboratory (WRRL) during the period October 1, 1996 - December 31, 1996. The Principal Investigator is Dr. Rodney J. Wittler. This report includes an inventory of the structures installed to date on Muddy Creek, a summary of the Low Water Crossing design and construction, a list of publications or reports issued by Reclamation, and a financial summary of WRRL expenses during the period.

Background

This progress report concerns the efforts of a partnership of Federal and local government agencies and a local citizen task force to solve the water quality problems associated with the incision of Muddy Creek near Great Falls, Montana. The United States Bureau of Reclamation (Reclamation) and Greenfield Irrigation District (GID) are collaborating to reduce return flow to Muddy Creek. Reclamation, Cascade County Conservation District (CCCD), and the Muddy Creek Task Force (MCTF), are collaborating to stabilize the gradient and plan form of the stream. Funding for the original agreement came from a grant by the State of Montana to the Cascade County Conservation District. Mr. Alan Rollo is the Muddy Creek Task Force Coordinator. Funding for the amendment comes partially from a State of Montana grant ($10,000) and a grant by the National Fish and Wildlife Foundation ($41,000) to the Cascade County Conservation District. Funding is part of the Cooperative Research & Development Agreement (CRDA) 96-1 and its amendments between Reclamation and the CCCD. The appendix to this progress report includes a copy of the CRDA.

New Project Sponsors

The National Fish and Wildlife Foundation is now an official sponsor of the *Muddy Creek Restoration and Watershed Enhancement Project*. The National Fish and Wildlife Foundation (NFWF) is a 501(c)(3) nonprofit organization dedicated to the conservation of natural resources, fish, wildlife, and plants. Among its goals are species habitat protection, environmental education, public policy development, natural resource management, habitat and ecosystem rehabilitation and restoration, and leadership training for conservation professionals. It meets these goals by forging partnerships between the public and private sectors and by supporting conservation activities that pinpoint and solve the root causes of environmental problems. Headquartered in Washington, D.C., NFWF was established by Congress in 1984. The Foundation invests in the best possible solutions to those problems by awarding challenge grants using its federally appropriated funds to match private sector funds. These combined resources fuel effective conservation projects; however, federal appropriations may not be used for NFWF's operating expenses. The Foundation has awarded 1,205 grants that have leveraged more than $168 million for conservation projects. NFWF's work is local, regional, national, and international in scope. To date, project locations include the 50 states, Puerto Rico, and 17 countries. None of NFWF's grants support lobbying or political advocacy. The National Fish and Wildlife Foundation works by:

- Forging innovative partnerships between the public and the private sector.
- Supporting projects that provide solutions for root causes of environmental problems.
- Awarding grants for conservation - 1,205 grants totaling over $158 million.
- Leveraging - for every $1.00 in federal matching funds, NFWF and its conservation partners provide more than $2.00 in direct non-federal contributions for a total of $3.00 on-the-ground.
- Maintaining minimal fundraising and administrative overhead -- less than five percent of the Foundation's total budget.
- Widely distributing grants - 504 grantees including federal, state and provincial agencies, colleges, universities, and both domestic and international conservation organizations.
- Working in a national and international scope - 50 states, the Bahamas, Belize, Canada, Costa Rica, Dominican Republic, Greenland, Guatemala, Haiti, Honduras, India, Jamaica, Kenya, Mexico, Panama, Puerto Rico, Russia, Tanzania, and the United Kingdom.

PROJECT PERFORMANCE

The US Geological Survey is in the progress of analyzing water quality data from local gaging stations. The purpose of the evaluation is to determine the relative impact of the project on water quality. The Task Force continues to monitor the progress of the USGS water quality analysis and will report on the results as soon as they are available from the USGS. There is growing anecdotal evidence that the erosion control measures are successful. Local confidence in the structural measures continues to increase. Firm scientific evidence of sediment yield reduction is pending based upon the water quality analysis by the USGS.

The Task Force continues to involve landowners in riparian management plans. Continuous, complete coverage of the riparian corridor along Muddy Creek by the landowners will accelerate the progress of the overall stream restoration.

Several grade control structures received minor maintenance this past year. Maintenance included replacing some stones, widening the groins of one structure, and choking the rock along the banks of the structures with topsoil to foster vegetative growth on the structures. There have been no substantial structural failures of the grade control structures, barbs, or revetments. The Task Force is gaining expertise in the construction phase based upon the performance of installed structures.

PROJECT TASKS

Progress Reports and Invoices

Reclamation will produce progress reports on all tasks for the Cascade County Conservation District. Progress reports will accompany invoices.

Final Report on Demonstration Project

Reclamation will produce a final report describing all aspects of the Muddy Creek Demonstration Stream Restoration Research Project. This report will be submitted to the Cascade County Conservation District, the Montana Area Office and the Office of the Research Director, US Bureau of Reclamation by September 30, 1997.

Individual Structure Evaluation and Inventory

Reclamation will produce an inventory of all structure installations on Muddy Creek that are part of the restoration project. The inventory will include location, description, drawing with dimensions, photo if available, and an evaluation of performance and endurance of each structure.

CAD Based Three-dimensional Model of Project Area

Reclamation will incorporate all surveying data provided by the NRCS into a three-dimensional CAD based model of the project area. The basis of the model is the 1995 topographic survey of the demonstration reach by the Muddy Creek Task Force. The model will include pre-construction cross-sectional surveys, water surface profiles, and the exhaustive cross-sectional survey completed by NRCS in the spring of 1995.

Design & Construct Low Cost Culvert Crossing

Reclamation will provide a demonstration design for a low-cost culvert crossing for Muddy Creek and supervise construction by October 31, 1996. The crossing will demonstrate dual functionality as a grade control structure and crossing. The crossing will be in the vicinity of buildings owned by the Wohlgemuth family. The design will be suitable for permitting by responsible agencies. The target cost for the construction of the crossing is $5,000.

Sight and Install Barbs

Reclamation will continue to provide construction supervision to Greenfield Irrigation District, a Muddy Creek Task Force member, for the purpose of installing barbs. Arrangements for specific types and dates for supervision will be determined and specified in writing by the Team Leader, the MCTF Coordinator, and the Greenfield Irrigation District Manager.

Engineering Design of Future Structures for Muddy Creek

As the resources for this agreement near exhaustion, Reclamation will provide a generalized plan for future structural modifications necessary for the continued restoration of Muddy Creek. The plan can include proposals for additional funding resources.

Miscellaneous

The Reclamation Team Leader will provide as necessary reports, papers, proposals, and scope development as directed by the MCTF Coordinator. The CCCD may request the presence of the Reclamation Team Leader at meetings of the MCTF. The miscellaneous tasks are secondary to all other tasks. and are assignable only within the financial resources of the project.

DELIVERABLES

The Reclamation Team Leader will deliver the following items to the CCCD:

- Progress Report and Invoices

- Four additional conference proceedings papers or refereed journal papers published before June 1, 1997.
- Travel Reports
- Data analysis in the form of a Project Data Book including photos, videos, drawings, reports, papers, computer files, and all related documentation.
- Demonstration Project Final Report
- Individual Structure Evaluation and Inventory
- CAD based 3-D model of project area
- Design of low cost culvert crossing
- Plans for future structures on Muddy Creek

MILESTONE SCHEDULE

- November 1, 1996 - Complete data reduction in cooperation with NRCS (Eby)
- January 1, 1997 - Inventory and Structure Evaluation, Progress Report & Invoice
- April 1, 1997 - 3-D CAD based model of project area, Progress Report & Invoice
- May 22, 1997 - Presentation of six papers on Muddy Creek at *Management of Landscapes Disturbed by Channel Incision* conference, Oxford, MS.
- June 1, 1997 - Progress Report & Invoice
- August 1, 1997 - Progress Report & Invoice
- September 30, 1997 - Demonstration Project Final Report

STRUCTURE INVENTORY

An inventory of all installed structures was completed in October, 1996 by Wittler & Rollo. There are four primary types of structures presently installed on Muddy Creek between the US Army Corps of Engineers Sill near Vaughn and one river mile above Gordon. The four types are Grade Control Structures (GCS), Barbs, Revetments, and Cutoff Revetments. There are two types of grade control structures, constructed at two design structural heights. Barbs vary in length throughout the project, but vary little in overall shape and function. Revetments are rock blankets installed along a reach of bank to protect against local bank erosion. Cutoff Revetments are blankets of rock placed on fill at an eminent cutoff location. In one case, near Wohlgemuth's upper pump site, a revetment was placed on both the upstream and downstream sides of the cutoff. At the other three locations the revetment was placed on the upstream side only. Each cutoff revetment includes barbs placed upstream and downstream of the revetments.

Grade Control Structure Inventory

There are eleven grade control structures named 1-A through 1-F, 2-A through 2-C, 2-E & 2-F. Figure 1 shows selected structure sites along Muddy Creek. The inventory includes a sill constructed by the US Army Corps of Engineers. The sill was designed for zero drop and constructed in February, 1994. Incision in Muddy Creek below the sill has led to a substantial drop across the sill at the present time. The total drop measured across the grade control structures, including the Corps sill, as shown in Table 1, is 15.16 feet as of October, 1996. The Gordon gage read 45 ft^3/s and the Vaughn gage read 63 ft^3/s. The total drop includes 1.19 feet at the Corps sill. The total design drop for the 11 structures was 17 feet. Not including the Corps sill, the total drop is 15.16-1.19 or 13.97 feet. Therefore, we have achieved 13.97/17 or 82% of the design head, at the flow rate of roughly 45 ft^3/s. Including the Corps sill increases the measured drop to 87% of the design drop.

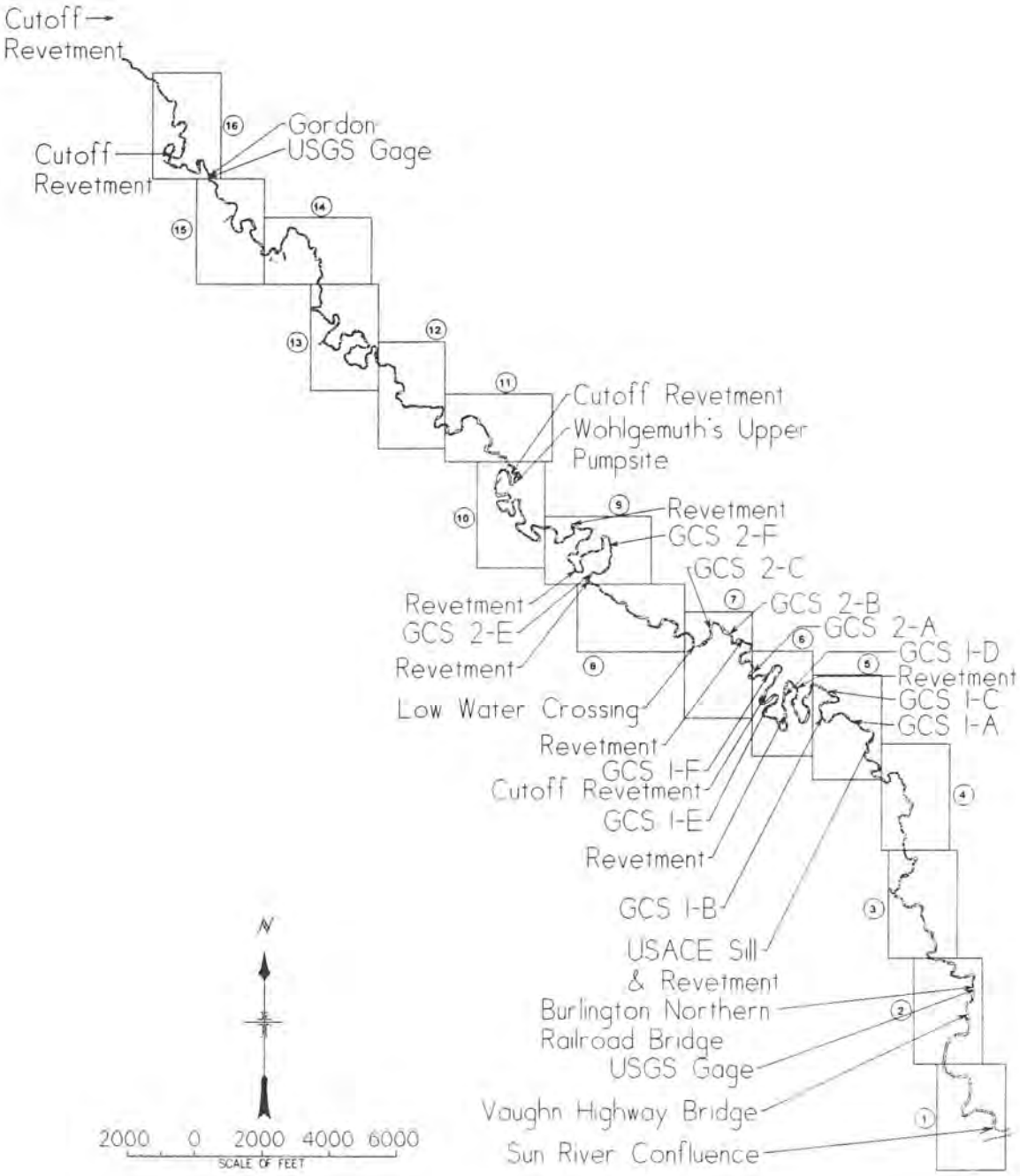

Figure 1. Selected sites along Muddy Creek.

Table 1. Grade control structure inventory.

GCS	Measured Drop (ft)	Design Drop (ft)	% of Design Drop
Sill	1.19	0	N/A
1-A	1.27	1.0	127%
1-B	0.78	1.0	78%
1-C	1.11	1.0	111%
1-D	1.09	1.0	109%
1-E	0.90	1.0	90%
1-F	0.99	2.0	49%
2-A	2.08	2.0	104%
2-B	1.79	2.0	90%
2-C	1.93	2.0	96%
2-D (LWC)	N/A	2.0	N/A
2-E	1.10	2.0	55%
2-F	0.93	2.0	46%
Total	15.16	17.0	Mean 87%

Structures 2-E and 2-F are juvenile structures. The drop at these two structures should evolve over the next two irrigation seasons. The other drops will continue to evolve as well, though the major evolution is complete after three irrigation seasons. The design drop is the design structural height of the structures, not the design hydraulic height. The hydraulic height is 0.5 to 1.0 feet less than the structural height due to the porosity of the rock and the associated interstitial flow.

The structures continue to operate as intended. Grade Control Structures 2-A, 2-B, and 2-C received maintenance during the report period. Structures 1-A, 1-B, and 1-C require minor maintenance. The second generation design structures, 2-E and 2-F, performed as expected during their first irrigation season. Complete evaluation of the structures is due after the 1997 irrigation season.

Barb Inventory

Barbs are rock jetties, triangular in plan, placed on the outside of bends, displacing the thalweg away from the bank. Barbs build stream banks and riparian areas by trapping bed load and suspended sediments. Other names of barbs include jetties, toe dikes, groins, habitat sills, and bendway weirs. Barbs slope from the bank to the stream angling upstream causing a weak back eddy next to the bank. Barbs vary in size depending upon channel size, shape and flow levels. Barb elevation is near the normal high water elevation or the top-of-bank. The elevation of the point of a barb is usually the bed or low water elevation.

Eddies between barbs allow for sediment deposition. During high discharges, high velocity flow against overhanging banks cause banks to collapse into areas between barbs. Bank collapse stops once the banks have reached a threshold slope. Sediment accumulation between barbs eventually results in riparian development. Over time the barbs become less visible as sediment accumulates and riparian vegetation develops. Figure 2 is a section of a typical barb on Muddy Creek. Figure 3 shows how a series of barbs act to turn the current away from the bank and cause eddies and sediment deposition between the barbs.

There are 160 barbs installed on Muddy Creek between Gordon and Vaughn, roughly 8 river miles. Figure 1 shows selected structure sites along Muddy Creek. Task force plans include installation of an equal number of barbs in this reach during the Fall of 1997. There are 33 barbs installed above Gordon, primarily in conjunction with the cutoff revetments in this reach. The Task Force plans include installation of 100-200 barbs in this reach.

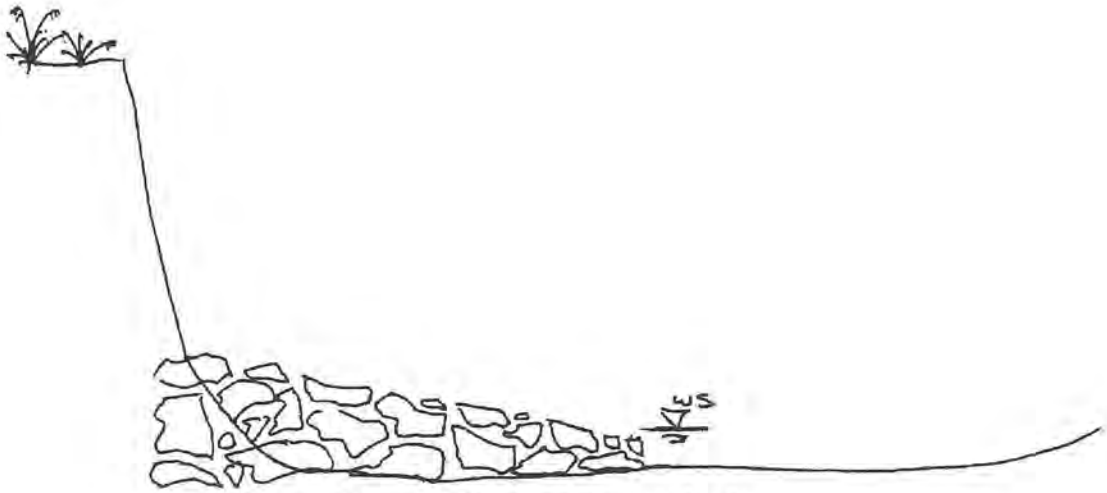

Figure 2. Section of typical barb.

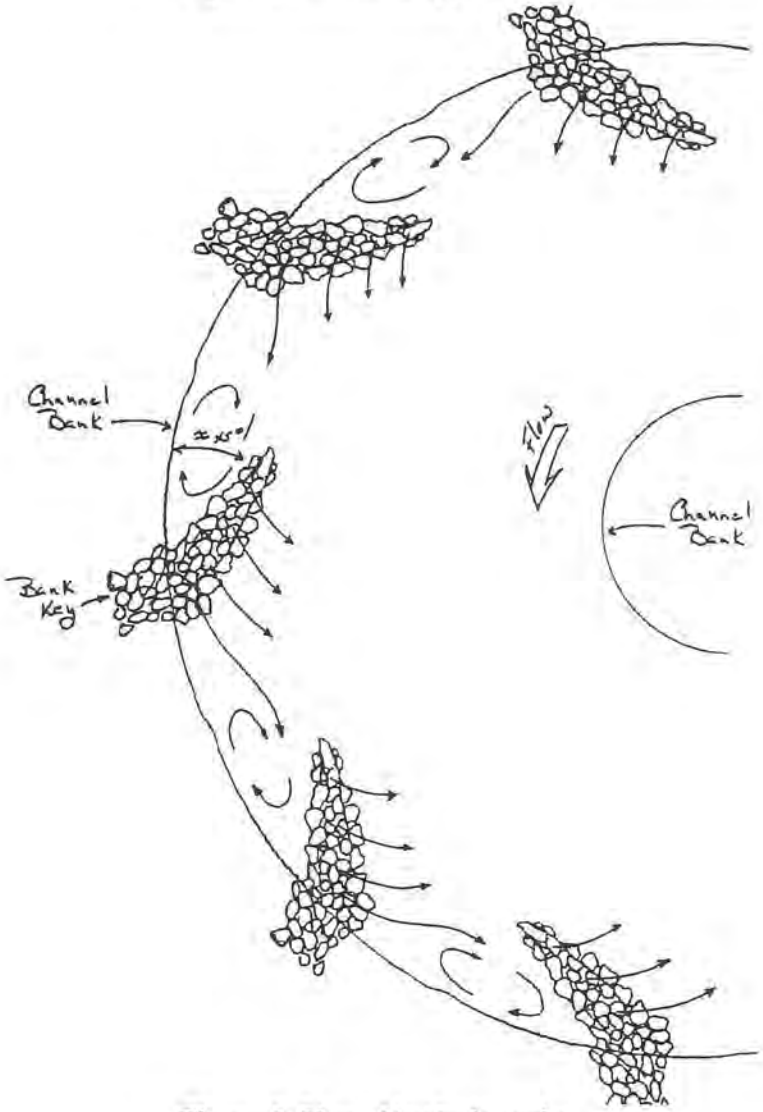

Figure 3. Plan of barbs in series.

Revetment Inventory

Revetments are rock blankets installed along a reach of bank to protect against local bank erosion. There are seven revetments installed on Muddy Creek. Figure 1 shows these sites on Muddy Creek.

1. Below the Wohlgemuth's upper pump site
2. Installed by the Burlington Northern railroad on the upper loop above GCS 2E.
3. Along the railroad below GCS 2E.
4. In the graded slide area below GCS 2B.
5. Between the barbs at the entrance to the new channel downstream of GCS 1D.
6. Downstream around the bend below the new channel on the left bank.
7. The revet installed by the USACE upstream of the sill.

Cutoff Revetment Inventory

Cutoff Revetments are blankets of rock placed on fill at an imminent cutoff location. Figure 1 shows selected structure sites along Muddy Creek. In one case, near Wohlgemuth's upper pump site, a revetment was placed on both the upstream and downstream sides of the cutoff. At the other locations the revetment was placed on the upstream side only. Each cutoff revetment includes barbs placed upstream and downstream of the revetment.

1. Upstream of GCS 1E (Spring 1996)
2. At the upper pump site near the Northwest border of Wohlgemuth's property. (Spring 1994)
3. Upstream of the county road bridge at Gordon (Spring 1996)
4. Upstream of Gordon roughly 1 river mile (Spring 1996)

Rock Stockpiles

The Task Force has five large working stockpiles of rock between Vaughn and Wohlgemuth's upper pump site and two large stockpiles above Gordon. There are several small stockpiles below Gordon. The matching, non-federal funding paid for the rock in the stock-piles. Additional stockpiles are being procured and delivered during the first quarter of 1997.

LOW WATER CROSSING

The Reclamation WRRL designed a low-cost culvert crossing for Muddy Creek in October 1996 and supervised construction in December 1996. The crossing design demonstrates dual functionality as a grade control structure and crossing. The crossing is in the vicinity of buildings owned by the Wohlgemuth family. The design is be suitable for permitting by responsible agencies. The target cost for the construction of the crossing is less than $5,000.

Design

The Cascade County Conservation District issued a Montana State 3A Authorization under the Natural Streambed and Land Preservation Act (310 Permit) on November 8, 1996. The 3A authorization allows for short-term activities that may cause unavoidable violations of state surface water quality standards for turbidity, total dissolved solids, or temperature. The USACE issued a 404 permit to the Task Force to design and install the LWC. Figure 4 is an area map of Muddy Creek near the Wohlgemuth farm buildings. The low water crossing location is in the lower left corner of the figure. Grade control structures 2C and 2B are downstream of the LWC.

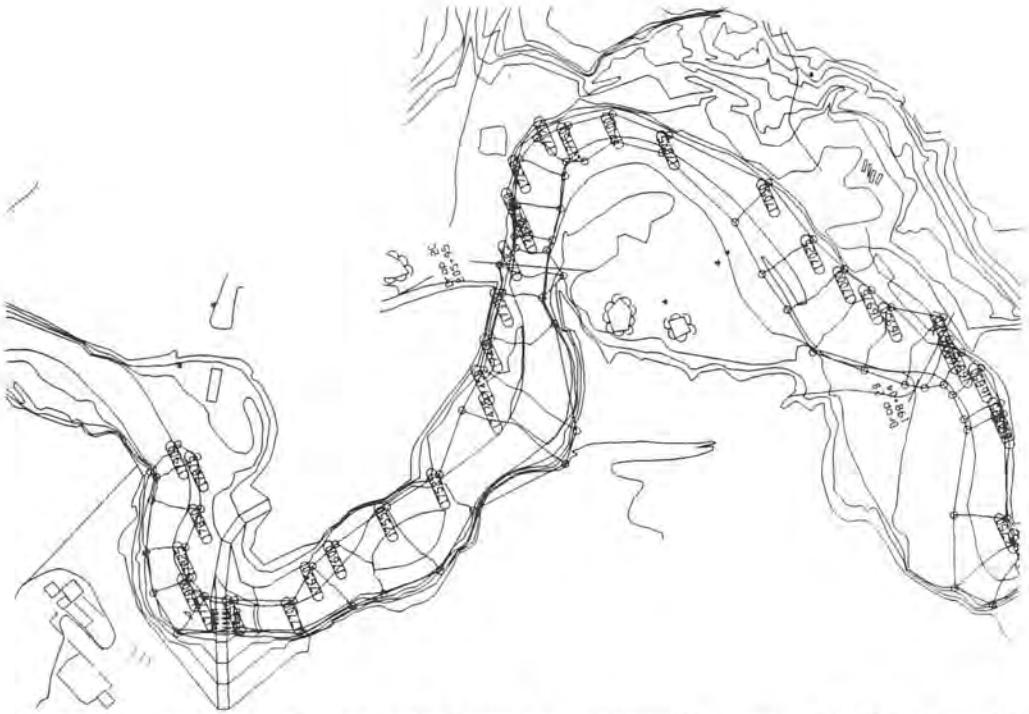

Figure 4. Area map of Low Water Crossing in lower left corner. GCS 2-C and 2-B are downstream of the low water crossing site.

Figure 5 shows the road cut and surrounding topography. The Low Water Crossing consists of four barrels of 38" x 57" pipe arch culvert. The figure shows the alignment of the barrels.

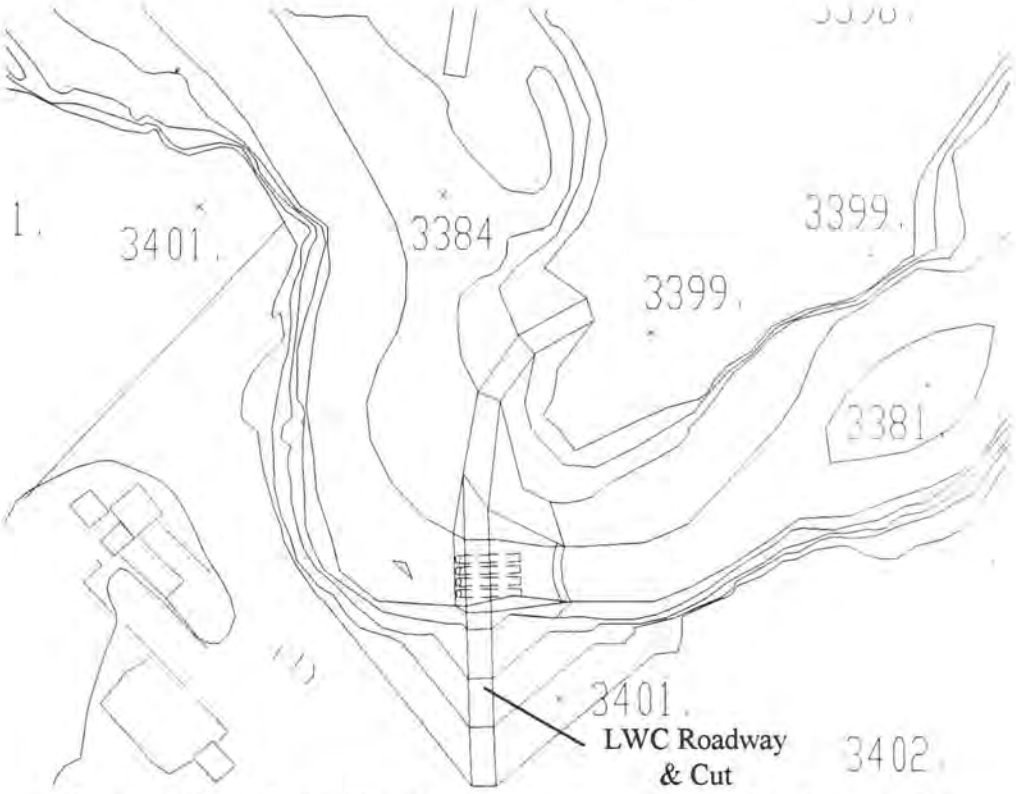

Figure 5. Low Water Crossing, road cut, and surrounding topography.

Low Water Crossing Plans

The Low Water Crossing (LWC) is a hybrid of the 2nd generation grade control structure design and a culvert crossing. The primary construction materials are rock and 38"x57" 40 foot long pipe arch culverts. The complete design of the LWC is shown in the appendix to this report. Figure 6 is a section of the LWC. The roadway width is based upon the farmers implement dimensions.

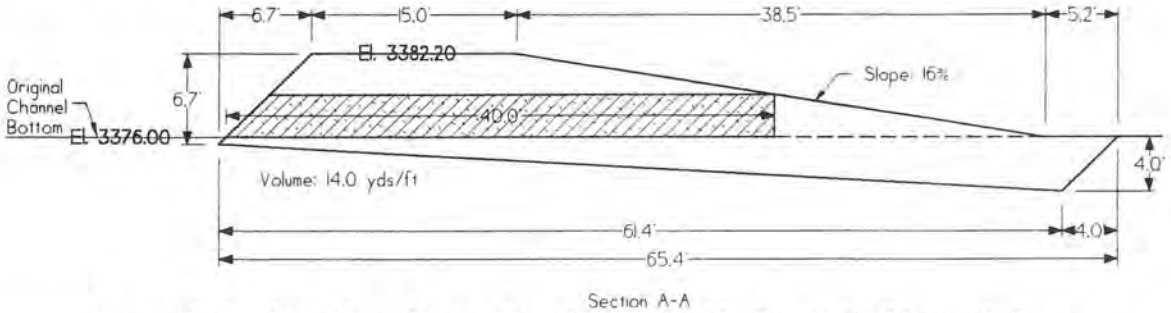

Figure 6. Section of Low Water Crossing on Muddy Creek, Wohlgemuth farm.

Figure 7 is a section of Muddy Creek at the upstream crest of the roadway on the Low Water Crossing. This section shows the degree of incision Muddy Creek has suffered during the past 60 years. The creek used to flow at elevation 3390 or above in this reach and is now at 3376. The section shows the water surface levels for four flows, 50, 395, 1000,and 2000 ft^3/s. The structure is designed to pass up to 395 ft^3/s prior to overtopping. Figure 8 shows the backwater curves for the various discharges in relation to grade control structures 2C and 2B.

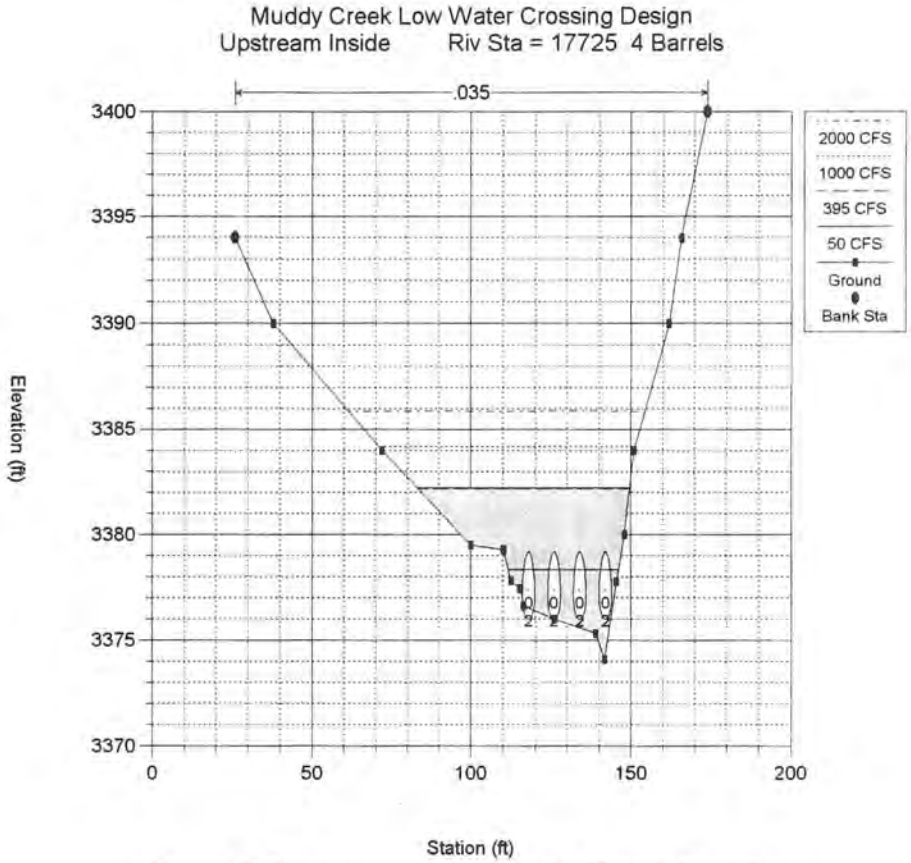

Figure 7. Upstream section at Low Water Crossing.

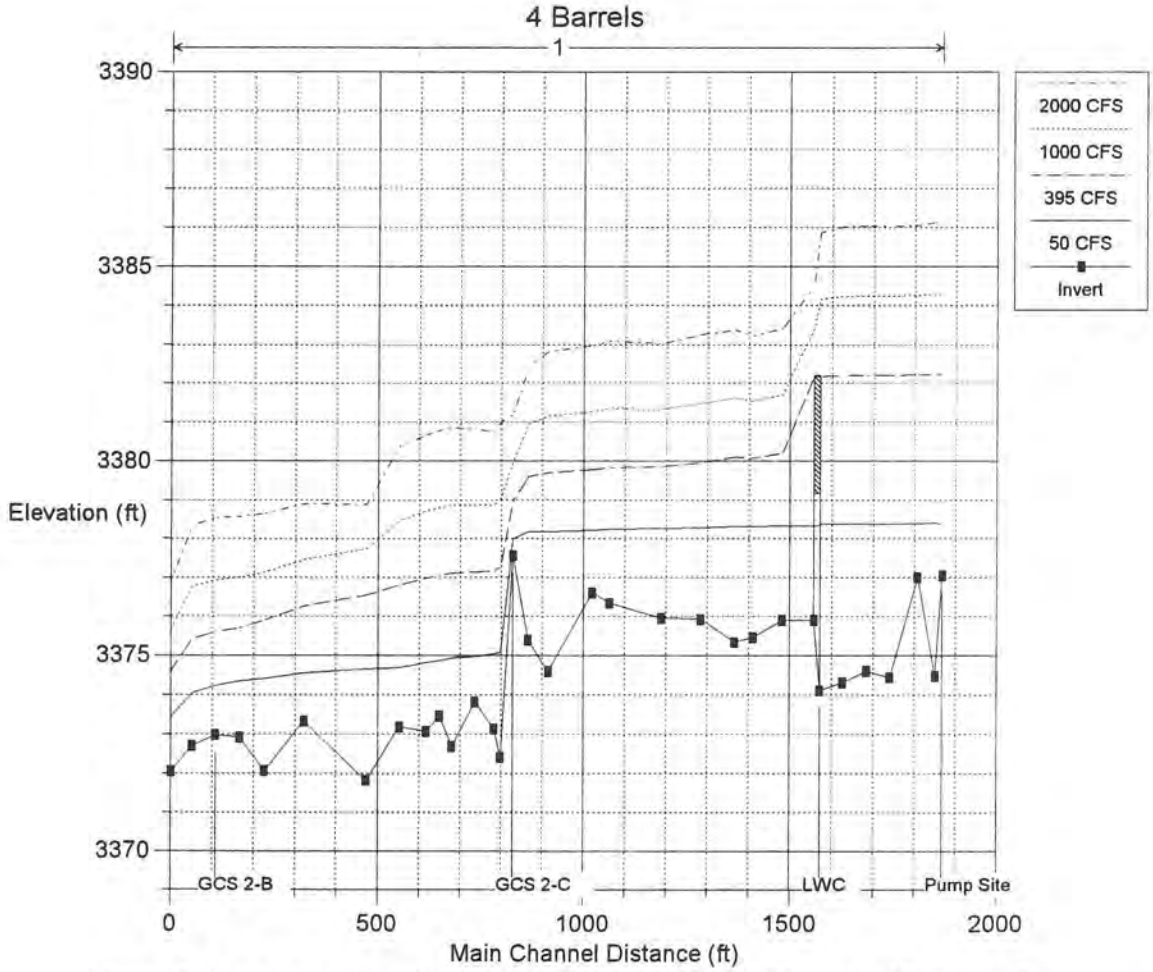

Figure 8. Low water crossing backwater analysis with 4 barrels. Water surface profiles: WS 1 - 50 ft^3/s, WS 2 - 395 ft^3/s, WS 3 - 1000 ft^3/s, WS 4 - 2000 ft^3/s. Main Channel Distance is upstream from structure 2-B.

Table 2 lists the hydraulic properties of the low water crossing. The structure is designed to pass 300 ft^3/s with one foot of freeboard on the roadway crest. The over topping discharge is 395 ft^3/s. At 1000 ft^3/s the drop is calculated to be roughly 2 feet, or the same magnitude as the higher grade control structures. The Low Water Crossing effectively serves as a grade control structure. In the inventory the LWC has been assigned the designation 2D. In fact, the original GCS construction plan called for a 2D structure and the original site is roughly 450 feet upstream of the LWC location. Therefore, for all practical purposes, the LWC satisfies the need for GCS 2D.

Table 2. Hydraulic properties of Low Water Crossing

Q Total (ft^3/s)	Drop (ft)	Freeboard (ft)
50	0.04	3.84
395	1.97	0.03
1000	2.46	-1.97
2000	2.47	-3.68

Materials

Table 3 lists the materials and modifications for the low water crossing. The total price for the culverts is $5,680. This is slightly above the target amount for the structure materials.

Table 3. Materials for low water crossing.

Number	Description	Unit Cost	Cost
8	57"x38" Pipe Arch Culvert, 20ft	$29.50/ft	$4720.00
4	45 degree bevel cut	$160/cut	$640.00
4	57"x38" Pipe Arch Band	$80/band	$320.00
		Total	$5680.00

Construction

Construction took place during the period of December 1, 1996 - December 19, 1996. Greenfield Irrigation District provided construction equipment and labor during this period. Wittler provided construction supervision.

PUBLICATIONS & REPORTS

Lynn Holt wrote the following article for the Department of Interior newspaper "People Land & Water." Lynn works for Reclamation in the Denver Technical Service Center. The focus of the article is Federal Partnerships. The article describes several examples of successful Public-Private partnerships. Muddy Creek was selected as a subject for the article. Sean Keeney and Rod Wittler assisted in the preparation of the article. Sean works for Reclamation in the Montana Area Office in Billings, Montana. The article appears in the December/January 1997 issue, Vol. 4, No. 1, of People Land & Water. For copies of this issue write to PLW, Main Interior, MS 6013, 1849 C Street, NW, Washington, D.C., 20240.

"PARTNERING" TAKES ON A WHOLE NEW MEANING

by Lynn Holt, Public Affairs Specialist, Bureau of Reclamation

Webster's defines the following:

part•ner, n. 1. A person associated with another or others in a common activity or interest. 2. One who cooperates with another in a venture, occupation, or challenge.
part•ner•ship, n. 1. The state of being a partner. 2. A contract entered into by two or more persons in which each agrees to furnish a part of the capital and labor for a business enterprise and by which each shares in some fixed proportion in profits and losses.

As defined by the Federal Government:
part•ner•ing, vt. 1. Committing to cooperate with another Federal, State, or local agency, special interest group or private entity to accomplish an activity of mutual and/or public benefit, with costs or in-kind services shared between the partners. 2. One of the best win-win situations available to agencies to initiate or complete projects in spite of today's budget crunch.

The "Partnership" concept is nothing new to the Bureau of Reclamation. Reclamation has been partnering for many years to more efficiently and economically accomplish its mission. The agency has entered into many Memorandums of Understanding (MOU's) and Cooperative Agreements with a myriad of partners to accomplish such things as restoring and enhancing riparian habitat; posting interpretive signs along wetlands; providing fishing education and opportunities for disabled children; providing nesting habitat for birds; constructing handicapped facilities at State parks; lake shoreline stabilization; and cultural resources inventories and site evaluations. Some noteworthy examples are summarized below:

Hackberry Flat, Oklahoma
Reclamation and The Williams Companies, Inc., have joined a partnering effort led by the State of Oklahoma to restore Hackberry Flat, a 3,750-acre natural basin in southwest Oklahoma. Prior to its drainage and conversion to farmland, it was the largest isolated wetland in the state and an important stopover for thousands of migrating waterfowl and shorebirds. The partnership includes numerous local, state, and Federal agencies, as well as non-Government organizations and groups.

This basin is part of a 7,250-acre parcel purchased by the State of Oklahoma's Department of Wildlife Conservation for use in its Hackberry Flat Wetland Restoration Project. Once the area is restored, it is expected to be used by over 200,000 waterfowl and shorebirds, including the endangered whooping crane. Reclamation and the Mountain Park Conservancy District will provide 2,352 acre-feet of water per year, and The Williams Companies have agreed to donate approximately 16 miles of steel pipe to deliver water to the basin from the supply source.

"The opportunity to partner with the State of Oklahoma and the Bureau of Reclamation for such a worthwhile project is exciting, and we look forward to doing what we can to make this effort a success," said Keith Bailey, Williams chief executive officer. The donated pipe will be collected from Williams' five natural gas pipe companies--Transcontinental Gas Pipe Line Corporation, Northwest Pipeline Corporation, Kern River Gas Transmission Company, Texas Gas Transmission Corporation, and Williams Natural Gas Company. It will be gathered over the next year and made available to the Oklahoma Department of Wildlife Conservation in the fall of 1997.

Las Vegas Wash Wetlands, Nevada

A section of wetlands at Las Vegas Wash in the Lake Mead National Recreation Area in Southern Nevada is being restored through Reclamation's partnering with the National Park Service and Lake Las Vegas Corporation.

Las Vegas Wash flows year-round from the Las Vegas Valley into Lake Mead's Las Vegas Bay. The primary source of water for the wetlands is from treated wastewater effluent, with intermittent storm drainage from the Las Vegas Valley. Formerly, the project area was dominated by exotic tamarisk (salt cedar), the wildlife habitat was degraded, and there was severe bank erosion due, in part, to increased flows into the Wash from population growth in Southern Nevada.

Reclamation's Denver Technical Service Center provided design for the project, and the Grand Canyon and Yuma Area Offices are cooperating to complete the construction. To bring a portion of this wetland area back to its original condition, crews have removed the tamarisk from the area through cutting, use of heavy equipment, and burning. Rock detention berms are being constructed to form two pools of water totaling 7.5 acres of wetlands and riparian habitat, as well as reducing the rate of water flow, and therefore, erosion. The Lake Las Vegas Corporation donated 20,000 cubic yards of rock for this portion of the project.

When construction is complete, the National Park Service will take the lead in vegetation management of the area by planting 10 acres of native vegetation, including emergents such as spikerush and sedge and riparian plants like cottonwood and willow. These wetlands will provide some degree of water treatment to the effluent while providing enhanced wildlife habitat and visitor recreational experiences. Also, as funding permits, the Park Service will develop a network of trails, interpretive exhibits, and observation platforms.

Upon completion, this project will be staffed by National Park Service employees and volunteers from the local community. It will complement the proposed Clark County Wetlands Park. Together, they will provide opportunities to educate and involve the public through a visitor center and research campus, trails, and interpretive displays along the riparian areas.

Parrott-Phelan Diversion Fish Screen, California

Butte Creek in Northern California has historically supported viable populations of fall- and spring-run chinook salmon. However, it is also a major source of water for wetlands on the Upper Butte Basin Wildlife Area, which provides important habitat for migratory waterfowl in the Pacific Flyway. As water was diverted from the Creek for agricultural and wetlands flooding, concerns arose over possible loss of salmon in the process.

So, with principal funding provided by the California Department of Fish and Game, Reclamation partnered with U.S. Fish and Wildlife Service, Ducks Unlimited, the M&T Ranch, and Parrott Ranch to assist in installation of a fish screen at the diversion point. Reclamation contributed $22,000 for site preparation for the fish screen, which will protect the fish while water is diverted for wetland flooding and post-harvest shallow inundation of rice straw for migratory waterbirds without damaging important anadramous fish runs.

Muddy Creek Demonstration Research Project, Montana

Muddy Creek, a tributary of the Sun River near Great Falls, Montana, has long been recognized as a "problem child" in the Upper Missouri River Basin. For decades, increased agricultural development and irrigation return flows have lead to extensive erosion of banks and the loss of acres of farmland every year. The aptly named Muddy Creek transports roughly 200,000 tons of sediment annually into the Sun River,

severely impairing the water quality in both the Sun and Missouri Rivers. In recent years, Montana designated Muddy Creek as the State's number one non-point source pollution problem.

In the early 1980's, operational changes and delivery system modifications on the Greenfields Irrigation District (District) began through Reclamation's Rehabilitation and Betterment Program. In a cooperative effort between the water users, the U.S. Natural Resources Conservation Service (NRCS), and other State agencies, on-farm changes in irrigation methods and efficiency resulted in a yearly reduction of approximately 20,000 acre-feet of irrigation return flows to the Creek.

In 1992, local interests formed the Muddy Creek Task Force. The Task Force called on Reclamation and the NRCS to demonstrate the latest river restoration and watershed planning technology in the most severely eroded reach of the stream. The goal of the demonstration project was the evaluation of a low cost grade control and bank protection design in a 4-mile

reach of the stream. Low profile rock structures were used to control the grade and to protect the eroding banks, giving the riparian vegetation a chance to establish. Also, limiting livestock access revitalized root systems and reduced physical trampling, further resulting in bank stabilization and improved riparian habitat.

"Muddy Creek is a perfect example of how teamwork can bring positive results and solutions to a major water quality problem," stated Alan Rollo, Task Force Coordinator for Muddy Creek Project. "It's been a great thrill to be a part of this worthwhile project."

Reclamation provided funding and technical assistance for this project. The NRCS is working with farmers, ranchers, and landowners to improve farming and ranching practices in the watershed. In addition, the NRCS is providing surveys, fencing, and grazing recommendations. The District provided the work force and equipment for the demonstration project.

From the success of these efforts, competitive grants from Montana Legislature, the Environmental Protection Agency, and the National Fish and Wildlife Foundation were awarded to the Task Force for the continuing restoration of Muddy Creek and the overall Sun River Watershed. An agreement was signed between Reclamation, the NRCS, the District and three local County Conservation Districts to continue to work together on a plan to address the water related issues of the basin. Significant gains have been made toward reaching the goal of restoring the Muddy Creek watershed and improving the water quality of the Sun and Missouri Rivers in Montana.

These examples are just a few of the many meaningful projects that Reclamation is involved in with a variety of partners throughout the West. It seems clear that, as agencies continue to downsize and budgets continue to shrink, "partnering" will surely continue to grow as a viable means of accomplishing important and exciting work!

For more information on this article contact Lynn Holt, 303-236-3289x308, D-5010, POB 25007, Denver, CO 80225.

FINANCES

The term of the NFWF portion of the project is from October 1, 1996, to November 30, 1997. Under this amendment the CCCD will disburse to Reclamation an amount not to exceed a total of $51,000. The contribution of Reclamation is in the form of labor, equipment, travel, and facilities.

Schedule

Reclamation will invoice the Cascade County Conservation District per the following schedule:

Date	Amount	Progress Report	Period
10/1/96	$10,000	No	10/1/96 to 12/31/96
1/1/97	$10,000	Yes	1/1/97 to 3/31/97
4/1/97	$11,000	Yes	4/1/97 to 5/31/97
6/1/97	$10,000	Yes	6/1/97 to 7/31/97
8/1/97	$10,000	Yes	8/1/97 to 9/30/97

Monthly financial reports and progress reports accompany invoices according to the schedule. The Cascade County Conservation District will disburse the invoice amount within 30 days of receipt of an invoice. Reclamation will not create a deficiency, that is, perform work in the absence of funding. Unexpended funds will be returned to the CCCD by Reclamation.

During the period of October 1 - December 31, 1996, the WRRL incurred the following expenses.

Table 4. Reimbursable Work - US Department of the Interior, Bureau of Reclamation.

Activity	10/1/96-12/31/96	CRDA Total
1. Personnel	$9,315.02	$24,7051.02
2. Indirect		
3. Travel	$502.00	$3,915.93
4. Contracts		($94.60)
5. ADP		
6. CADD		
7. Other		
Total Costs	$9,817.02	$28,572.35
Receipts		$28,000.00
Total Costs Less Receipts	$9817.02	$572.35

Appendix

COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT

CRDA-96-1

Muddy Creek Demonstration Stream Restoration Research Project

Cascade County Conservation District Agreement 96-1

This Cooperative Research and Development Agreement (CRDA) is entered into by and between the Cascade County Conservation District (CCCD), in conjunction with the Muddy Creek Task Force (MCTF), and the US Bureau of Reclamation (Reclamation) under the authority of the Technology Transfer Act of 1986 (Public Law 99-502) Section 11 "Cooperative Research and Development Agreements". This CRDA also serves as a service agreement between the CCCD and the Reclamation Technical Service Center. The parties agree as follows:

Article 1. Definitions

1.1 "Cooperative Research and Development Agreement" refers to research activities described in Article 2 that are jointly undertaken by the CCCD and Reclamation.

1.2 "Invention" is any invention or discovery that is or may be patentable under Title 35 of the United States Code.

1.3 The term "made" in relation to an invention, is the conception or first actual reduction to practice of such invention.

1.4 "Proprietary Information" is information that embodies trade secrets developed at private expense or that is confidential business or financial information; provided, further, that Proprietary Information does not include any information that:

(i) is generally known or available from other sources without restrictions concerning its confidentiality;

(ii) has been made available by the owner(s) to others without restrictions concerning its confidentiality; and

(iii) is already available to the Government without obligation concerning its confidentiality.

1.5 "Subject Data" is all written or other graphic information and data first produced in the performance of this Agreement.

1.6 "Subject Invention" is any invention conceived or first actually reduced to practice in the performance of work under this Agreement.

Article 2. Statement of Work

The cooperative research activities under this Agreement shall be performed in accordance with the Statement of Work attached hereto as Appendix A. Any modification to this initial scope of work shall be by mutual written agreement between the CCCD and Reclamation.

Article 3. Term/Financial Obligation

3.1 The term of the project is from October 1, 1995, to September 30, 1997. Reclamation hereby confirms that it commenced the work on October 1, 1995. The total contribution of the CCCD shall be as described in Article 3.2. The contribution of Reclamation shall be in the form of labor, equipment, travel, and facilities only.

3.2 The CCCD will disburse to Reclamation the amount of $18,000 before December 31, 1995. Except as may otherwise be hereafter agreed to in writing by the parties, the total cost to the CCCD here under shall not exceed $18,000, and the CCCD shall not be obligated to pay to Reclamation any amount in excess of said $18,000. Invoices shall be sent to:

Alan Rollo
Muddy Creek Task Force Coordinator
808 52nd St. S.
Great Falls, MT 59405

The CCCD shall submit payment to:

US Bureau of Reclamation
Attn.: Mark Hooper, D-7330
P.O. Box 25007
Denver, CO 80225-007

CRDA No. 96-1

Please note "CRDA No. 96-1" on all correspondence and checks.

3.3 Reclamation will maintain separate, current accounts and records concerning its obligations and expenditures under this agreement, and shall provide to the CCCD quarterly a brief report reflecting the use of the CCCD funds. Also, a brief final fiscal report concerning the project will be furnished to the CCCD at the completion of the project. Upon the request and at the expense of the CCCD, the aforementioned accounts and records maintained by Reclamation shall be subject to reasonable review by the CCCD upon reasonable advance notice. Such reviews shall not be performed more frequently than once every twelve (12) months during the term of the project.

Article 4. Patent Rights

4.1 Reporting. Reclamation shall promptly report to the CCCD each Subject Invention disclosed to Reclamation by its employees. The CCCD shall promptly report to Reclamation each Subject Invention disclosed to it by its employees or members.

4.2 Company Employee Inventions. Reclamation, on behalf of the US Government, waives any ownership rights the US Government may have in Subject Inventions made by the CCCD employees or MCTF members under the project, and agrees that the CCCD shall have the option to retain title to any such employee Subject Invention. The CCCD shall promptly notify Reclamation upon making this election, and agrees to file patent applications on such Subject Invention at its own expense and in a timely fashion. The CCCD agrees to grant to the US Government on its employees Subject Inventions a nonexclusive, irrevocable, paid-up license in the patents covering a Subject Invention to practice or have practiced, throughout the world by, or on behalf of the US Government, for its own benefit and without the right to engage in production or to practice for profit, directly or through third parties acting on its behalf. Such nonexclusive license shall be evidenced by a confirmatory license agreement prepared by the CCCD in a form satisfactory to Reclamation. (See Paragraph 4.4)

4.3 Reclamation Employee Inventions. Reclamation, on behalf of the US Government, shall have the initial option to retain title to each Subject Invention made by its employees and in each Subject Invention made jointly by a CCCD employee or MCTF member and a Reclamation employee. In the event that Reclamation informs the CCCD that it elects to retain title to such joint Subject Invention, the CCCD agrees to assign whatever right, title and interest it has in and to such joint Subject Invention to Reclamation. (See Paragraph 4.4)

4.4. Filing of Patent Applications. The party having the right to retain title and file patent applications on a specific Subject Invention may elect not to file patent applications thereon provided that it so advises the other party within ninety (90) days from the date it reports the Subject Invention to the other party. Thereafter, the other party may elect to file patent applications on the Subject Invention and the party initially reporting such Subject Invention agrees to assign its right, title and interest in such Subject Invention to the other party and cooperate with such party in the preparation and filing of patent applications thereon. The assignment of the entire right, title and interest to the other party pursuant to this paragraph shall be subject to the retention by the party assigning title of a nonexclusive, irrevocable, paid-up license to practice, or have practiced, the Subject Invention throughout the world solely for its own benefit and without the right to engage in commerce, directly or indirectly in the patented technology. In the event that neither of the parties to this Agreement elect to file a patent application on subject invention, either or both (if a joint invention) may, at their sole discretion and subject to reasonable conditions, release the right to file to the inventor(s) with a license in each party of the same scope as set forth in the immediate preceding sentence.

4.5 Patent Expenses. All of the expenses attendant to the filing of patent applications as specified in 4.4 above, shall be borne by the party filing the patent application. Any post filing and post patent fees shall also be home by the same party. Each party shall provide the other party with copies of the patent applications it files on any Subject Invention along with the power to inspect and make copies of all documents retained in the official patent application files by the applicable patent office.

Article 5. Data and Publication

5.1 Release Restrictions. Reclamation shall have the right to use all Subject Data for any Governmental purpose, but shall not release such Subject Data publicly except: (i) Reclamation, when reporting on the results of sponsored research, may publish Subject Data, subject to the provisions of Paragraph 5.3 below; and (ii) Reclamation may release such Subject Data, where

such release is required pursuant to a request under the Freedom of Information Act (5 U.S.C. Section 552); provided, however, that such data shall not be released to the public, if a patent application is to be filed (35 U.S.C. Section 205) until the party having the right to file has had a reasonable time to file.

5.2 Proprietary Information. The CCCD shall place a Proprietary Notice on all information it delivers to Reclamation under this Agreement that the CCCD asserts is proprietary. Reclamation agrees that any information designated as proprietary which is furnished by the CCCD to Reclamation under this Agreement, shall be used by Reclamation only for the purpose of carrying out this Agreement. Information designated as proprietary shag not be disclosed, copied, reproduced or otherwise made available in any form whatsoever to any other person, firm, corporation, partnership, association or other entity without the prior written consent of the CCCD, except as such information may be subject to disclosure under the Freedom of Information Act (5 U.S.C. 552). Reclamation agrees to use its best efforts to protect information designated as proprietary from unauthorized disclosure. The CCCD agrees that Reclamation is not liable for the disclosure of information designated as proprietary which, after notice to and consultation with the CCCD, the Commissioner of Reclamation or his designee determines may not lawfully be withheld, pursuant to the dispute resolution procedure in Article 7, or which a court of competent jurisdiction shall adjudge to require disclosure.

5.3 Publication.

5.3.1 Reclamation may submit for publication the results of the research work associated with this project. Depending on the extent of contribution made, employees of the CCCD or MCTF may be cited as co-authors. In no event, however, shall the name of the CCCD or MCTF or any of its trademarks and trade names be used in any publications without its prior written consent.

5.3.2 Reclamation and the CCCD agree to confer and consult prior to the publication of Subject Data to assure that no Proprietary Information is released and that patent rights are not jeopardized. Prior to submitting a manuscript for review which contains the results of the research under this Agreement, or prior to publication if no such review is made, each party shall be offered an opportunity to review such proposed publication and to file patent applications in a timely manner, if it is so entitled under this Agreement.

Article 6. Termination

6.1 The CCCD and Reclamation each have the right to terminate this Agreement upon thirty (30) days notice in writing to the other party.

6.2 In the event of withdrawal of the CCCD, payments previously received by Reclamation pursuant to Article 3 of this Agreement will be retained by Reclamation to be used in support of the project, but no further payment by the CCCD to Reclamation will be required. In such case, benefits to the CCCD under this Agreement shall be deemed forfeited as a result of such the CCCD withdrawal.

6.3 In the event of termination by Reclamation, Reclamation shall refund to the CCCD the prorated portion of the CCCD payments previously made to Reclamation pursuant to Article 3 of the Agreement in excess of the CCCD pro-rata share of the actual costs incurred by Reclamation in performing the work here under. A report on results to the date of termination will be prepared

by Reclamation, and the cost of the report may be deducted from any refund amount due to the CCCD pursuant to this sub-article 6.3, but need not otherwise be paid by the CCCD.

Article 7. Disputes

7.1 Any dispute arising under this Agreement which is not disposed of by agreement of the parties shall be submitted jointly to the signatories of this Agreement for decision.

7.2 If the signatories are unable to jointly resolve a dispute within a reasonable period of time (in no event to exceed ninety (90) days) after submission of the dispute for resolution, the matter shall be promptly submitted to the Commissioner of Reclamation, or his designee, for resolution.

7.3 Continuation of Work. Pending the resolution of any dispute or claim pursuant to this article, the parties agree that performance of all obligations specified under this Agreement shall be continued diligently in accordance with the terms and conditions of this Agreement.

Article 8. Liability

8.1 Property. The US Government shall not be responsible for damages to any property of the CCCD provided to Reclamation pursuant to this Agreement.

8.2 CCCD Employees. The CCCD agrees to indemnify and hold harmless the US Government for any loss, claim, damage, or liability for personal injury (or death) and/or for damage to tangible property caused by the negligent or other wrongful act or omission of any employee of the CCCD arising in connection with this Agreement except to the extent that such loss, claim, damage or liability arises from the negligent or other wrongful act or omission of Reclamation or its employees. Reclamation shall be solely responsible for the payment of all claims for the damage to or loss of property, personal injury or death, or otherwise, arising out of any negligent or other wrongful act or omission of its employees in connection with the performance of work under this Agreement.

8.3 Disclaimer. Reclamation makes no express or implied warranty as to any matter whatsoever, including the conditions of the research or any invention or product, whether tangible or intangible, made, or developed under this Agreement, or the ownership, merchantability, or fitness for a particular purpose of the research or any Invention or product.

8.4 Force Majeure. Neither party shall be liable for any delay in performance of its obligations herein due to any unforeseeable event beyond its reasonable control and not caused by its fault or negligence, including, but not limited to, flood, drought, earthquake, storm, fire, pestilence, lightning and other natural catastrophes, epidemic, war, riot, civic disturbance or disobedience, strikes, labor dispute, or failure, threat of failure, or sabotage of facilities, or any order or injunction made by a court or public agency. In the event of the occurrence of such a force majeure event, the party rendered unable to perform shall promptly so notify the other party. It shall further use its best efforts to resume performance as quickly as possible and shall suspend performance only for such period of time as is necessary as a result of the force majeure event.

Article 9. Miscellaneous

9.1 No Benefits. No member of, or delegate to the United States Congress, or resident commissioner, shall be admitted to any share or part of this Agreement, nor to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

9.2 Governing Law. The construction, validity, performance and effect of this Agreement for all purposes shall be governed by the laws applicable to the Government of the United States.

9.3 Entire Agreement. This Agreement constitutes the entire agreement between the parties concerning the subject matter hereto, and supersedes any prior understanding or written or oral agreement relative to said matter.

9.4 Headings. Titles and headings of the Sections and Subsections of this Agreement are for convenience only, and shall in no way govern or affect the interpretation thereof.

9.5 Amendments. If either party desires to amend this Agreement, the parties shall, upon reasonable notice of the proposed amendment by the party desiring the change, confer in good faith to determine the desirability of such amendment. No amendment hereto shall be effective or binding unless set forth in a written amendment to this Agreement signed by the duly authorized representatives of both parties hereto.

9.6 Assignment. Neither this Agreement nor any rights or obligations of either party here under may be assigned, delegated or otherwise transferred by either party without the prior written consent of the other party.

9.7 Notices. All notices pertaining to or required by this Agreement shall be in writing, and shall be directed to the signatory(s) at their respective addresses shown below.

9.8 Independent Contractors. The relationship of the parties to this Agreement is that of independent contractors and not as agents of each other or as joint venturers or partners. Reclamation shall maintain sole and exclusive control over its personnel and operations.

9.9 Use of Name or Endorsements. (a) The CCCD shall not use the name of Reclamation or the Department of the Interior on any product or service which is directly or indirectly related to either this Agreement or any patent, license or assignment agreement that implements this Agreement, without the prior approval of Reclamation. (b) By entering into this Agreement, Reclamation does not directly or indirectly endorse any product or service provided, or to be provided, by the CCCD, its successors, assignees, or licensees. The CCCD shall not in any way imply that this Agreement is an endorsement of any such product or service.

9.10 Key Reclamation Personnel. The key Reclamation personnel for participation in this CRDA are:

Name	Tel
Philip H. Burgi	(303) 236-5985
Dr. Rodney J. Wittler, Team Leader	(303) 236-2000 x447

The Cascade County Conservation District key contact for participation in this CRDA is:
Debby Wiggers
1807 3rd St. NW
Great Falls, MT 59404
(406) 727-3603

The MCTF Coordinator is the key contact for participation in this CRDA:
Alan Rollo
808 52nd St. S.
Great Falls, MT 59405
(406) 727-4437

Financial Reports

Reclamation will provide the CCCD with quarterly reports of project expenditures during the term of this project. The first such quarterly report shall be due January 15, 1996, for the first quarter of FY 1996.

Article 10. Duration of Agreement and Effective Date

10.1 Duration of Agreement. It is mutually recognized that a demonstration project such as that undertaken here under cannot be rigidly defined in advance, and that the contemplated time periods for completion of each phase are good faith guidelines subject to adjustment by mutual written agreement, to fit circumstances as the project proceeds. In no event will the term of this Agreement extend beyond December 31, 1997, unless it is amended by the parties in accordance with Article 9 of this Agreement. The provisions of Article 4 shall survive the termination of this Agreement.

10.2 Effective Date. This Agreement shall enter into force as of the latest date of the signatures below.

MCTF: _____ Date: _____

Name: Alan Rollo
Title: Muddy Creek Task Force Coordinator
Address: 808 52nd St., S.
Great Falls, MT 59405

Bureau of Reclamation: _____ Date: _____

Name: Dr. Stanley Ponce
Title: US Bureau of Reclamation Research Director
Address: D-6700
PO Box 25007
Denver, CO 80225

Appendix A

STATEMENT OF WORK
US DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Muddy Creek Demonstration Stream Restoration Project

1. STATEMENT OF WORK

1.1. Background

This agreement concerns the efforts of a partnership of Federal and local government agencies and a local citizen task force to solve the water quality problems associated with the incision of Muddy Creek near Great Falls, Montana. The United States Bureau of Reclamation and Greenfields Irrigation District are collaborating to reduce return flow to Muddy Creek. Reclamation, Cascade County Conservation District, and the Muddy Creek Task Force, are collaborating to stabilize the gradient and plan form of the stream.

Project Sponsors

The Sun River Watershed project sponsors include the Cascade County Conservation District (CCCD), Lewis & Clark County Conservation District (LCCCD), Teton County Conservation District (TCCD), Muddy Creek Task Force, Greenfields Irrigation District (GID), Fort Shaw Irrigation District (FSID), Broken O Ranch, Rocky Reef Ditch Company, and the Sun River Ditch Company. Federal, state, and local agencies include the US Bureau of Reclamation, US Fish & Wildlife Service (USF&W), US Bureau of Land Management (BLM), US Forest Service (USFS), Montana Department of Environmental Quality (DEQ), Montana Department of Natural Resources and Conservation (DNRC), Montana Department of Fish, Wildlife and Parks (DFWP), Montana State University Extension Service, Cascade County, City of Great Falls, Montana Power Company (MPC), Burlington Northern Railroad (BN), Medicine River Canoe Club (MRCC), Missouri River Flyfishers, Missouri Breaks Audubon Chapter, Great Falls Chamber of Commerce, Nilan Water Users, Tri-Area Water Users, Communities of Sun Prairie, Vaughn, Sun River, Fort Shaw, Simms, Augusta, Fairfield, and Power, and independent landowners.

Description

Sun River Watershed is east of the continental divide and south of Glacier National Park. It covers an area of 2,200 square miles (1,408,000 acres), with roughly 356 square miles (228,096 acres) in northwest Cascade County, 1089 square miles (696,960 acres) in southern Teton County. The Sun River starts in the Bob Marshell Wilderness area and meanders out of the mountains through rolling grass-covered foothills and farmland to its confluence with the Missouri River at the City of Great Falls.

Muddy Creek, a tributary of the Sun River in the Upper Missouri River Basin, joins the Sun River 15 miles upstream from the Sun-Missouri confluence at Great Falls, Montana. The Creek drains approximately 314 square miles of agricultural land. Muddy Creek is a sinuous stream augmented by irrigation return flows resulting in an eight-fold increase from the mean historical flow.

Irrigation return flow into Muddy Creek from developed agriculture is causing the stream to rapidly incise, accelerating the meandering and cutoff process. The stream has incised roughly thirty-three feet (10 meters) in glacially deposited silty soil. In 1993 Reclamation approved a low cost erosion control scheme as a demonstration research project. Success of the demonstration project may lead to expansion of the project to the headwaters.

The erosion control scheme includes chevron weir rock ramps for grade control, barbs for plan form control, and willow post planting for bank stabilization. The demonstration project is on a four mile reach of stream experiencing the most active erosion. Reclamation is responsible for the design and placement of the rock ramps and barbs, evaluation of performance, and environmental and historic preservation compliance. Cascade County Conservation District is revegetating the area with native grasses and willows and surveying for the monitoring plan. The Task Force secured the necessary permits and provided overall project guidance. Greenfields Irrigation District, a task force member, provided all construction equipment and personnel as an in-kind contribution.

The increased creek flow from irrigation return flows has caused extensive erosion of the fine grained alluvial soils and has transported up to 200,000 tons of sediment annually into the Sun River. Much of this material comes from large scale bank slumping and vertical degrading of the stream bed in the Creek's lower reach. The sediment load transported by the Creek has severely impacted the water quality in both the Sun and Missouri Rivers.

1.2. Objectives

The objective of the Muddy Creek Demonstration Stream Restoration project is to solve the water quality problem associated with the sediment derived from the stream, to rehabilitate and restore the riparian corridor, and to develop new technology for restoring altered streams.

1.3. Scope of Work

A. Task 1: Muddy Creek Task Force Coordination Meeting

The Reclamation Team Leader, Dr. Rodney J. Wittler, shall be in attendance at a coordination meeting of the Muddy Creek Task Force, in Great Falls, Montana, on November 7, 1995. The Team Leader shall participate in short term and long term project planning, especially technical issues related to stream restoration in the Muddy Creek riparian corridor.

B. Task 2: Data Analysis

The Reclamation Team Leader shall perform data analysis necessary to support the decisions and plans of the Muddy Creek Task Force. In addition, the Team Leader shall perform data analysis necessary for documenting and monitoring progress of the project in cooperation with personnel of the US Natural Resources Conservation Service. Portions of the analysis may be performed during a Mini-Sabbatical, as part of the Reclamation Mini-Sabbatical program, in cooperation with Professor Chester Watson, and Colorado State University.

C. Task 3: Construction Supervision

The Reclamation Team Leader shall provide construction supervision to Greenfields Irrigation District, a Muddy Creek Task Force member. Arrangements for specific types and dates for supervision shall be determined and specified in writing by the Team Leader, the MCTF Coordinator, and the Greenfields Irrigation District Manager.

D. Task 4: Miscellaneous

The Reclamation Team Leader shall provide as necessary reports, papers, proposals, and scope development as directed by the MCTF Coordinator. The CCCD may request the presence of the Reclamation Team Leader at meetings of the MCTF. The miscellaneous tasks are secondary to Tasks A, B, and C, and are assignable only within the financial resources specified in Section 3.2.

1.4. Deliverables

The Reclamation Team Leader shall deliver the following items to the CCCD:

- Quarterly Progress Reports beginning January 15, 1996
- Four conference proceedings papers or refereed journal papers published before February 1, 1997.
- A proposal for Reclamation Research funds, part of the Reclamation R&TD function, for FY97.
- Scope of work for Phase II of the Muddy Creek Demonstration Stream Restoration project.
- Travel Reports
- Data analysis in the form of a Project Data Book including photos, videos, drawings, reports, papers, computer files, and all related documentation.

1.5. Milestone Schedule

November 30, 1995 - Scope of work, Phase II

December 4-8, 1995 - Construction supervision

March 1, 1996 - Initial Data Analysis

June 1, 1996 - Completion of Phase II construction

September 30, 1996 - Completion of Phase I & II Data analysis

1.6. Budget

Tasks 1, 2, 3, 4:	$15,000
Travel	$3,000
Total	$18,000

AMENDMENT
COOPERATIVE RESEARCH & DEVELOPMENT AGREEMENT 96-1
US DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Muddy Creek Demonstration Stream Restoration Project

AMENDMENT TO THE AGREEMENT

Article 3. Term/Financial Obligation

3.1.A1 The term of the amendment is from October 1, 1996, to November 30, 1997.

3.2.A1 Under this amendment the CCCD will disburse to Reclamation an amount not to exceed a total of $51,000. Except as may otherwise be hereafter agreed to in writing by the parties, the total cost to the CCCD here under this amendment shall not exceed $51,000, and the CCCD shall not be obligated to pay to Reclamation any amount in excess of $69,000 under the entire CRDA. The contribution of Reclamation shall be in the form of labor, equipment, travel, and facilities only.

3.4.A1 Reclamation shall invoice the Cascade County Conservation District per the following schedule:

Date	Amount	Progress Report	Period
10/1/96	$10,000	No	10/1/96 to 12/31/96
1/1/97	$10,000	Yes	1/1/97 to 3/31/97
4/1/97	$11,000	Yes	4/1/97 to 5/31/97
6/1/97	$10,000	Yes	6/1/97 to 7/31/97
8/1/97	$10,000	Yes	8/1/97 to 9/30/97

Monthly financial reports and progress reports shall accompany the invoice according to the schedule. The Cascade County Conservation District will disburse the invoice amount within 30 days of receipt of an invoice. Reclamation will not create a deficiency, that is, perform work in the absence of funding. Unexpended funds will be returned to the cooperator by Reclamation.

The Cascade County Conservation District shall submit payment to:

US Bureau of Reclamation
Attn.: Mark Hooper, D-7330
P.O. Box 25007
Denver, CO 80225-007

Please note "CRDA No. 96-1: T01-0981-9715-131-01-0-1" on all correspondence and checks.

Article 10. Duration of Agreement and Effective Date

10.2 This Amendment shall enter into force as of the latest date of the signatures below.

MCTF: _____ Date: _____

Name: Alan Rollo
Title: Muddy Creek Task Force Coordinator
Address: 808 52nd St., S.
Great Falls, MT 59405

Bureau of Reclamation: _____ Date: _____

Name: Dr. Stanley Ponce
Title: US Bureau of Reclamation Research Director
Address: D-6700
PO Box 25007
Denver, CO 80225

AMENDMENT TO THE STATEMENT OF WORK

1.1. Amendment to the Background

This agreement concerns the efforts of a partnership of Federal and local government agencies and a local citizen task force to solve the water quality problems associated with the incision of Muddy Creek near Great Falls, Montana. The United States Bureau of Reclamation and Greenfields Irrigation District are collaborating to reduce return flow to Muddy Creek. Reclamation, Cascade County Conservation District, and the Muddy Creek Task Force, are collaborating to stabilize the gradient and plan form of the stream. Funding for the original agreement came from a grant by the State of Montana to the Cascade County Conservation District. Funding for the amendment comes partially from the State of Montana grant ($10,000) and a grant of $41,000 by the National Fish and Wildlife Foundation (NFWF) to the Cascade County Conservation District.

New Project Sponsors

The National Fish and Wildlife Foundation is now an official sponsor of the *Muddy Creek Restoration and Watershed Enhancement Project*. The National Fish and Wildlife Foundation (NFWF) is a 501(c)(3) nonprofit organization dedicated to the conservation of natural resources, fish, wildlife, and plants. Among its goals are species habitat protection, environmental education, public policy development, natural resource management, habitat and ecosystem rehabilitation and restoration, and leadership training for conservation professionals. It meets these goals by forging partnerships between the public and private sectors and by supporting conservation activities that pinpoint and solve the root causes of environmental problems. Headquartered in Washington, D.C., NFWF was established by Congress in 1984. The Foundation invests in the best possible solutions to those problems by awarding challenge grants using its federally appropriated funds to match private sector funds. These combined resources fuel effective conservation projects; however, federal appropriations may not be used for NFWF's operating expenses. The Foundation has awarded 1,205 grants that have leveraged more than $168 million for conservation projects. NFWF's work is local, regional, national, and international in scope. To date, project locations include the 50 states, Puerto Rico, and 17 countries. None of NFWF's grants support lobbying or political advocacy. The National Fish and Wildlife Foundation works by:

- Forging innovative partnerships between the public and the private sector.
- Supporting projects that provide solutions for root causes of environmental problems.
- Awarding grants for conservation - 1,205 grants totalling over $158 million.
- Leveraging - for every $1.00 in federal matching funds, NFWF and its conservation partners provide more than $2.00 in direct non-federal contributions for a total of $3.00 on-the-ground.
- Maintaining minimal fundraising and administrative overhead -- less than five percent of the Foundation's total budget.
- Widely distributing grants - 504 grantees including federal, state and provincial agencies, colleges, universities, and both domestic and international conservation organizations.
- Working in a national and international scope - 50 states, the Bahamas, Belize, Canada, Costa Rica, Dominican Republic, Greenland, Guatemala, Haiti, Honduras, India, Jamaica, Kenya, Mexico, Panama, Puerto Rico, Russia, Tanzania, and the United Kingdom.

1.3.A1 Amendment Tasks

A. Task A1 - Progress Reports and Invoices

Reclamation shall produce progress reports on all tasks described in this agreement to the Cascade County Conservation District. Reports shall accompany invoices.

B. Task A2 - Final Report on Demonstration Project

Reclamation shall produce a final report describing all aspects of the Muddy Creek Demonstration Stream Restoration Research Project. This report will be submitted to the Cascade County Conservation District, the Montana Area Office and the Office of the Research Director, US Bureau of Reclamation by September 30, 1997.

C. Task A3 - Individual Structure Evaluation and Inventory

Reclamation shall produce an inventory of all structure installations on Muddy Creek that are part of the restoration project. The inventory shall include location, description, drawing with dimensions, photo if available, and an evaluation of performance and endurance of each structure.

D. Task A4 - CAD Based Three-dimensional Model of Project Area

Reclamation will incorporate all surveying data provided by the NRCS into a three-dimensional CAD based model of the project area. The basis of the model is the 1995 topographic survey of the demonstration reach by the Muddy Creek Task Force. The model should include pre-construction cross-sectional surveys, water surface profiles, and the exhaustive cross-sectional survey completed by NRCS in the spring of 1995.

E. Task A5 - Design Low Cost Culvert Crossing

Reclamation shall provide a demonstration design for a low-cost culvert crossing for Muddy Creek and supervise construction by October 31, 1996. The crossing shall demonstrate dual functionality as a grade control structure and crossing. The crossing shall be in the vicinity of buildings owned by the Wohlgemuth family. The design shall be suitable for permitting by responsible agencies. The target cost for the construction of the crossing shall be less than $5,000.

F. Task A6 - Sight and Install Barbs

Reclamation shall continue to provide construction supervision to Greenfields Irrigation District, a Muddy Creek Task Force member for the purpose of installing barbs. Arrangements for specific types and dates for supervision shall be determined and specified in writing by the Team Leader, the MCTF Coordinator, and the Greenfields Irrigation District Manager.

G. Task A7 - Engineering Design of Future Structures for Muddy Creek

As the resources for this agreement near exhaustion, Reclamation shall provide a generalized plan for future structural modifications necessary for the continued restoration of Muddy Creek. The plan can include proposals for additional funding resources.

H. Task A8 - Miscellaneous

The Reclamation Team Leader shall provide as necessary reports, papers, proposals, and scope development as directed by the MCTF Coordinator. The CCCD may request the presence of the Reclamation Team Leader at meetings of the MCTF. The miscellaneous tasks are secondary to all other tasks. and are assignable only within the financial resources specified in Section 3.2.A1

1.4. Deliverables

The Reclamation Team Leader shall deliver the following items to the CCCD:

- Progress Report and Invoices
- Four additional conference proceedings papers or refereed journal papers published before June 1, 1997.
- Travel Reports
- Data analysis in the form of a Project Data Book including photos, videos, drawings, reports, papers, computer files, and all related documentation.
- Demonstration Project Final Report
- Individual Structure Evaluation and Inventory
- CAD based 3-D model of project area
- Design of low cost culvert crossing
- Plans for future structures on Muddy Creek

1.5. Milestone Schedule

- November 1, 1996 - Complete data reduction in cooperation with NRCS (Eby)
- January 1, 1997 - Inventory and Structure Evaluation, Progress Report & Invoice
- April 1, 1997 - 3-D CAD based model of project area, Progress Report & Invoice
- May 22, 1997 - Presentation of six papers on Muddy Creek at *Management of Landscapes Disturbed by Channel Incision* conference, Oxford, MS.
- June 1, 1997 - Progress Report & Invoice
- August 1, 1997 - Progress Report & Invoice
- September 30, 1997 - Demonstration Project Final Report

1.6. Budget

Tasks A1, A2, A3, A4 A5, A6, A7, A8:	$41,000
Travel	$10,000
Total	$51,000

Muddy Creek Low Water Crossing Design

Structure Location

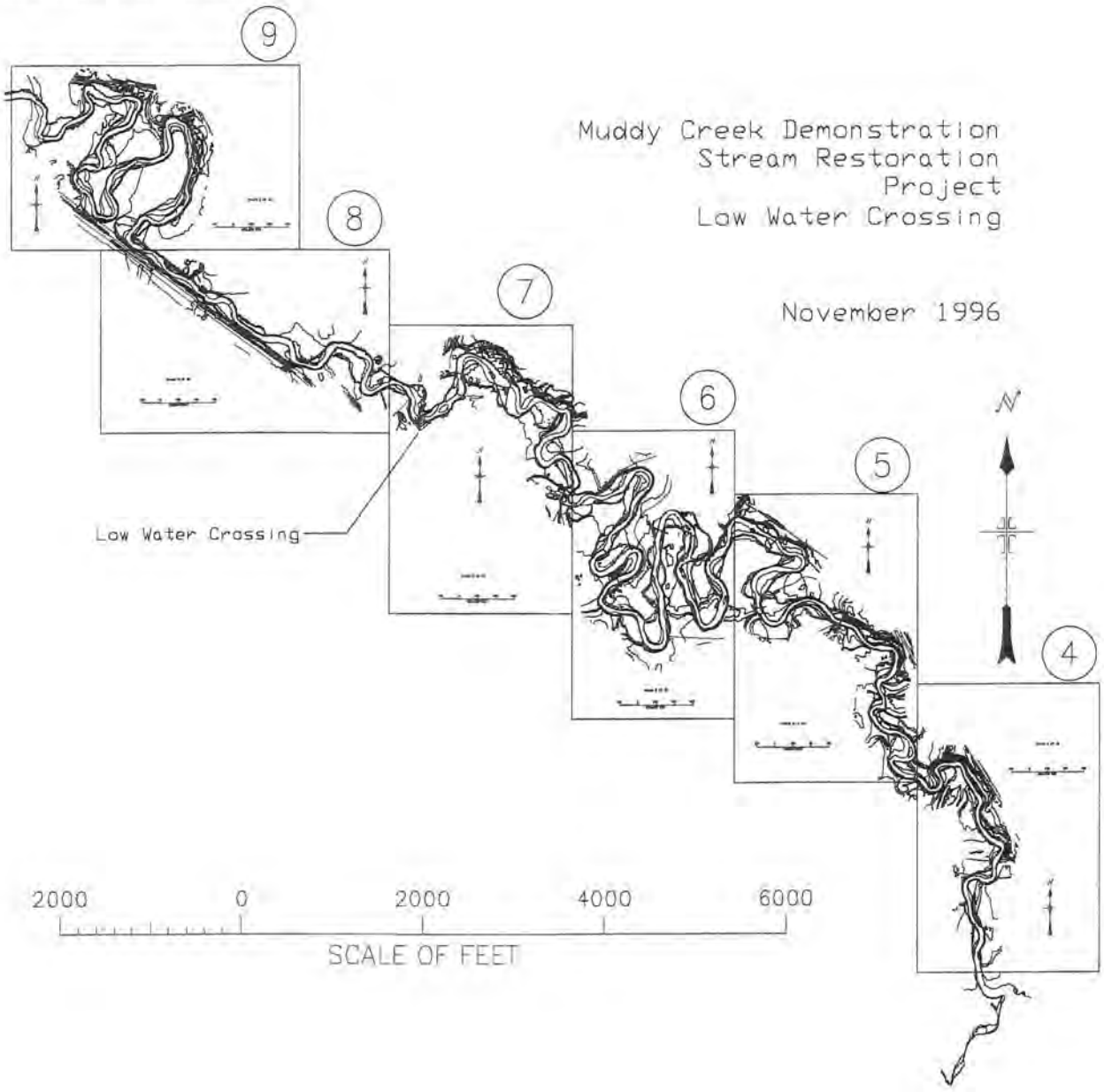

Figure 1. Map of lower Muddy Creek. Sun River - Muddy Creek confluence is in the lower right corner of the map.

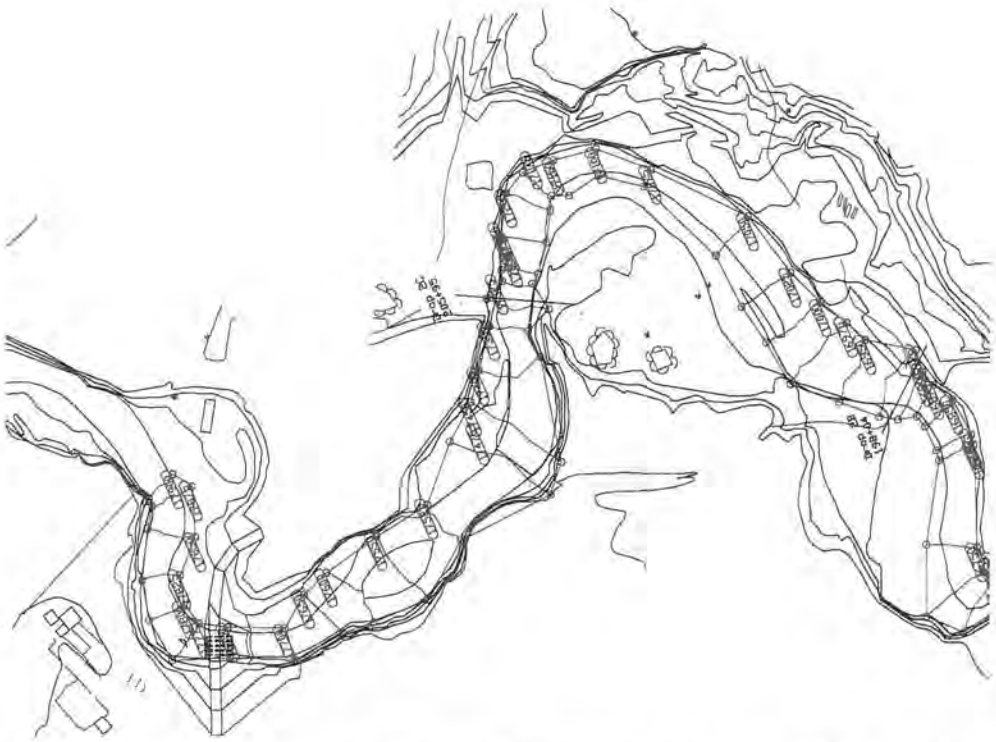

Figure 2. Area map of Low Water Crossing. Grade control structures 2-C and 2-B are downstream of the low water crossing site.

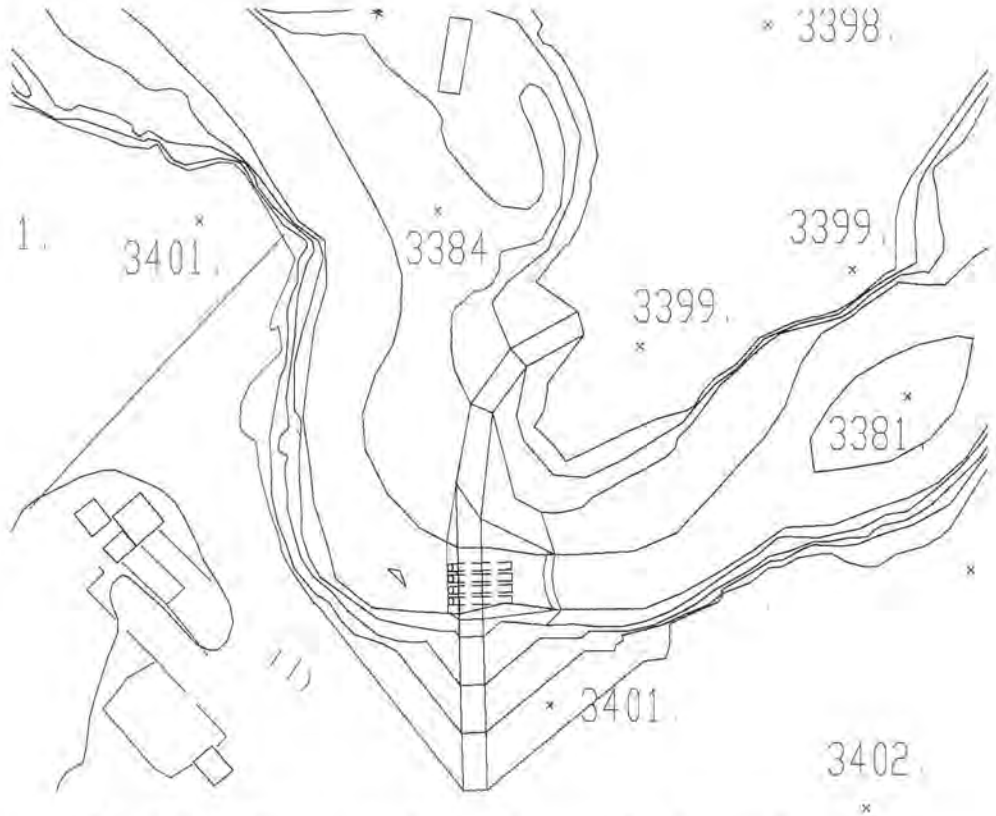

Figure 3. Low Water Crossing, road cut, and surrounding topography.

Figure 4. Downstream view from pump site. LWC site is in the center of the photograph.

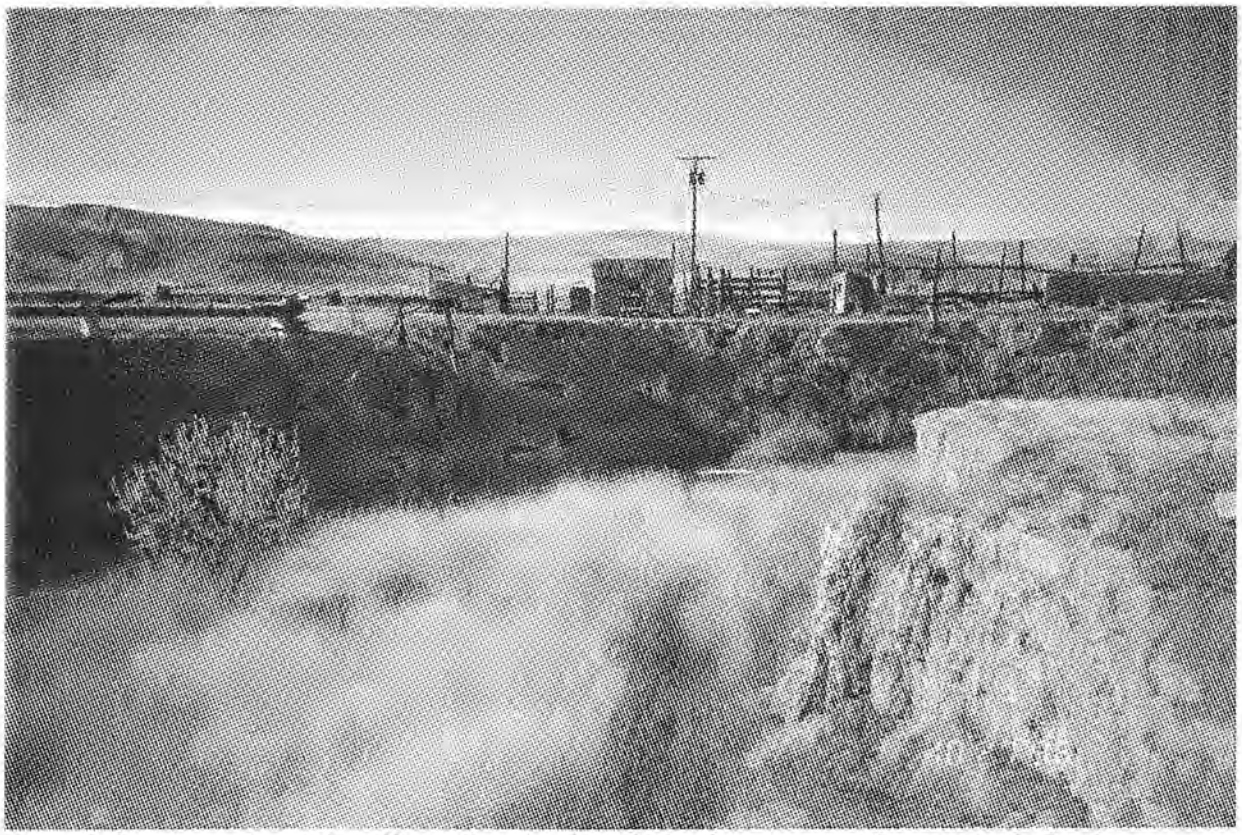

Figure 5. Upstream view of Low Water Crossing Site. Right abutment is at the posts in the bank.

Low Water Crossing Plans

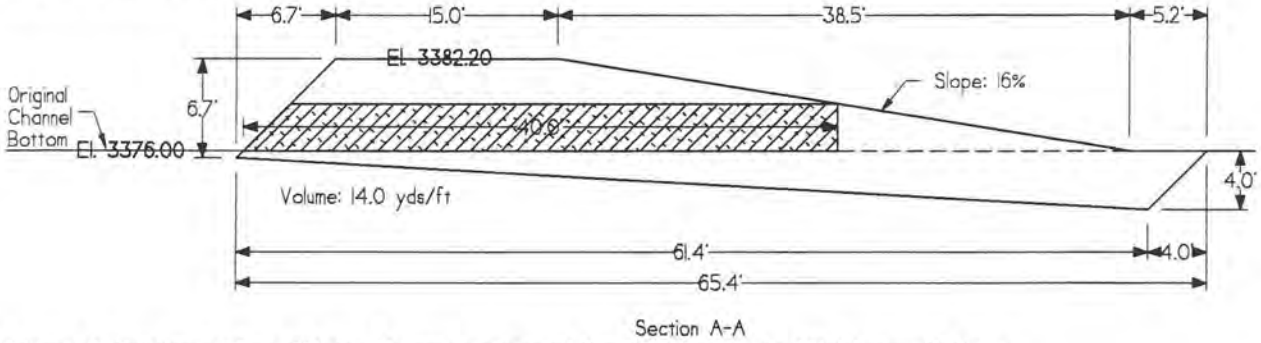

Figure 6. Section of Low Water Crossing planned for Muddy Creek, Wohlgemuth farm.

Water Surface Profile

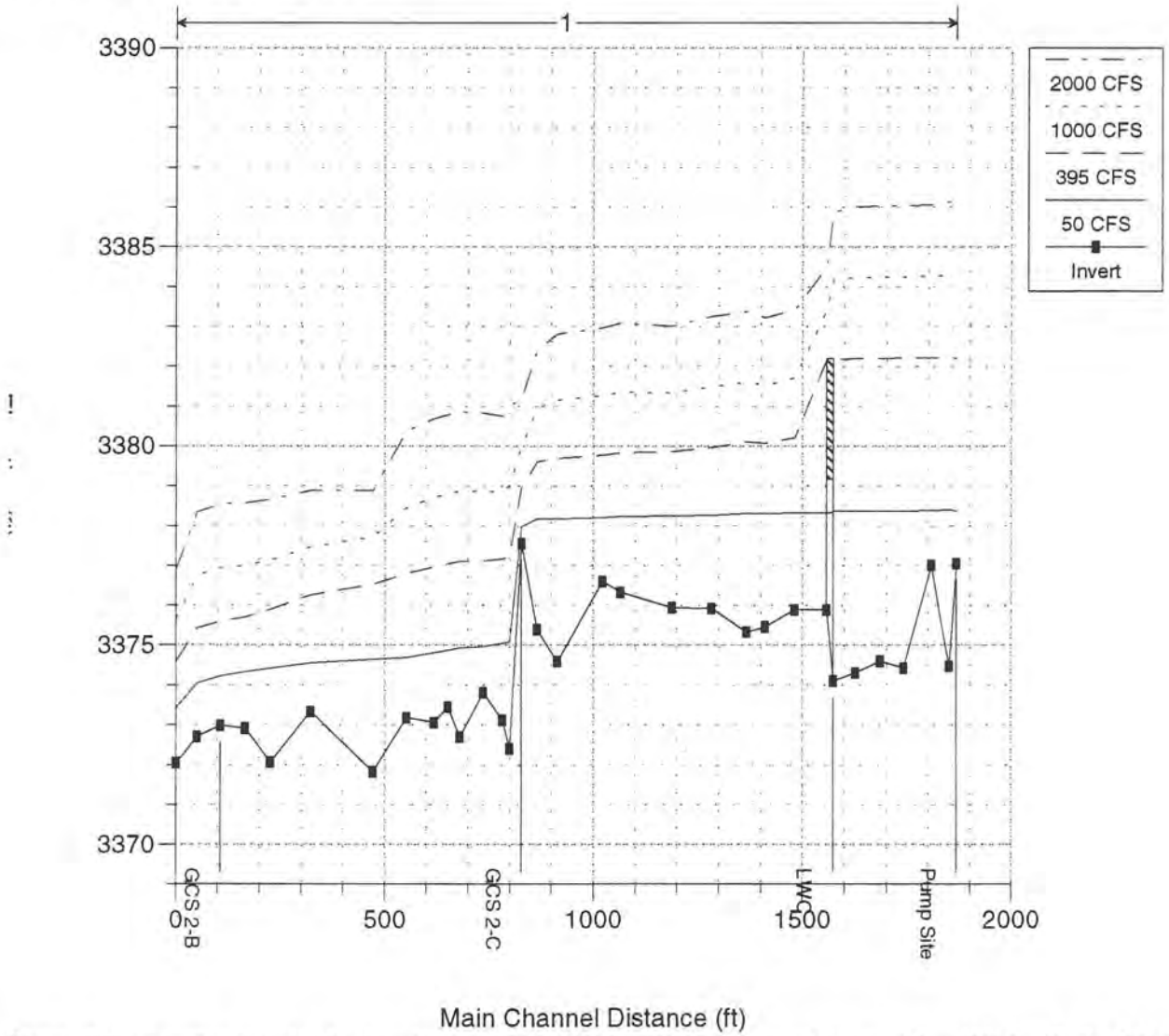

Figure 7. Low water crossing backwater analysis with 4 barrels. Water surface profiles: WS 1 - 50 cfs, WS 2 - 395 cfs, WS 3 - 1000 cfs, WS 4 - 2000 cfs. Main Channel Distance is upstream from structure 2-B.

Materials

Table 1. Materials for low water crossing. Greenfields Irrigation District procured the materials.

Number	Description	Unit Cost	Cost
8	57x38 Pipe Arch Culvert, 20ft	$29.50/ft	$4720.00
4	45 degree bevel cut	$160/cut	$640.00
4	57x38 Pipe Arch Band	$80/band	$320.00
		Total	$5680.00

Hydraulic Data

Table 2. HEC-RAS Plan: Muddy Creek Reach: 1 11/7/96 - 4 Barrels

Q Total (cfs)	Drop (ft)	Freeboard (ft)
50	0.04	3.84
395	1.97	0.03
1000	2.46	-1.97
2000	2.47	-3.68

X-Section Plots

The viewpoint of these sections is looking downstream. The right top-of-bank was generally at elevation 3400.00 while the left top-of-bank was generally at elevation 3394.00. The left top-of-bank borders the alfalfa field belonging to Gary Wohlgemuth. The right top-of-bank between sections 17900 and 17800 borders the abandoned buildings belonging to the Wohlgemuth's. The sections are a composite of the 1995 topography from aerial photography and the 1995 X-Section survey by the NRCS and MCTF. The two surveys were manually joined by Rodney Wittler. Slight variations in the sections may result when the two surveys are officially joined by the NRCS during the winter of 1996-97.

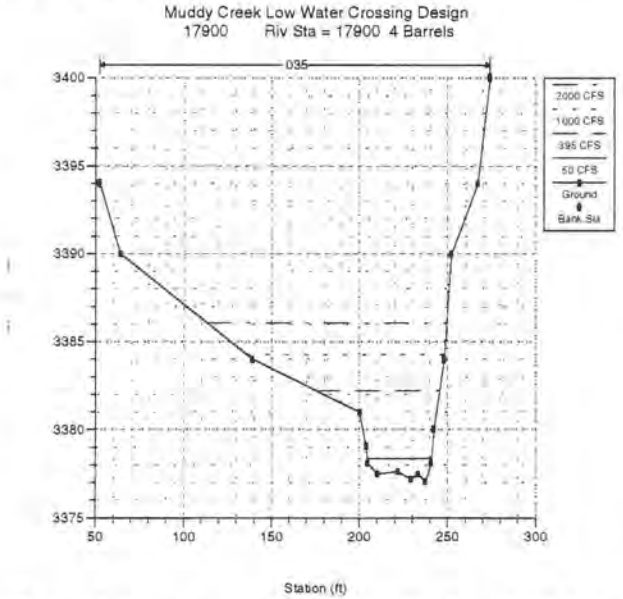

Figure 8. Upper most X-Section, Station 17900. This station is close to the Wohlgemuth pump site.

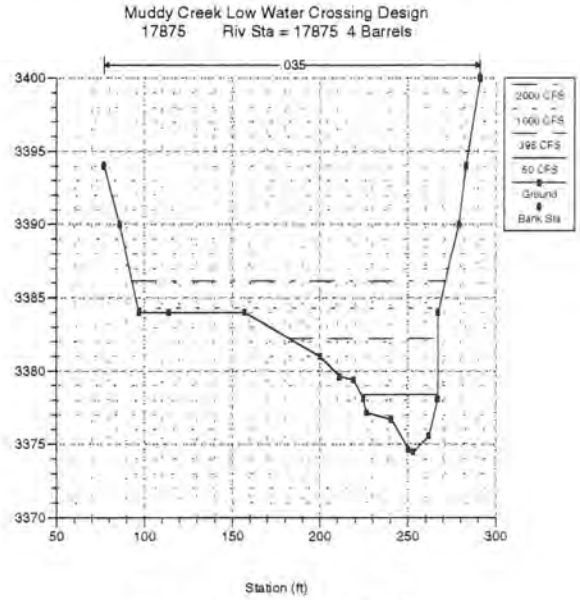

Figure 9. Station 17875.

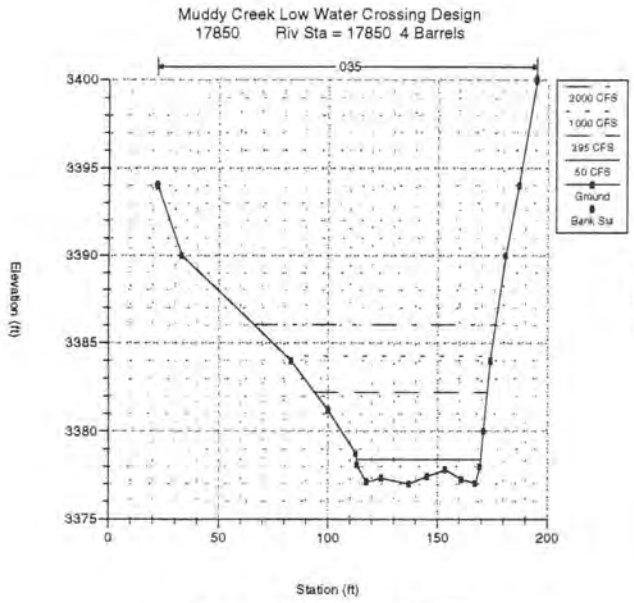

Figure 10. Station 17850.

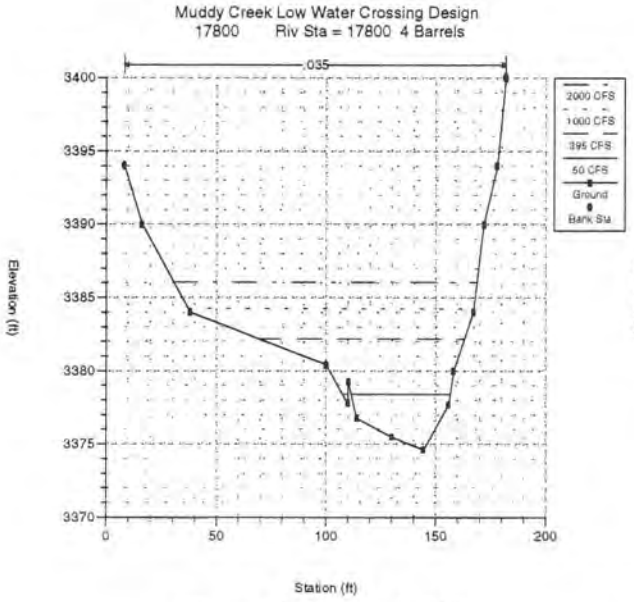

Figure 11. Station 17800.

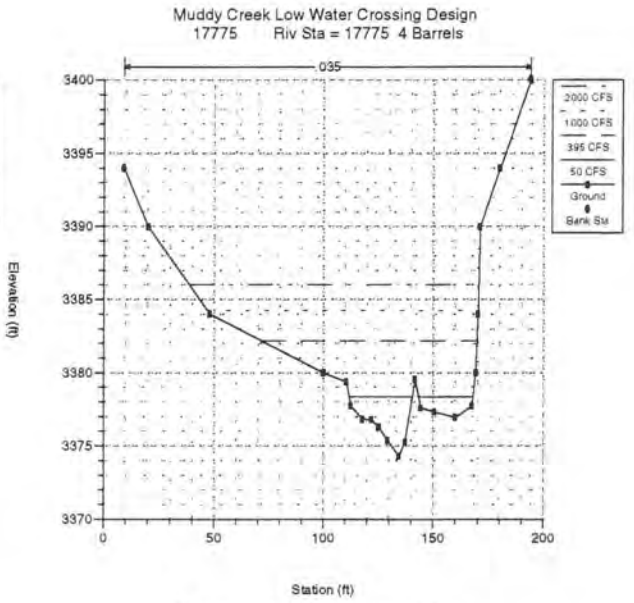

Figure 12. Station 17775.

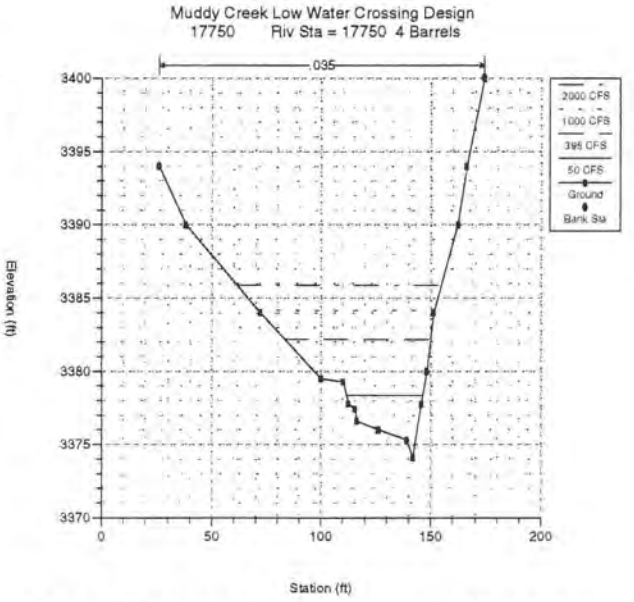

Figure 13. Station 17750. Upstream of Low Water Crossing. This is HEC-RAS section 4.

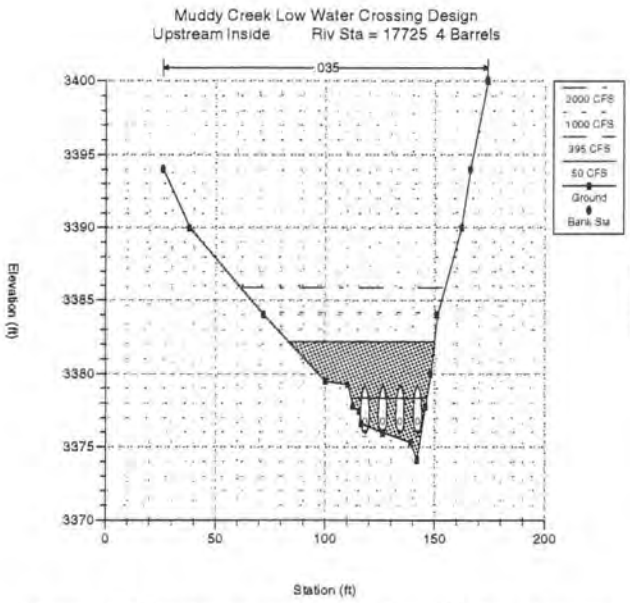

Figure 14. Upstream section at Low Water Crossing. This is HEC-RAS section 2.

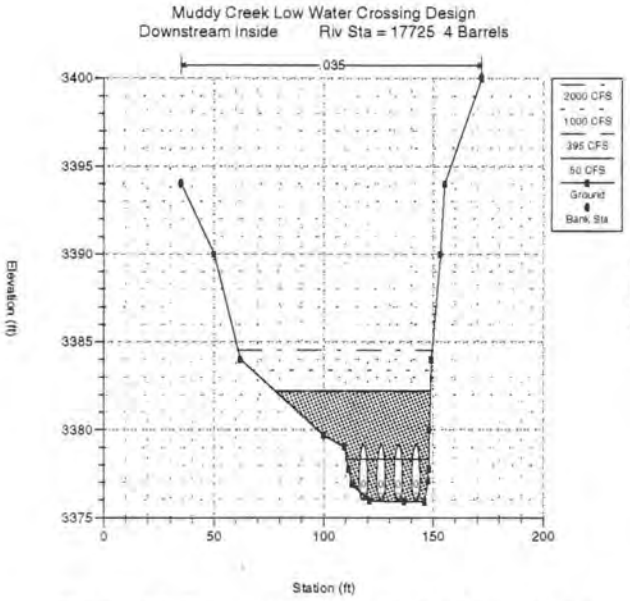

Figure 15. Down stream section at Low Water Crossing. This is HEC-RAS section 2.

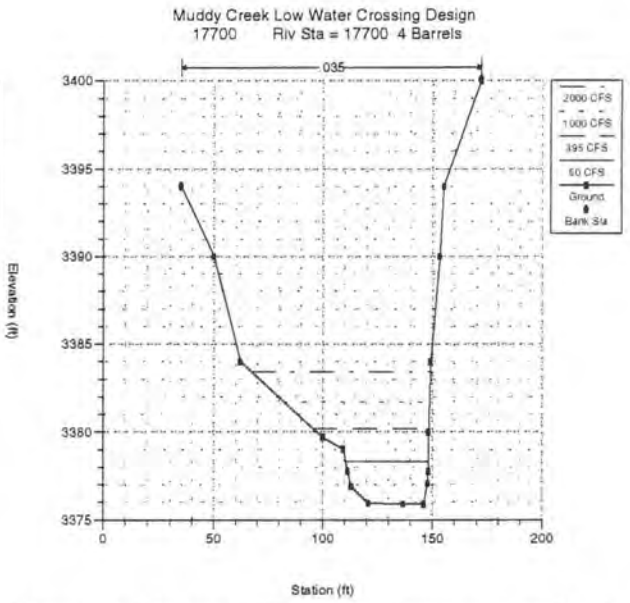

Figure 16. Station 17700. Down stream of Low Water Crossing. This is HEC-RAS section 1.

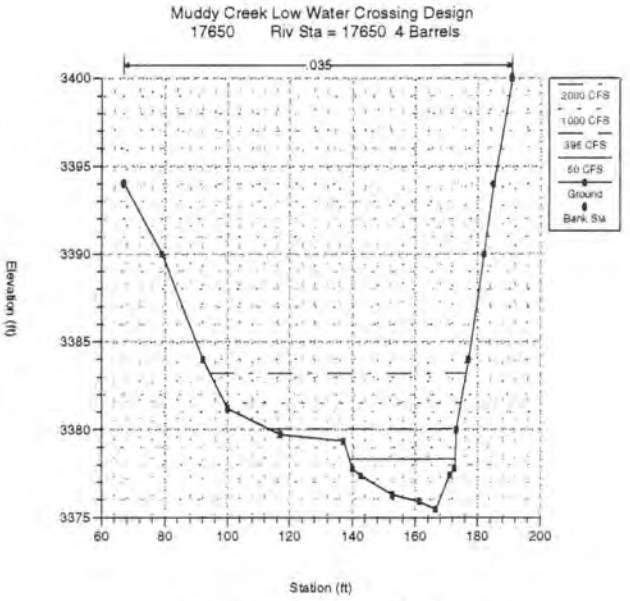

Figure 17. Station 17650.

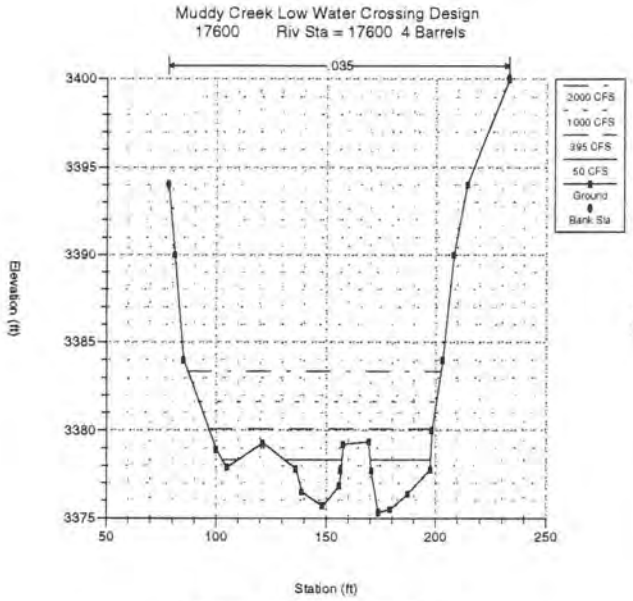

Figure 18. Station 17600.

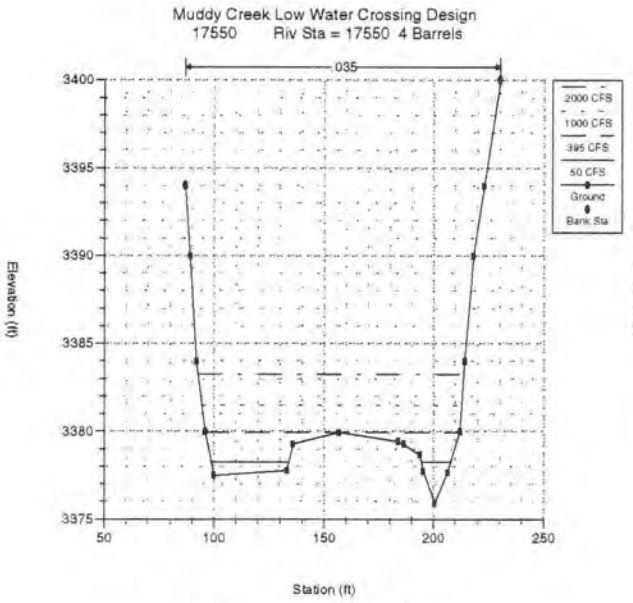

Figure 19. Station 17550.

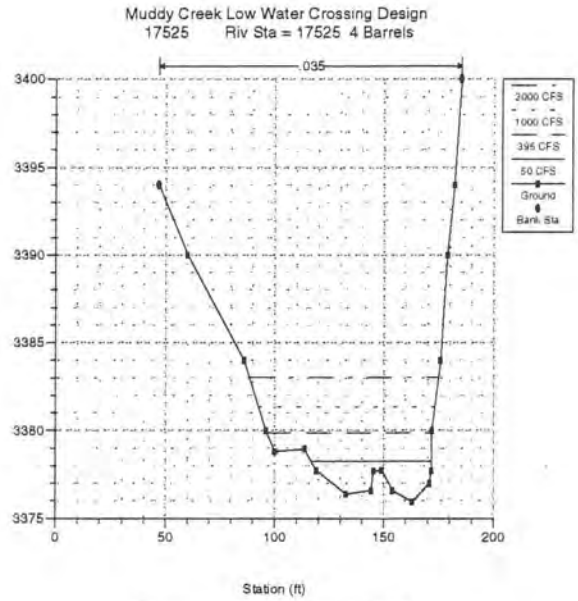

Figure 20. Station 17525.

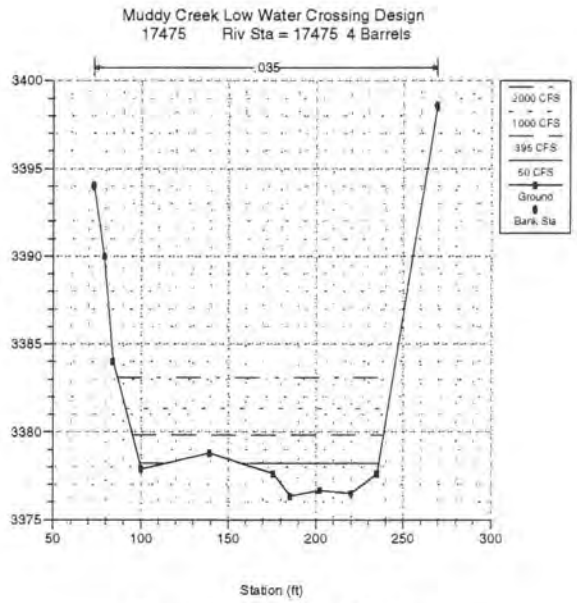

Figure 21. Station 17475.

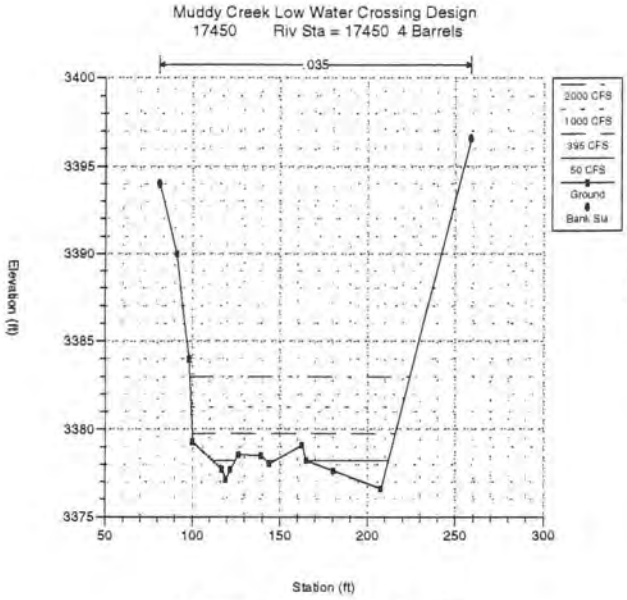

Figure 22. Station 17450.

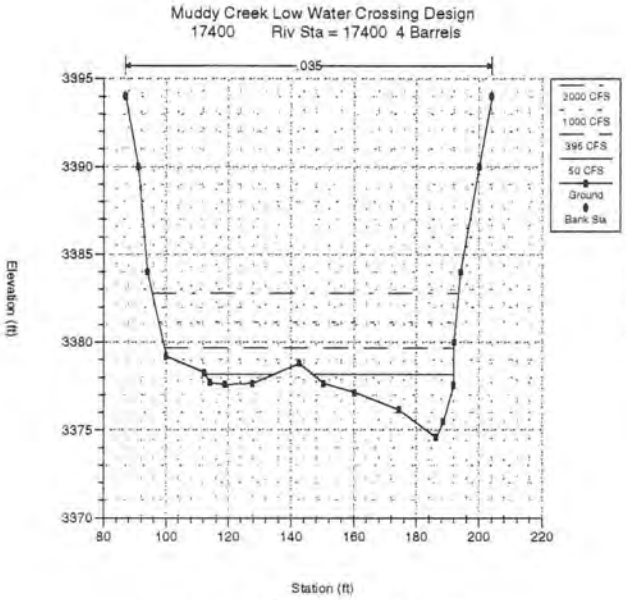

Figure 23. Station 17400.

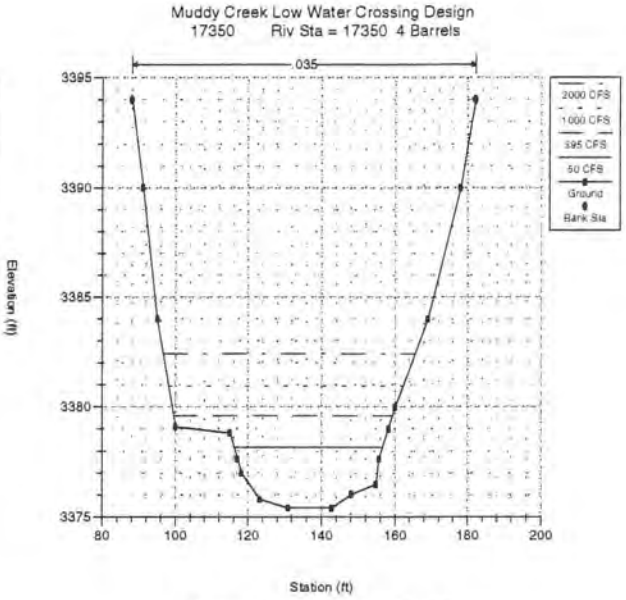

Figure 24. Station 17350.

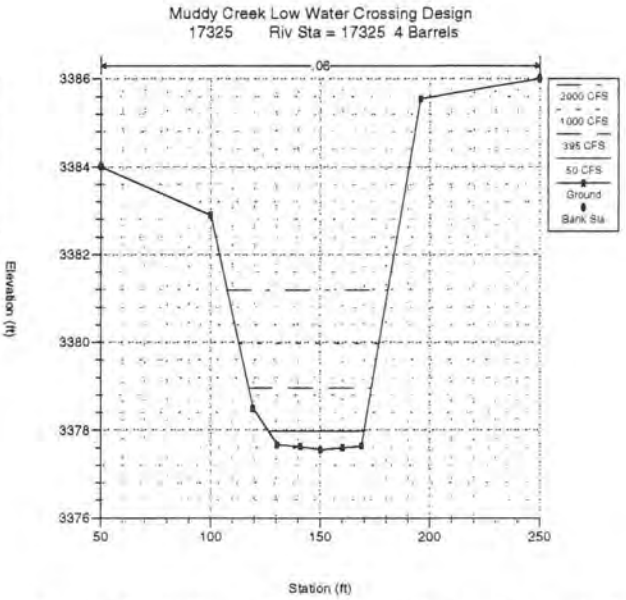

Figure 25. Station 17325. This section is the crest of grade control structure 2-C.

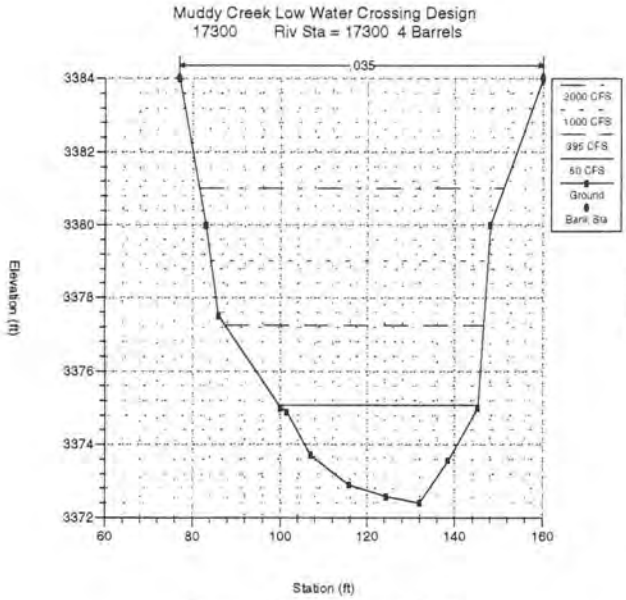

Figure 26. Station 17300.

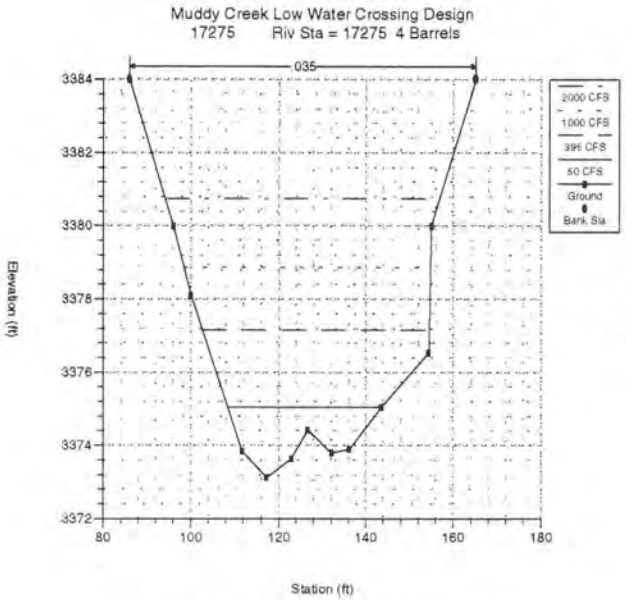

Figure 27. Station 17275.

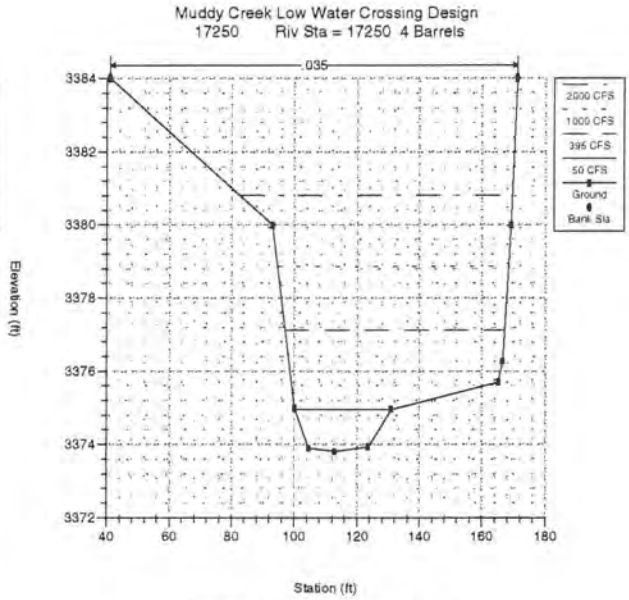

Figure 28. Station 17250.

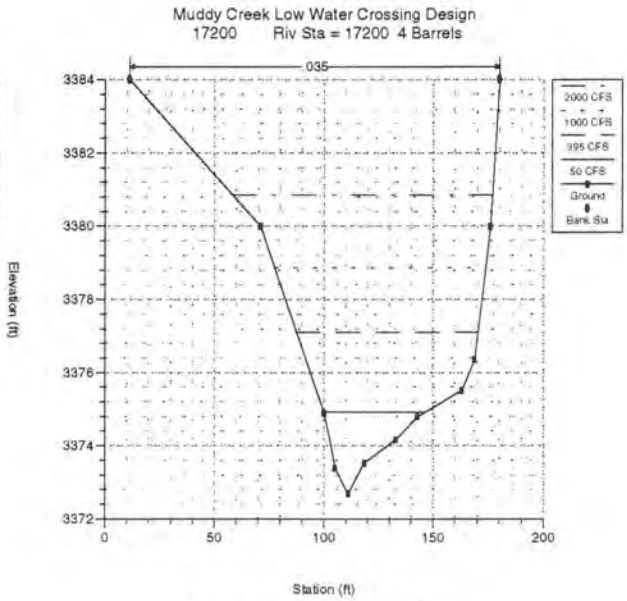

Figure 29. Station 17200.

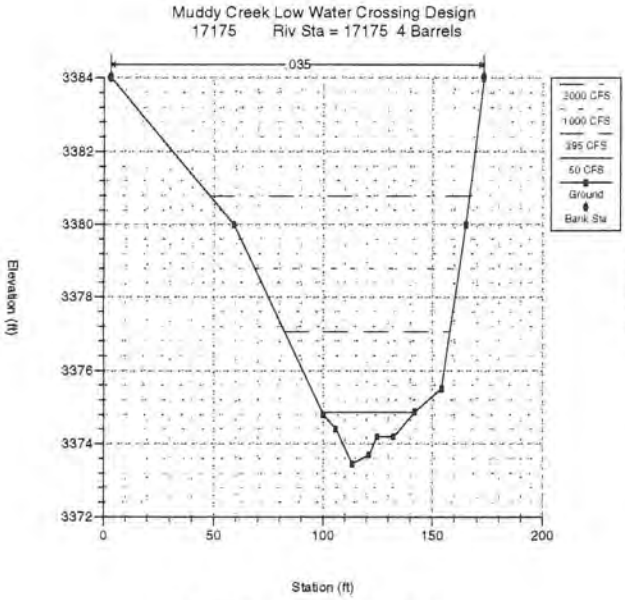

Figure 30. Station 17175.

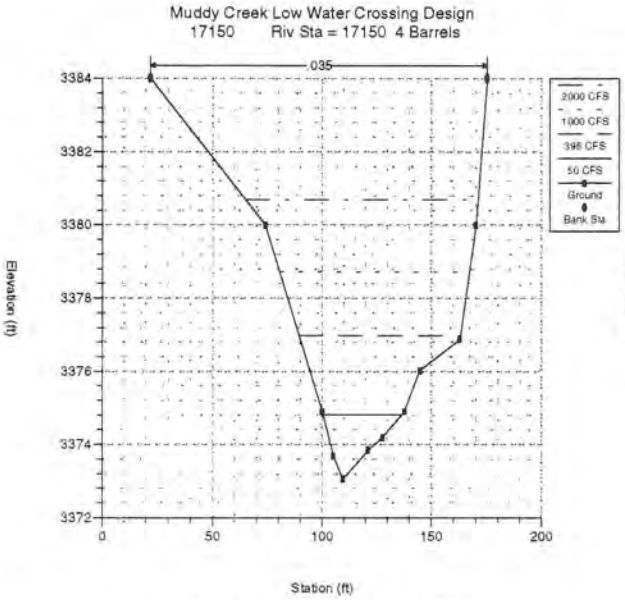

Figure 31. Station 17150.

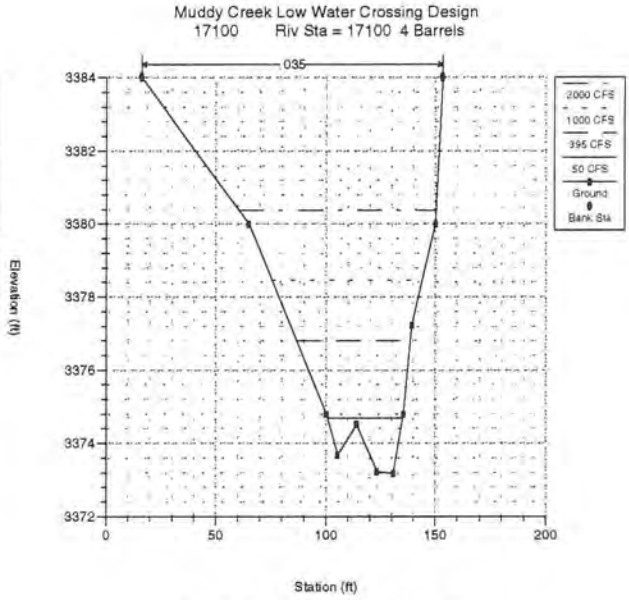

Figure 32. Station 17100.

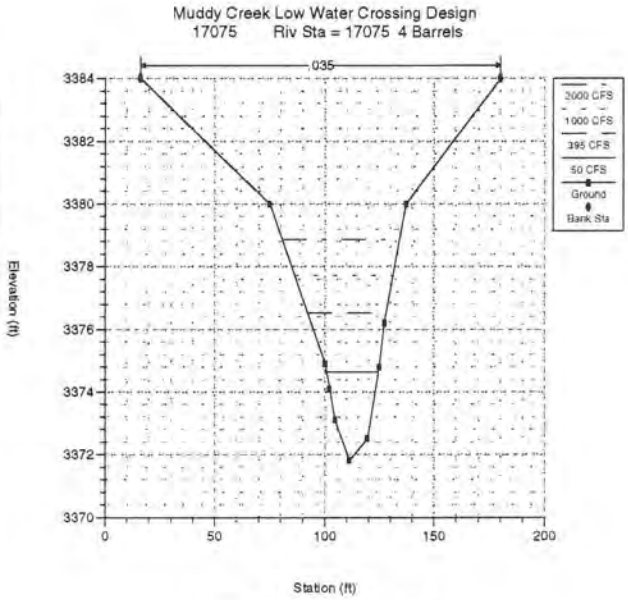

Figure 33. Station 17075.

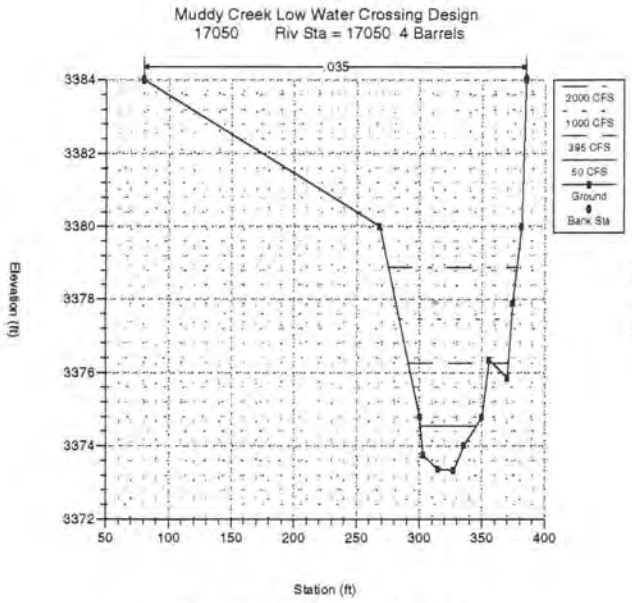

Figure 34. Station 17050.

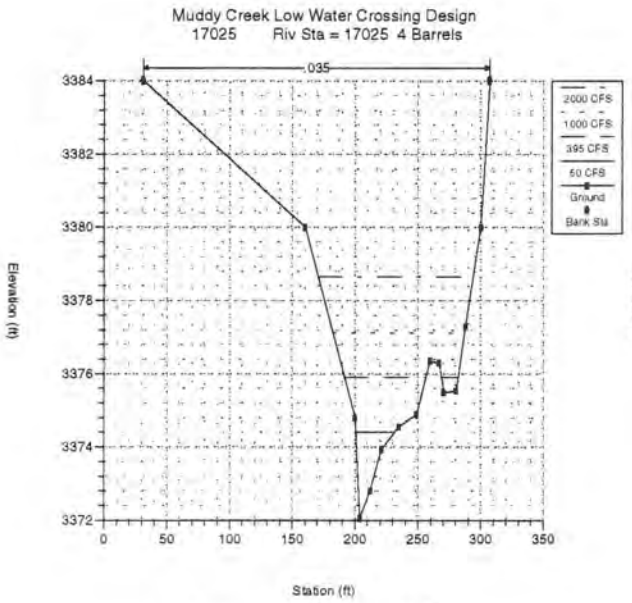

Figure 35. Station 17025.

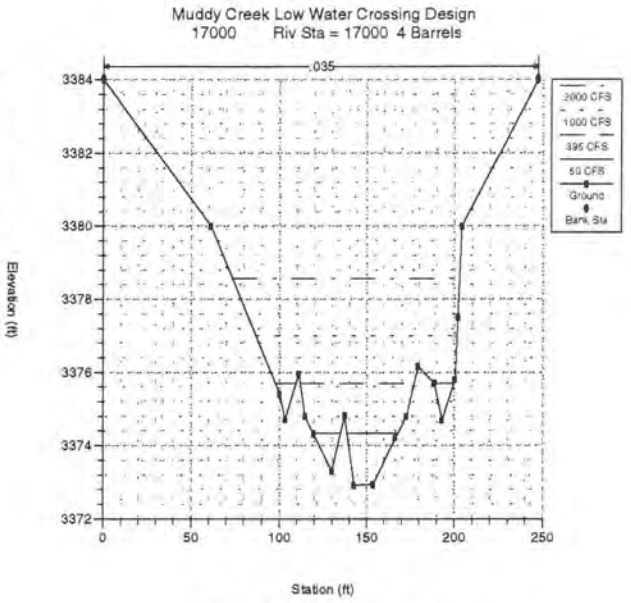

Figure 36. Station 17000.

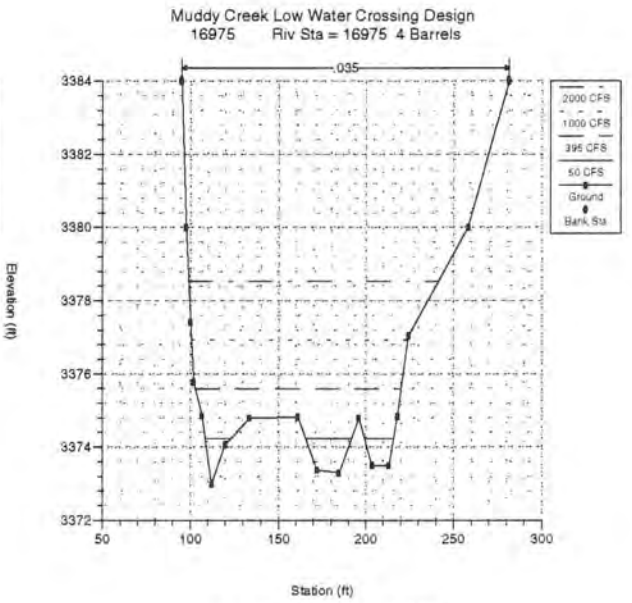

Figure 37. Station 16975.

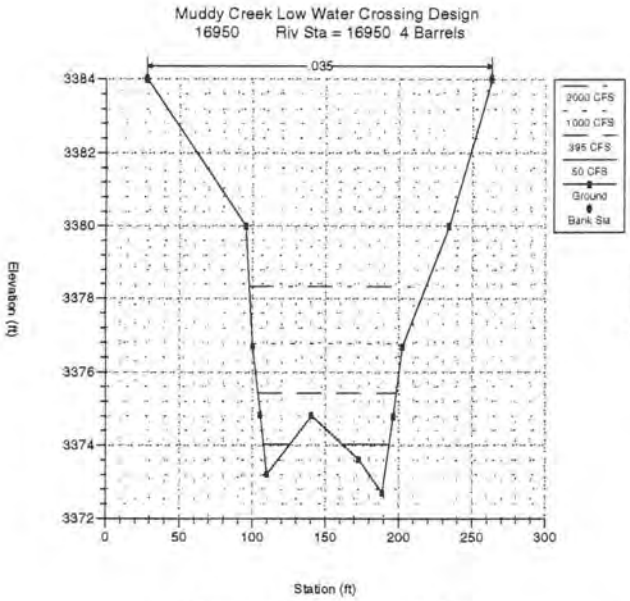

Figure 38. Station 16950.

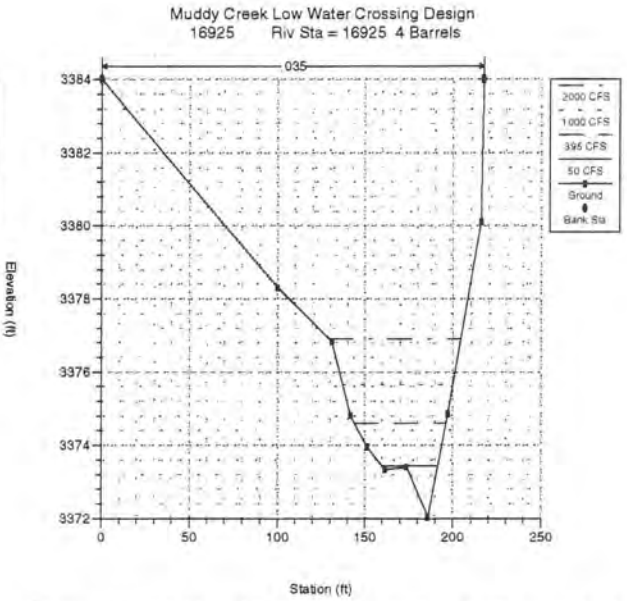

Figure 39. Station 16925. This section is the crest of grade control structure 2-B.

Appendix A

HEC-RAS Tabular Data

Table 3. HEC-RAS Plan: Muddy Creek Low Water Crossing Reach: 1 11/13/96 - 4 Barrels

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Avg Vel (ft/s)	Q Area (sq ft)	T-Width (ft)	Froude #
17900	50	3377.05	3378.38		3378.42	0.001812	1.61	31.01	36.31	0.31
17900	395	3377.05	3382.2		3382.26	0.000535	1.95	202.65	69.76	0.2
17900	1000	3377.05	3384.27		3384.37	0.000704	2.54	393.37	112.58	0.24
17900	2000	3377.05	3386.08		3386.25	0.000806	3.23	618.82	136.43	0.27
17875	50	3374.47	3378.4		3378.4	0.000053	0.52	96.69	43.26	0.06
17875	395	3374.47	3382.23		3382.25	0.000139	1.19	330.82	84.48	0.11
17875	1000	3374.47	3384.3		3384.35	0.000399	1.8	554.21	171.14	0.18
17875	2000	3374.47	3386.13		3386.21	0.00037	2.29	874.36	178.17	0.18
17850	50	3377	3378.39		3378.4	0.000402	0.86	58.22	56.73	0.15
17850	395	3377	3382.22		3382.24	0.000146	1.26	313.9	78.78	0.11
17850	1000	3377	3384.27		3384.33	0.000269	2.04	490.05	93.55	0.16
17850	2000	3377	3386.05		3386.19	0.000469	2.98	671.94	110.48	0.21
17825	50	3374.43	3378.38		3378.38	0.0001	0.66	75.39	37.21	0.08
17825	395	3374.43	3382.21		3382.23	0.000154	1.23	320.3	85.23	0.11
17825	1000	3374.43	3384.26		3384.31	0.000277	1.9	525.21	113.68	0.16
17825	2000	3374.43	3386.04		3386.15	0.000407	2.71	738.3	125.42	0.2
17800	50	3374.6	3378.38		3378.38	0.000036	0.45	112.33	47.27	0.05
17800	395	3374.6	3382.2		3382.22	0.00012	1.1	358.11	94	0.1
17800	1000	3374.6	3384.25		3384.29	0.000222	1.69	590.91	130.13	0.14
17800	2000	3374.6	3386.03		3386.13	0.000311	2.41	830.34	138.16	0.17
17775	50	3374.31	3378.37		3378.38	0.000103	0.58	86.5	53.19	0.08
17775	395	3374.31	3382.2		3382.21	0.000122	1.08	365.3	98.1	0.1
17775	1000	3374.31	3384.24		3384.28	0.000211	1.69	592.94	123.15	0.14
17775	2000	3374.31	3386.01		3386.11	0.000318	2.44	819.33	131.73	0.17
17750	50	3374.1	3378.36	3376.07	3378.37	0.000084	0.64	78.14	34.56	0.07
17750	395	3374.1	3382.17	3377.63	3382.2	0.000194	1.45	272.28	66.25	0.24
17750	1000	3374.1	3384.17	3379.07	3384.26	0.000384	2.39	418.88	80.3	0.36
17750	2000	3374.1	3385.88	3380.89	3386.07	0.00068	3.53	566.7	93.09	0.43
17725	Culvert									
17700	50	3375.89	3378.32		3378.33	0.00008	0.62	81.09	37.57	0.07
17700	395	3375.89	3380.2		3380.3	0.000802	2.43	162.28	52.51	0.24
17700	1000	3375.89	3381.71		3381.96	0.001628	3.97	251.78	66.21	0.36
17700	2000	3375.89	3383.41		3383.85	0.002238	5.3	377.68	81.68	0.43
17650	50	3375.46	3378.31		3378.32	0.000195	0.84	59.21	33.63	0.11
17650	395	3375.46	3380.07		3380.21	0.001824	2.98	132.42	59.96	0.35
17650	1000	3375.46	3381.53		3381.81	0.002432	4.3	232.5	75.46	0.43
17650	2000	3375.46	3383.22		3383.68	0.002427	5.47	365.66	81.98	0.46
17600	50	3375.33	3378.31		3378.31	0.000085	0.52	96.38	60.35	0.07
17600	395	3375.33	3380.11		3380.14	0.000441	1.57	251.03	101.68	0.18

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Avg Vel (ft/s)	Q Area (sq ft)	T-Width (ft)	Froude #
17600	1000	3375.33	3381.61		3381.71	0.000605	2.44	409.13	108	0.22
17600	2000	3375.33	3383.37		3383.54	0.00072	3.3	605.25	115.36	0.25
17550	50	3375.92	3378.27		3378.29	0.001312	1.3	38.6	48.78	0.26
17550	395	3375.92	3379.96		3380.06	0.002614	2.58	153.14	115.84	0.4
17550	1000	3375.92	3381.49		3381.63	0.001326	3.01	332.15	118.23	0.32
17550	2000	3375.92	3383.25		3383.46	0.001082	3.68	542.86	120.88	0.31
17525	50	3375.94	3378.25		3378.26	0.000143	0.63	78.88	55.16	0.09
17525	395	3375.94	3379.86		3379.93	0.000785	2.12	186.71	75.51	0.24
17525	1000	3375.94	3381.34		3381.51	0.001113	3.31	302.49	80.7	0.3
17525	2000	3375.94	3383.02		3383.34	0.001388	4.52	442.72	86.57	0.35
17475	50	3376.33	3378.23		3378.24	0.000145	0.52	96.83	94.92	0.09
17475	395	3376.33	3379.83		3379.86	0.00033	1.28	308.81	143.51	0.15
17475	1000	3376.33	3381.35		3381.4	0.000369	1.88	531.67	150	0.18
17475	2000	3376.33	3383.09		3383.19	0.000408	2.5	798.95	157.43	0.2
17450	50	3376.6	3378.2		3378.22	0.001276	1.16	43.12	63.93	0.25
17450	395	3376.6	3379.77		3379.83	0.001029	1.96	201.94	115.91	0.26
17450	1000	3376.6	3381.27		3381.38	0.000863	2.64	378.84	120.37	0.26
17450	2000	3376.6	3382.97		3383.15	0.000852	3.4	588.5	125.45	0.28
17400	50	3374.59	3378.18		3378.18	0.00014	0.58	85.78	67.14	0.09
17400	395	3374.59	3379.69		3379.74	0.000648	1.85	214.01	92.59	0.21
17400	1000	3374.59	3381.16		3381.28	0.000837	2.84	351.73	95.03	0.26
17400	2000	3374.59	3382.81		3383.05	0.001022	3.91	511.04	97.92	0.3
17350	50	3375.39	3378.18	3376.02	3378.18	0.000061	0.55	90.19	40.52	0.07
17350	395	3375.39	3379.61	3377.32	3379.7	0.000928	2.45	161.19	59.81	0.26
17350	1000	3375.39	3380.95	3378.63	3381.21	0.001647	4.09	244.57	64.04	0.37
17350	2000	3375.39	3382.41	3380.19	3382.94	0.002418	5.86	341.3	68.8	0.46
17325	50	3377.55	3377.98	3377.98	3378.15	0.077097	3.37	14.84	43.24	1.01
17325	395	3377.55	3378.96	3378.96	3379.54	0.050771	6.13	64.4	55.61	1
17325	1000	3377.55	3379.98	3379.98	3380.97	0.042737	7.99	125.11	63.6	1
17325	2000	3377.55	3381.19	3381.19	3382.63	0.037876	9.61	208.18	73.14	1
17300	50	3372.4	3375.08		3375.08	0.000109	0.63	78.98	45.63	0.08
17300	395	3372.4	3377.25		3377.31	0.000503	2.05	192.69	59.03	0.2
17300	1000	3372.4	3379.02		3379.19	0.000813	3.31	302.09	63.27	0.27
17300	2000	3372.4	3381.01		3381.34	0.001133	4.62	432.92	69.56	0.33
17275	50	3373.12	3375.05		3375.08	0.000869	1.31	38.19	35.2	0.22
17275	395	3373.12	3377.16		3377.29	0.001439	2.96	133.25	51.87	0.33
17275	1000	3373.12	3378.85		3379.16	0.001854	4.44	225.36	56.37	0.39
17275	2000	3373.12	3380.75		3381.3	0.002284	5.93	337.23	62.76	0.45
17250	50	3373.81	3374.95		3375.01	0.002361	1.87	26.71	30.71	0.35
17250	395	3373.81	3377.13		3377.22	0.00115	2.47	160.18	70.01	0.29
17250	1000	3373.81	3378.87		3379.06	0.001183	3.51	285.11	73.64	0.31

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Avg Vel (ft/s)	Q Area (sq ft)	T-Width (ft)	Froude #
17250	2000	3373.81	3380.82		3381.15	0.001445	4.58	437.03	87.09	0.36
17200	50	3372.69	3374.93		3374.94	0.000549	1.02	48.89	46.53	0.18
17200	395	3372.69	3377.1		3377.16	0.00065	1.95	202.48	82.85	0.22
17200	1000	3372.69	3378.86		3378.98	0.000751	2.78	360.12	96.31	0.25
17200	2000	3372.69	3380.85		3381.04	0.000863	3.51	570.03	118.66	0.28
17175	50	3373.45	3374.87		3374.91	0.002412	1.66	30.13	42.29	0.35
17175	395	3373.45	3377.05		3377.14	0.001092	2.37	166.87	75.55	0.28
17175	1000	3373.45	3378.8		3378.95	0.001129	3.18	314.65	93.58	0.31
17175	2000	3373.45	3380.79		3381.01	0.001141	3.82	523.04	118.57	0.32
17150	50	3373.06	3374.81		3374.85	0.001532	1.54	32.4	35.96	0.29
17150	395	3373.06	3376.97		3377.09	0.001689	2.73	144.82	73.5	0.34
17150	1000	3373.06	3378.71		3378.91	0.00143	3.52	284.15	86.45	0.34
17150	2000	3373.06	3380.69		3380.97	0.0014	4.25	470.54	105.77	0.36
17100	50	3373.18	3374.69		3374.73	0.001998	1.69	29.51	34.49	0.32
17100	395	3373.18	3376.8		3376.96	0.001999	3.28	120.55	51.9	0.38
17100	1000	3373.18	3378.45		3378.77	0.002517	4.56	219.48	68.5	0.45
17100	2000	3373.18	3380.38		3380.83	0.002502	5.38	371.61	89.94	0.47
17075	50	3371.82	3374.65		3374.67	0.000353	1.16	43.18	23.83	0.15
17075	395	3371.82	3376.53		3376.78	0.002441	4	98.73	35.91	0.43
17075	1000	3371.82	3377.72		3378.44	0.005579	6.8	147.04	44.9	0.66
17075	2000	3371.82	3378.88	3378.49	3380.37	0.009499	9.81	203.82	53.57	0.89
17050	50	3373.33	3374.55		3374.58	0.001271	1.34	37.27	44.45	0.26
17050	395	3373.33	3376.25		3376.39	0.002294	2.94	134.44	76.74	0.39
17050	1000	3373.33	3377.46		3377.74	0.002762	4.23	236.35	89.46	0.46
17050	2000	3373.33	3378.89		3379.33	0.002906	5.37	372.77	102.43	0.5
17025	50	3372.06	3374.41		3374.45	0.001349	1.56	31.98	30.98	0.27
17025	395	3372.06	3375.9		3376.09	0.004249	3.51	112.6	77.67	0.51
17025	1000	3372.06	3377.13		3377.43	0.003851	4.38	228.12	104.76	0.52
17025	2000	3372.06	3378.65		3379.04	0.002901	4.98	401.93	123.42	0.49
17000	50	3372.91	3374.33		3374.36	0.001429	1.38	36.18	44.82	0.27
17000	395	3372.91	3375.7		3375.85	0.003376	3.11	126.88	88.23	0.46
17000	1000	3372.91	3376.99		3377.21	0.002684	3.79	263.88	114.7	0.44
17000	2000	3372.91	3378.57		3378.87	0.00204	4.38	456.64	129.55	0.41
16975	50	3372.98	3374.23		3374.26	0.00218	1.42	35.18	57.36	0.32
16975	395	3372.98	3375.59		3375.68	0.002014	2.38	165.7	117.3	0.35
16975	1000	3372.98	3376.93		3377.08	0.001442	3.06	326.95	123.34	0.33
16975	2000	3372.98	3378.53		3378.74	0.001325	3.71	538.87	142.31	0.34
16950	50	3372.7	3374.04		3374.09	0.004212	1.82	27.43	50.58	0.44
16950	395	3372.7	3375.42		3375.55	0.00275	2.85	138.68	94.97	0.42
16950	1000	3372.7	3376.76		3376.97	0.002116	3.69	271.28	103.31	0.4
16950	2000	3372.7	3378.34		3378.65	0.001969	4.47	447.56	120.66	0.41

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Avg Vel (ft/s)	Q Area (sq ft)	T-Width (ft)	Froude #
16925	50	3372.04	3373.43	3373.43	3373.65	0.024431	3.73	13.39	31.49	1.01
16925	395	3372.04	3374.6	3374.6	3375.21	0.017015	6.26	63.07	52	1
16925	1000	3372.04	3375.67	3375.67	3376.67	0.01454	8.03	124.51	62.68	1
16925	2000	3372.04	3376.91	3376.91	3378.33	0.013007	9.54	209.62	74.82	1

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Preparer: I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Member: Rodney J. Wittler Date: 1/17/97
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