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ALTERNATIVE IRRIGATION DIVERSION DEMONSTRATION PROJECT

FINAL REPORT
1987 FIELD TRIALS

PREPARED BY
THE CLARK FORK COALITION
P.O. BOX 7593
MISSOULA, MT 59807
CONTACT PETER NIELSEN
(406)542-0539
DENNIS WORKMAN
(406)542-5507
and
BITTERROOT TROUT UNLIMITED
P.O. BOX 262
HAMILTON, MT 59840

INTRODUCTION

Water is a scarce and valuable resource in the arid west. Conflicts between agricultural interests and recreationists over the use of water from our rivers and streams are becoming more prevalent and intense each year.

One of the main focal points for this conflict is the use of bulldozers and other heavy equipment by ranchers and farmers to divert water from streams for irrigation use. Such practices can be quite destructive to aquatic habitat. Recent dry years in western Montana have brought an increase in bulldozer diversion activity on streams like the Bitterroot River, with the attendant disruption of streambed gravels, streambank sediments and the loss of much aquatic habitat.

What can be done to solve the problem?

Montana water rights are based on a doctrine of first in time, first in right. Established rights to use water from our rivers and streams predate Montana Statehood, and are protected by the Constitution and Montana water law.

Montana's Natural Streambed and Land Preservation Act (NSPLA) of 1975 reiterates this constitutional guarantee in its policy statement, and further protects water rights in the structure of the law.

The NSPLA is administered by the Soil and Water Conservation Districts across the state. The Districts have adopted rules for administering the law, which further protect water rights and the traditional methods of diverting water from streams.

The use of bulldozers to construct diversion dikes from streambed gravels requires a permit from the local Conservation District under the NSPLA. Administrative rules specifically prohibit the use of gravels in the construction of any project unless there is no other reasonable alternative.

This is the challenge to which we must respond. Hundreds of streambed gravel dike diversions are permitted each year in Montana because there is no reasonable alternative for diverting large volumes of water from swiftly flowing streams.

From the rancher's perspective, the purchase, operation and maintenance of a bulldozer capable of doing a diversion job is a major expense. In many cases, this annual streambed disturbance causes stream mechanics to react, making the job more difficult and costly each year. Most ranchers would welcome a less expensive alternative.

From the sportsman's perspective, this annual disturbance destroys the trout food base of aquatic insects, disrupts potential spawning and rearing areas for fish, causes streambed and bank erosion, and can cause boat portage and floating hazards.

During the 1987 irrigation season the Clark Fork Coalition conducted tests on an alternative irrigation diversion structure, in cooperation with the Bitterroot Chapter of Trout Unlimited and two Western Montana irrigation ditch companies. The purpose of the structure and the tests was to develop an alternative to the use of streambed gravel for diversion dikes. The demonstration project was supported with grants from Trout Unlimited's Operation Protect and the Montana Trout Foundation.

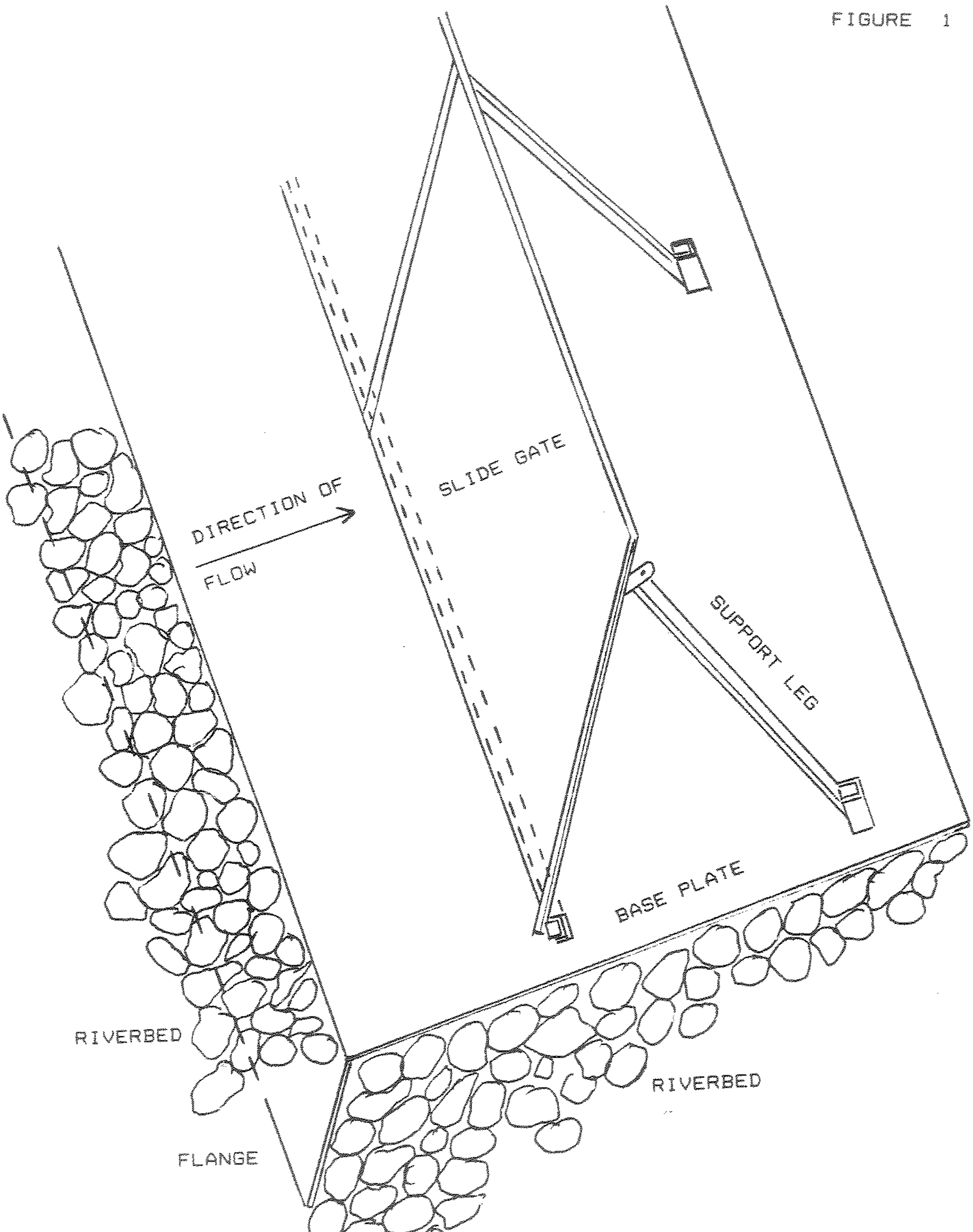
STRUCTURAL SPECIFICATIONS

The alternative irrigation diversion structure rests on a series of 4'x8' base plates made from 1/4 inch thick plate steel. The base plate has a one-foot wide flange on the upstream edge which is pressed into the streambed to cut off flow under the structure, prevent erosion of streambed gravel from under the base plate, and to hold the diversion in place in the stream. Water is diverted by steel slide gates supported by steel frames which are 3 feet in height. The frames are supported in an upright position on the plates by legs which pin to the frame and set in sockets on the base plates. The frames are held to the base plates by a channel iron socket, welded to each base plate, into which the base of the frame fits. Each plate has two chain loops for lifting and transport. Several of the base plates with frames and gates are placed end to end in the stream to create a diversion structure. The base plates overlap each other by 3 inches to prevent water from flowing between the units. (Fig. 1)

The project is designed to solve several known problems and fit specific criteria. It is transportable by an ordinary farm tractor and easily installed by two people. It is economical, durable, repairable, strong enough to support a 3 foot head of water and adjustable to meet variable flow conditions. It can

PORTABLE IRRIGATION DIVERSION STRUCTURE

FIGURE 1



stabilize the stream bottom by protecting it from erosion and aggradation. It does not initiate streambank erosion.

STUDY AREAS

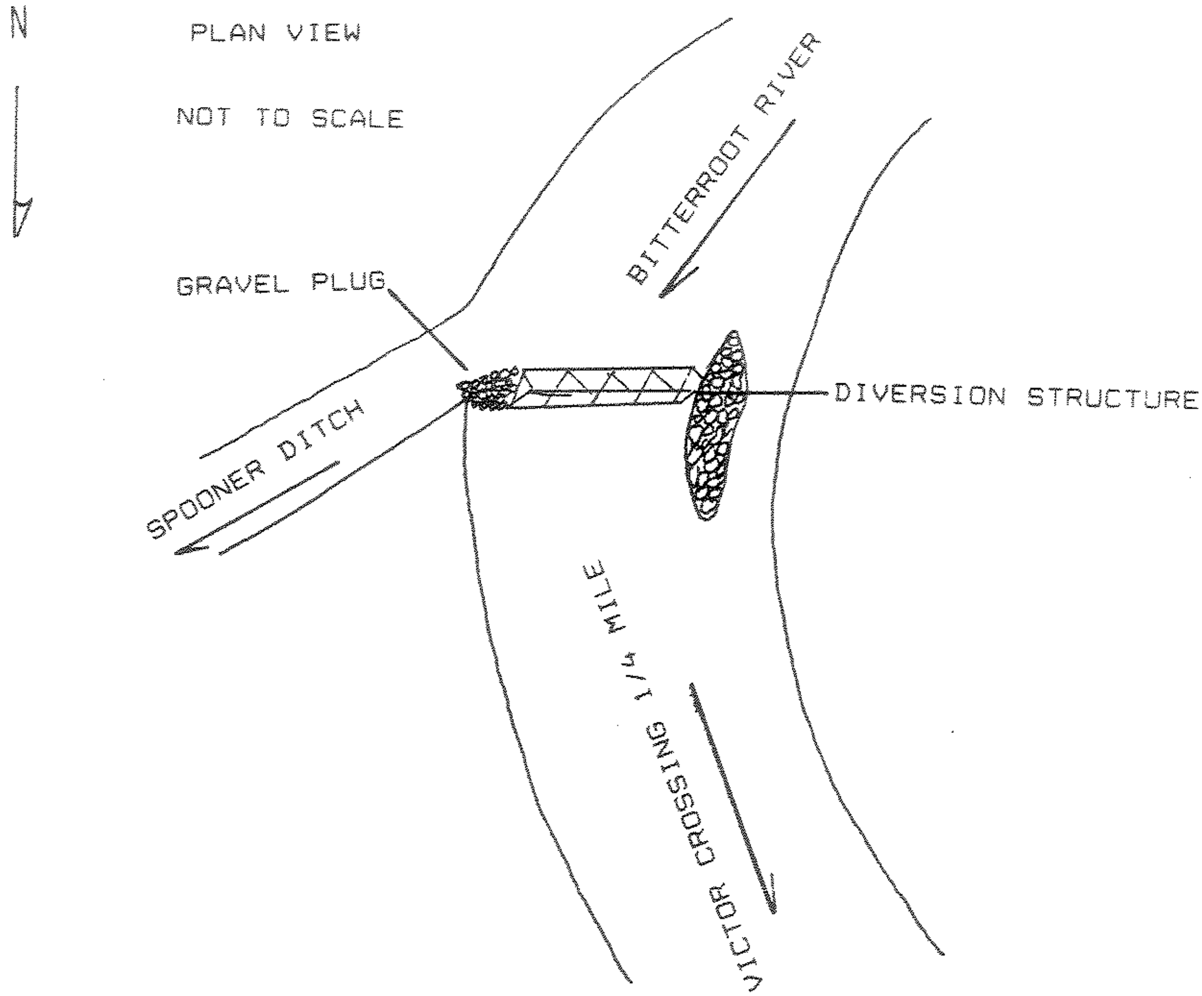
The Spooner Ditch Company diversion on the east channel of the Bitterroot River, near Victor, was one of two experimental sites chosen for this project. At this location the streambed was composed of cobbles, up to about four inch diameter mixed with sand and gravel. The bottom contour sloped away from the mouth of ditch to the deepest point of the channel, which was approximately in the center of the channel, and then sloped up to the gravel bar on the side opposite the irrigation ditch. This channel configuration proved to be nearly ideal, and the portable diversion was placed perpendicular to the stream flow. (Fig 2)

The French Grass Valley Ditch, west of Missoula on the Clark Fork River, was the second site used for testing. The streambed was composed of mostly cobble up to approximately 6 inches in diameter mixed with a small amount of gravel and sand. Streambed material had been deposited in the mouth of a north channel of the Clark Fork River, where the irrigation diversion is located, forcing much of the river's flow to the south channel. This made it difficult for the irrigation company to get sufficient amounts of water down the north channel to their headgate during periods of low river flow.

Bottom contour of the site sloped both north and south from

BITTERROOT RIVER TEST SITE

FIGURE 2



a high point at the junction of the two channels. The diversion structure was placed at the junction, perpendicular to flow in the south channel and parallel to flow in the north channel. (Fig. 3)

The fabrication and installation of the 1987 irrigation diversion project was recorded on videotape for future educational purposes.

RESULTS

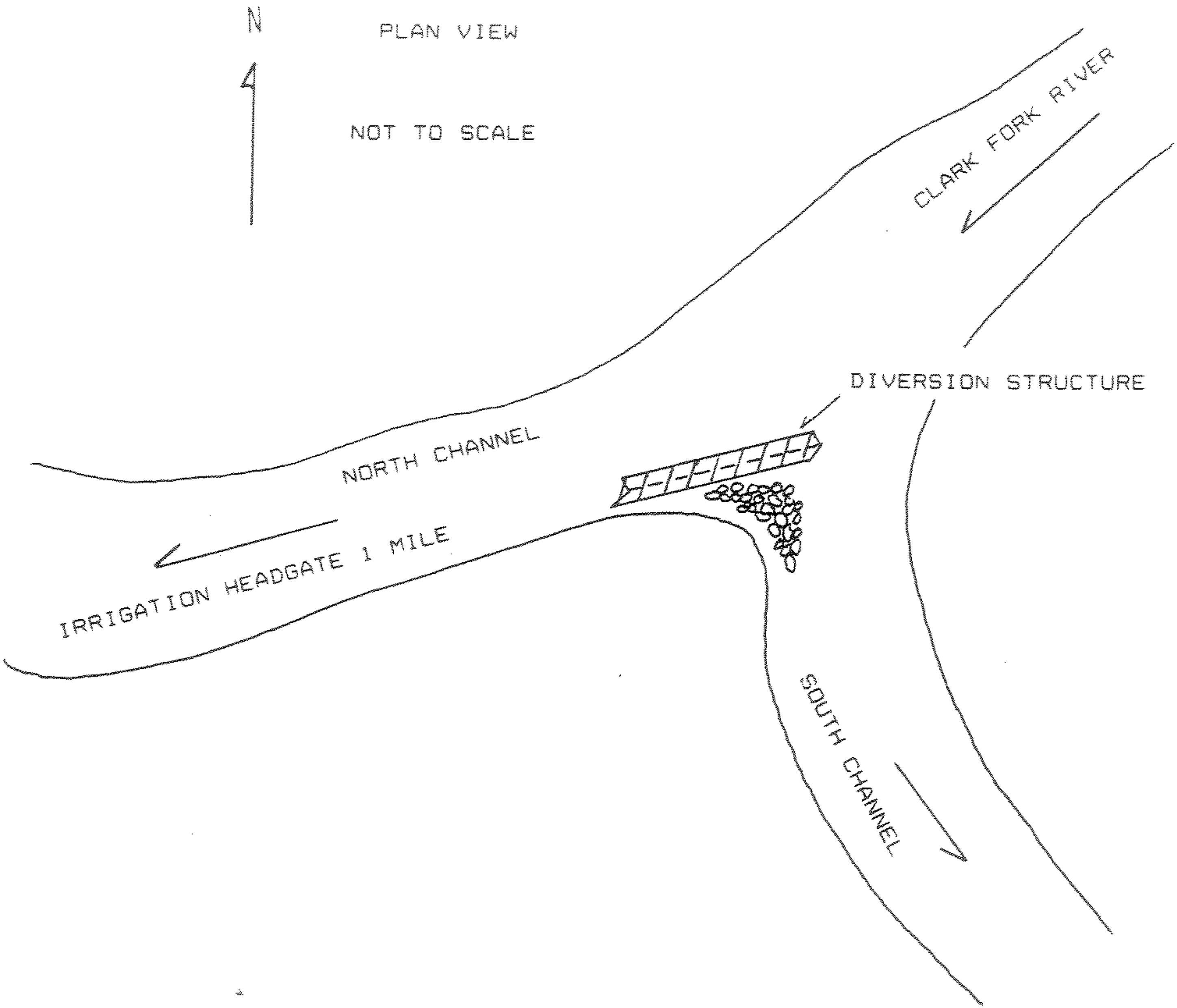
Bitterroot Site

On June 23, 1987 four base plate sections, with frames and slide gates, were placed in the Bitterroot River at the head of the Spooner Ditch. In the past, ditch operators had used a tractor/loader to construct a gravel dike all the way across the stream channel. At the end of each irrigation season a gravel plug was normally placed in the ditch and the gravel diversion dike was left to be washed away by the river during spring run-off.

Ralph Simonsen, one of the Spooner Ditch users, and Dennis Workman placed the portable diversion structures using a John Deer farm tractor with frontend loader to lift the sections from a dump truck and transport them into the stream. The base plates were guided into place by hand as they were lowered into place by the tractor. Even though the plates weighed approximately 500

CLARK FORK RIVER TEST SITE

FIGURE 3



pounds each, the strong current of the stream made it necessary to place them approximately 3 feet upstream of their intended final resting place. Once all four plates rested on the bottom of the stream the tractor was driven on the upstream edge of the plates to press the 12-inch flange into the streambed.

A problem was encountered at this point. As the tractor drove on the plates they moved out of position relative to one another. They are designed to overlap one another by 3 inches to prevent water current from eroding gravel beneath the structure. A pry bar was used to realign the plates as they were pressed into the gravel. They could only be pressed approximately 8 inches into the gravel because of the hardness of the streambed. This apparently was adequate because they remained stable throughout the irrigation season.

Frames and gates were put in place. Once this was done water began flowing down the ditch and around the outer end of the structure. The flow around the outer end of the structure began eroding the streambed under the outer section, and the outside slide gate was removed to eliminate this erosion.

During the irrigation season the gates were manipulated to adjust flows in the ditch and the river as needed. Water purchased from Painted Rocks Reservoir by the Montana Department of fish, Wildlife and Parks for minimum instream flow was allowed to remain in the river. The portable diversion structure provided the necessary flexibility to allow instream flows to pass. Gravel diversion dikes do not have this flexibility. Once the integrity of a gravel dike is partially broken it tends to wash away entirely.

A problem at this site developed in July when a heavy rainstorm and a reservoir release combined to raise the level of the river significantly. This caused the river to overtop the structure and erode away a gravel plug between the ditch opening and the structure. This gravel plug was installed before the test structure was put in place, serving as a diversion dike in early summer when the river level was higher. The gravel plug was washed away, but the test structure was unaffected.

On September 24th, the diversion structure was removed from the river. By this time irrigation from the Spooner Ditch had stopped and all slide gates had been removed from the structure to allow water to flow through the frames, and over the base plates. This flow had eroded a depression in the streambed approximately one foot deep and two to three feet wide along the downstream edge of the base plates. This was the only noticeable change in channel configuration as a result of the structure.

Clark Fork Site

On July 7, 1987, 8 base plates with frames and slide gates were placed in the Clark Fork River, at the head of Kelly Island (Figure 3). Because of increasing difficulty in obtaining adequate flows in the north channel, and the irrigation ditch, the ditch company had planned to hire a contractor to bulldoze the gravel deposition out of the mouth of the north channel. When presented with the opportunity to use the alternative diversion structures, the company agreed not to bulldoze the river channel.

A rubber tired tractor with loader and backhoe was used to place the structure in the river. Water velocity and depth were much greater at this site than they were at the Bitterroot site, and the heavier tractor was needed for stability. The loader was used to transport the structure from a goose neck trailer to the river.

The backhoe was used to drive the base plate flanges into the river bed, instead of driving on the plates as was done at the other site. As on the Bitterroot site, it was difficult to press the flanges into the river bed and maintain alignment of the base plate sections relative to one another. Hardness of the streambed was the primary cause of this problem. Because of excessive overlap between some of the base plates, some difficulty was experienced in attaching the slide gate frames to the base plates, but it was accomplished by using a pry bar to realign the plates.

Water velocity in the south channel was high. When slide gates were placed in the southern most section, erosion of the streambed began immediately as a result of increased water velocity around the end of the diversion. Pressure on the gates of this section was too high for us to remove them by hand, and gravel had to be piled on this section to keep it from washing downstream. Erosion of the streambed from under this section was very rapid. The section tilted and slid away from the line of the structure, and eventually washed down stream about 100 yards. It was later retrieved with a boat.

Despite the loss of the southernmost section, the remaining structure served it intended purpose. Water flowed parallel to the structure in the north channel. It eroded a trench, approximately 18 inches deep, along the front of the structure, exposing the base plate flanges which had been pressed into the streambed. There was no apparent effect on structural stability, and except for the southern most base plate it was stable and effective in diverting water from the south channel to the north channel where the irrigation headgate was located.

The Clark Fork structure was removed from the river on September 24, 1987 using a small tractor and long chain to drag the sections to the edge of the river where they could be picked up and loaded on a trailer.

Discussion

Both projects served their intended purpose of diverting water for irrigation use without the construction of damaging gravel dikes. However, several shortcomings were noted during the course of the tests. Pressing the base plate flanges 12 inches into the streambed was nearly impossible because of the hardness of the streambeds. However, no particular problem resulted from this difficulty except the expenditure of time in the attempt. Once assembled, there was no apparent erosion of the streambed under the structures. It seems important to press the flanges into the streambed as far as possible but the full 12 inches does not appear to be necessary. It was difficult to keep the plates in alignment with one another while pressing the flanges into the gravel. This caused some difficulty in mounting the gate frames on the plates. The slide gates and frames were heavy and cumbersome to handle in fast moving water on slippery footing. Because of their weight, the slide gates would not remain partially open without being propped up. This somewhat reduced the flexibility of the diversion. The gates were too tall, creating a problem at the Bitterroot site when high flow was forced around the end of the structure, washing away the gravel plug between the diversion and the ditch opening. Had they not been so tall, pressure from high flow could have been relieved by flowing over the gates at a lower stage, possibly preventing washout of the gravel plug. The sockets which held the frame legs were constructed of sections of box steel. These sockets filled with small gravel that, in some instances, was difficult to remove.

In order to be effective an alternative diversion structure must meet certain criteria:

1. It must be portable, durable, repairable and economical. The structure tested was easily portable by an ordinary farm

tractor. Conditions imposed by the stream would determine the size of machine needed to do the job in most cases. Because it was constructed of steel it was very durable and would be easily repaired. Steel is expensive and probably makes this particular model less attractive than gravel dikes in the short term. Recommendations will be made in the next section of this report to reduce construction cost.

2. It must be easily installed by two people and a farm tractor with a front end loader in one day.

Ease of installation probably does not compare favorably with building a gravel dike with a bulldozer or tractor. The most difficult part of the installation was carrying and placing the heavy frames and gates. Again, recommendations will be made to correct this problem. Also, knowing that the flange probably does not need to be fully seated will reduce the amount of time and effort expended attempting to accomplish this.

3. It must be capable of supporting a 3 foot head of water.

Experience from the Bitterroot site indicates that the structure is stable and strong enough to support a 3 foot head of water. In most situations, the waqter level actually need to be raised by a foot or less to accomplish a diversion to an irrigation ditch.

4. It should be easily adjustable to match water supply and demand.

The slide gates proved to be easily adjustable but because of their weight they lacked some flexibility, as noted above.

This can easily be overcome by modifying the structure design and materials (see Recommendations).

In addition to meeting the above criteria the structure should solve certain hydraulic problems.

1. It should minimize unnatural streambed erosion and aggradation.

The structure caused small amounts of streambed erosion at both test sites. The amounts of erosion were not significant, especially compared to the huge disturbance associated with building a large gravel dike. The base plates functioned well, under a wide range of flows including overtopping, and prevented undermining of the structure. There was no aggradation associated with the portable diversion.

2. It should minimize diversion-associated streambank erosion.

No streambank erosion occurred at either of the test sites. This should, however, be watched in future tests.

3. It should develop sufficient hydraulic head to satisfy variable water demand.

The test structure appears to solve this problem.

Recommendations

The Clark Fork Coalition plans to continue this demonstration project in 1988, modifying the structure, and testing the improved design at two new locations.

To reduce construction costs, increase the ease of installation and improve flexibility of the diversion we recommend the following changes to the frame and slide gate arrangement. (See Figure 4)

1. Replace the slide gate frames with post uprights, and replace the leg supports that were used with the frames. The new posts would have box steel tubing welded to the end so they can be hooked to the plates in the same manner as the frames.

2. Replace the slide gates with wood boards, probably 2"x6" dimensional lumber, which would be placed across the post uprights to divert the water. Boards would be stacked edge to edge to the desired height, and held in place by the upstream water pressure.

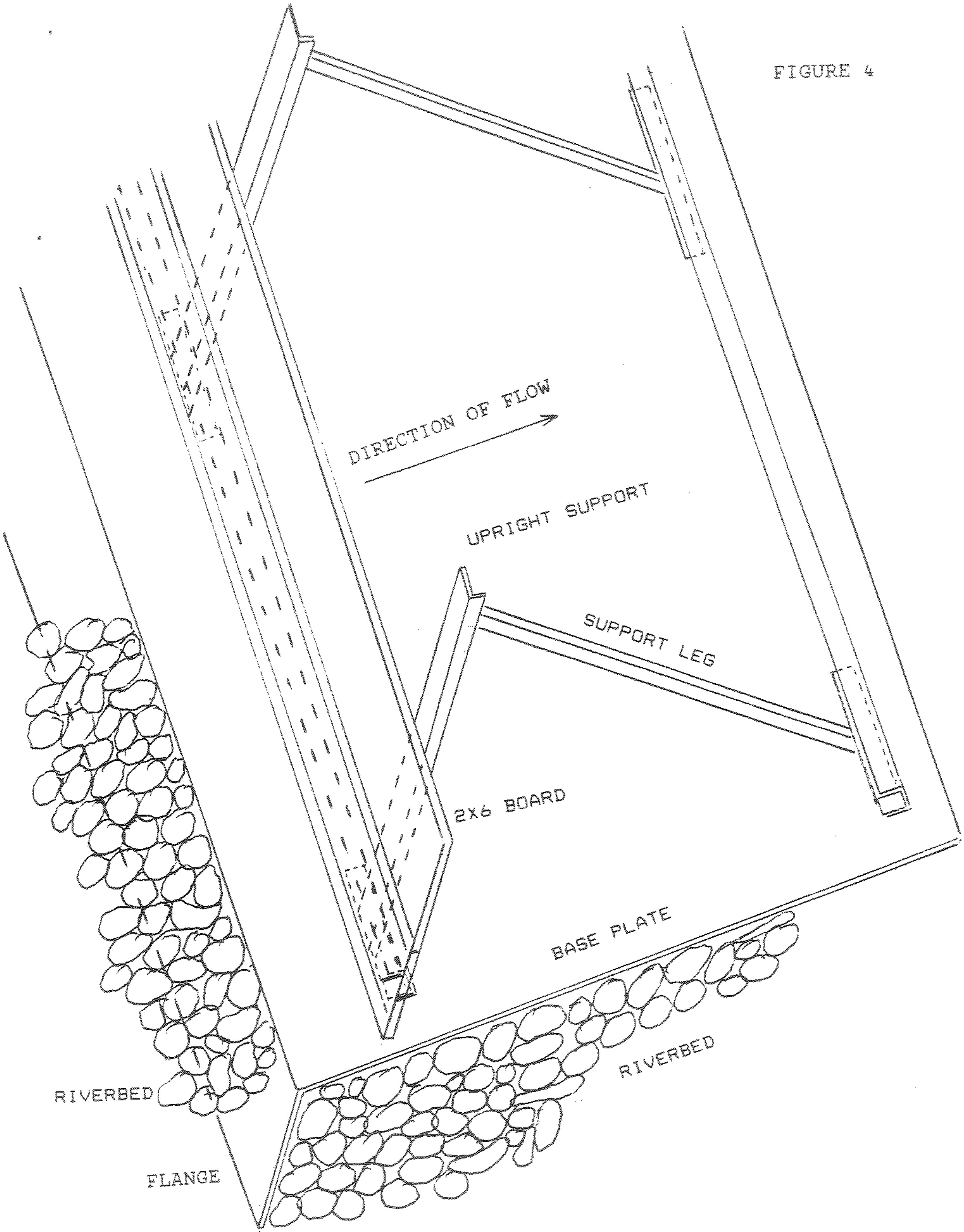
3. Replace the box steel support leg sockets with a channel iron support full length of the base plate.

The Coalition plans to modify the existing structures with these changes, and test them again during the 1988 irrigation season. The proposed modifications should improve many characteristics of the project, including ease of installation, flexibility, and cost. The modifications and 1988 installations are expected to add about $500 to this demonstration project's total cost. The Coalition plans to seek contributions from interested donors for this additional cost in 1988.

The modified design would cost roughly half as much as the design tested in 1987. Each eight foot section would cost

MODIFIED PORTABLE IRRIGATION DIVERSION STRUCTURE

FIGURE 4



approximately $200, instead of $400 as in this project. An average diversion on a small, to medium sized stream could require the installation of five modified structures, costing approximately $1,000. The construction of a gravel diversion dike at a similar site would require the operation of a bulldozer, or similar heavy equipment. At the going rate of $50 per hour and $100 to $200 equipment transportation charges, an average gravel dike could cost from $500 to $1,000 to install. Actual costs are highly dependant on site-specific conditions. Ranchers at the Webfoot Ditch on the Bitterroot River estimate their annual gravel dike installation cost at $700. Additional maintenance is often required on gravel dikes, since they are susceptible to erosion during water level fluctuations. In addition, gravel dikes should be removed from the stream following an irrigation season, incurring additional costs. But the Conservation Districts in Montana do not typically require dike removal as a part of the 310 permit, or enforce such a provision if it is included in the permit.

The modified structure design to be tested in 1988 should require much less installation time than the structure tested in 1987. We expect that the time required to install the modified design will compare favorably to the time required to construct a gravel dike. Equipment costs would be much lower than necessary for a gravel dike, since light duty farm equipment can be used for installation in place of heavy duty bulldozers.

As noted above, actual costs for the installation of gravel dikes are dependant on site-specific conditions, and it is difficult to generalize about the comparable economics of gravel dikes and our alternative diversion structure. It is possible, however, to consider the economics on a case-by-case basis. The Webfoot Ditch Company on the Bitterroot, for instance, spends about $700 per year to install a gravel dike. They have not been required to remove the dike following the irrigation season, although this could be required by the Conservation District. Annual installation and removal costs for the Webfoot Ditch could total about $1,000 per year. The same diversion could be accomplished with eight sections of our modified alternative structure, which could cost $1,600 for materials and fabrication. Assuming that the Ditch Company could provide its own farm tractor for the installation, equipment costs would be minimal. Thus, the Webfoot Ditch Company could pay for the fabrication and materials costs of the alternative structure in less than two years with the savings from bulldozer rental fees required to install a gravel dike. If the Ditch Company was able to do its own welding and fabrication, the cost of the alternative structures could be reduced to about $1,000 at today's steel prices. Thus, the Webfoot Ditch Company could pay for the materials for the alternative structures within one year's time, from the savings of bulldozer rental fees. The Ditch Company would incur minimal additional costs for the use of its farm tractor. Some additional time might be required if the Company performed its own welding. The modified structures are not expected to require more time to install than a gravel dike. Once purchased or fabricated, the alternative diversion structures can be used year after year with only minimal maintenance.

It appears that the economics of the modified alternative diversion structure would be quite favorable. The costs and benefits should be carefully considered on a case-by-case basis. The benefits of the alternative structures for aquatic resources are, of course, difficult to quantify, but substantial.

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The Clark Fork Coalition plans to complete a 15 minute video production on the 1987 project, and to use this production to provide information and education to interested groups, including ranchers and conservationists in 1988. Video production services have been donated to the Coalition for this project, and the only additional costs to be incurred by the production in 1988 are expected to be about $500, for video duplication and transportation for presentation to interested groups.

The 1987 Alternative Irrigation Diversion Demonstration Project was a success. Both installations served their intended purpose of diverting irrigation flows without the construction of damaging gravel dikes. Many lessons were learned which will allow improvements to the structure design. Continued demonstration will be conducted in 1988, using a modified design which is less costly and more efficiently installed.

EXPENSE REPORT

Fabrication and shipping	$5,100
Communications	
Telephone	$ 72
postage	$ 28
Publicity	
Newsletter (Clark Fork Coalition)	$ 100
final report, typing, reproduction, distribution	$ 100
TOTAL	$5,400

Donated Services and Expenses

Project Staff Time (600 hours) Peter Nielsen, Clark Fork Coalition, and Dennis Workman, Dept. Fish, Wildlife and Parks.

Installation Time - Spooner Ditch Co. and Frenchtown Grass Valley Ditch Co. (40 hours)

Travel to meetings, and project sites approximately 1,000 miles

Video Recording - (40 hours) Bill Thomas, Department of Fish, Wildlife and Parks.

Project Grant administration and Reporting (Clark Fork Coalition)