Original Project Objectives

In our original proposal to the National Fish & Wildlife Foundation (NFWF) in August 1996 we stated the following project objectives:

1. Increase the number of sprinkler irrigators who use water and energy saving technologies in critical Montana watersheds;
2. Provide local, community level support networks for irrigators choosing more water efficient methods;
3. Demonstrate to Montana agricultural producers and landowners that there are large energy and water conservation potentials in most sprinkler irrigated operations;
4. Link water savings DIRECTLY to watershed preservation;
5. Develop a model that can be applied in other regions of the Intermountain West where agricultural water use is an issue.

Below we have evaluated the project's success in meeting these objectives.

Objective #1: Increase the number of sprinkler irrigators who use water and energy saving technologies in critical Montana watersheds

In our 1996 proposal to NFWF, we envisioned launching irrigation efficiency programs in two drainages with "chronically dewatered stream" status and at-risk fish populations. We hoped to enlist at least 20 irrigators as participants during the first two years of our project. We came close to meeting that target, and in the past year our project has grown rapidly and begun to expand throughout Montana.

During 1998, our initial irrigation season, we had six ranches in the project, all in the Jefferson valley. In 1999 we expanded to 17 ranches, including 12 along the Jefferson River and five along the Boulder River, an important spawning tributary to the Jefferson. In 2000 we made a conscious decision to keep project expansion to a minimum while we field tested a promising new irrigation efficiency tool, the AM400 soil moisture monitor. We retained all 17 of our participants from 1999 and added two new participants, giving us 19 ranches, 42 fields, and about 3000 acres in the project. These included one ranch in the upper Clark Fork basin and a ranch in the upper Missouri watershed.

After the 2000 irrigation season we were sufficiently impressed with the AM400 soil moisture monitor that we were ready to expand again. We were also receiving requests from around Montana for information about the AM400. We did not have the time or funds to respond to all of these requests, but we received funding from Montana Fish, Wildlife, and Parks that enabled us to substantially expand our project in the Jefferson valley while launching new irrigation efficiency efforts in the Big Hole, Beaverhead, and Blackfoot watersheds. At the present time we are working with 51 ranches: 18 ranches along the Jefferson; five ranches along the Boulder; 13 ranches along the Blackfoot; six ranches along the Big Hole (including our first flood-irrigator); four ranches along the Beaverhead; two ranches on the upper Clark Fork; and one ranch apiece in the Yellowstone, upper Missouri, and Ruby basins. NCAT has now assisted in the installation of 63 AM400 soil moisture monitors. (Some ranches are using more than one monitor.) We work with about 65 ranch owners or managers on a regular basis, and our retention rate has been near 100 percent. Only one irrigator has dropped out of our project, when he decided to subdivide his property and quit farming. One of the project's most significant accomplishments has been building trust and developing good working relationships with so many Montana farmers, ranchers, agency staff, and agricultural organizations.

Just as important as our expanding network of participants and relationships, the project has succeeded in introducing a promising new irrigation efficiency technology to Montana. NCAT installed the first AM400 soil moisture monitor in Montana and we continue to oversee the largest field test of this device anywhere. We have described the advantages of the AM400 in detail in an earlier programmatic report. Compared to other soil moisture sensing tools, the AM400 combines modest cost and a very high degree of user-friendliness. Soil moisture readings take place automatically, every eight hours, and irrigators can also get instantaneous soil moisture readings any time they like at the push of a button. Soil moisture readings from the past five weeks are displayed graphically on an LCD display screen, making moisture trends vivid and eliminating the need for calculation.

What is revolutionary about the AM400 (and the copycat devices that are beginning to appear) is the way it gives average agricultural producers much greater control over the irrigation process. This kind of control had been available previously, but generally at a cost beyond the reach of average farmers and ranchers, requiring expensive equipment or the hiring of private consultants.

Objective #2: Provide local, community level support networks for irrigators choosing more water efficient methods

In our 1996 proposal to NFWF, we stressed the importance of developing non-coercive partnerships with irrigators. We also emphasized the importance of self-reliance and local control. We said that we would use a "community organizing approach to recruit local project participants," including one-on-one meetings with potential participants, a conscious effort to identify and contact community leaders, and a series of presentations to local groups. We promised to build a Stakeholders' Advisory Group, "composed of Montana citizens interested in both maintaining and protecting Montana's wild fisheries and its agriculture sector and rural way of life."

Our hopes for creating a local support network for progressive irrigators in the Jefferson valley have been largely met. Meanwhile, local involvement and interest in revitalizing the Jefferson fishery have grown in ways that we could not possibly have imagined in 1996.

Our Stakeholders' Advisory Group has now met three times, in the winters of 1998-9, 1999-2000, and 2000-1. Participants have included project participants; representatives from Montana Fish, Wildlife, & Parks; other project funders; representatives from sustainable agriculture groups (including the Alternative Resources Energy Organization); and representatives from the Montana Department of Natural Resources and Conservation.

In our 1996 proposal to NFWF, we expressed the hope that the Stakeholders' Advisory Group would eventually lead fundraising efforts for the project. This has not yet happened, although NCAT's own fundraising efforts have been successful. In addition to the National Fish & Wildlife Foundation, funders have included the Fanwood Foundation; Ferguson Foundation; General Service Foundation; George Grant Chapter of Trout Unlimited; Golden Sunlight Mine; Greenville Foundation; Montana Department of Environmental Quality; Montana Fish, Wildlife, & Parks; Montana Power Company; Montana Trout Foundation; Norcross Wildlife Foundation; and the U.S. Environmental Protection Agency.

During a planning session for our first Stakeholders' Advisory Group meeting, NCAT staff members came up with the idea of urging local residents to create a local watershed group for the Jefferson valley. We floated this idea at our 1998-9 Stakeholders' meeting, and a small informal watershed group began meeting in the spring of 1999. Over the past two years this group has evolved into a very significant and dynamic group, the Jefferson River Watershed Council (JRWC). During the first year of its existence, the fledgling Watershed Council played a crucial role in mitigating the effects of last summer's drought. In the spring of 2000 the group managed to reach consensus on a drought management plan and instream flow targets. Through a combination of conservation measures, shared sacrifice, and better communication, JRWC met its instream flow targets for all but seven days last summer. While streams were going dry all over Montana, flows in the upper Jefferson River increased almost continuously during the first three weeks of August.

When we decided to locate our project in the Jefferson valley in 1997, we said that an indicator of project success would be decreasing irrigation withdrawals into the ditches where we have participants. In 2000 we saw strong evidence that these kinds of decreases occurred. As shown in the chart below, the three largest ditches on the river substantially limited their diversions, and flows in these ditches were 5 - 20% below normal almost continuously from mid-July onward. Biologists believe that last summer's low stream flows undoubtedly caused harm to the Jefferson River fishery, but these impacts were less severe than they would have been without the cooperative efforts of local irrigators, encouraged and facilitated by JRWC.

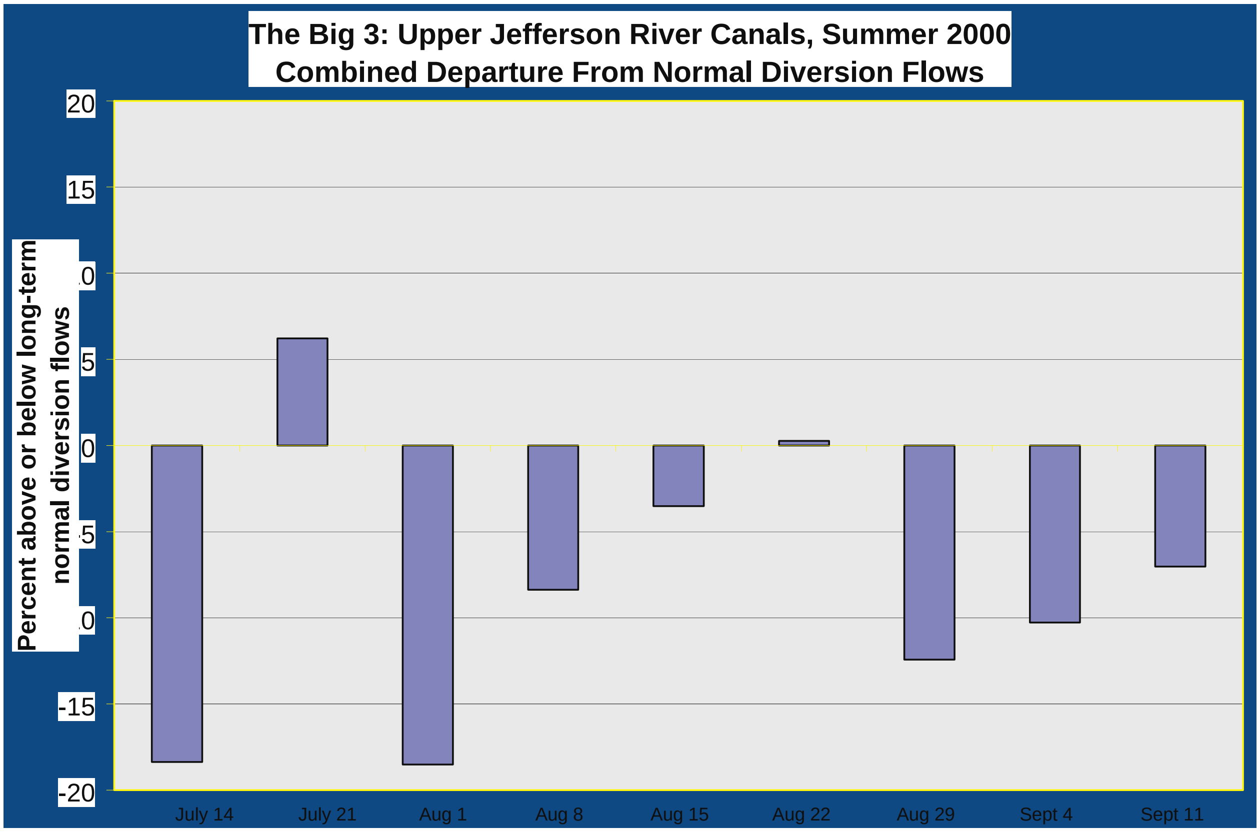


Chart courtesy of David Amman, Montana Department of Natural Resources and Conservation

During the past year JRWC has chosen a president, agreed on ground rules, raised $14,000, and continued to discuss water management issues. NCAT has served on the JRWC Steering Committee since the group's inception and many of our project participants are key members of the group. Monthly Watershed Council meetings are attended by 15-40 stakeholders, including local ranchers, farmers, anglers, guides, agency staff, and other people representing local governments and businesses. The group operates on a purely voluntary basis, and decisions are made by consensus. A part-time facilitator was hired in June 2001, giving the group much greater capacity to initiate projects and raise money.

Now that JRWC is on solid footing, we view it as the logical group to provide local leadership and support for irrigation efficiency in the Jefferson Valley. As one of its first official projects, JRWC worked with NCAT on getting an AgriMet weather station installed in the Jefferson valley this spring. Once it is fully operational, the AgriMet station will replace the weather station NCAT has operated in the valley over the past few years. The Bureau of Reclamation will manage and maintain the weather station, providing high quality evapotranspiration information to local agricultural producers via mail, e-mail, fax, internet, and through local newspapers. In conjunction with the launching of the new weather station, JRWC also co-sponsored with NCAT an Irrigation Water Management Workshop in March 2001, attended by around 50 irrigators.

The Montana Rivers Project has made a conscious commitment to working with local watershed groups in other areas too. This spring we put on training workshops for local watershed groups in the Big Hole and Blackfoot valleys, showing irrigators how to install their own monitors and assisting these watershed groups in launching their own irrigation efficiency programs. Our workshop for the Big Hole Watershed Committee took place on April 10 and was attended by around a dozen local irrigators. Also in attendance were staff members from the Beaverhead Conservation District and Dillon office of the Natural Resources Conservation Service (NRCS). Our workshop for the Blackfoot Challenge took place on May 9. Irrigators in these watersheds have been installing their own monitors, with technical help from NCAT. NRCS staff members have carried out subsequent workshops along the Beaverhead and Red Rock Rivers. We will return at the end of the irrigation season to download soil moisture information, meet with all irrigators, and carry out an evaluation of each of these projects.

In a very encouraging development last fall, the National Fish and Wildlife Foundation, Trout Unlimited, and the Orvis Company recently announced a major long-term effort to work with JRWC to restore and improve the Jefferson River fishery. In announcing its national fundraising campaign for the Jefferson River, the Orvis Company cited the efforts of "a burgeoning watershed group made up of local citizens." A fulltime coordinator was hired in spring 2001 to lead this effort. The project will focus on improving stream flows, reducing fish losses due to irrigation, restoring tributary habitats, and promoting long-term planning that will benefit the river and its fishery, as well as protecting the open spaces and extensive undeveloped land along the river – increasingly rare in Montana's river valleys.

Objective #3: Demonstrate to Montana agricultural producers and landowners that there are large energy and water conservation potentials in most sprinkler irrigated operations

During 2000 we had 27 pumps in our project, ranging from 7.5 to 150 horsepower. Irrigation systems included 6 pivot systems, 12 "hand line" systems, and 9 "wheel line" or mixed systems. Participants grew alfalfa, pasture, and various spring grains (including barley and oats). We calculated water consumption for all participants, using power bill information and (previously tested) flow rates. For 23 of the pumping systems in the project, we also had access to 1999 power bill information, enabling us to make direct comparisons of 1999 and 2000 energy and water consumption. Here are the results:

	1999	2000	change
Electricity used (kWh)	929,170	1,108,082	+ 19.3%
Water consumed (gallons)	1,065,062,096	1,303,594,598	+ 22.4%

During NCAT's 1993-4 pilot irrigation efficiency project, carried out in cooperation with the Broadwater Conservation District, dramatic watering reductions were reported in the range of 33 to 70 percent. With these results in mind, our 1996 proposal to NFWF expressed the hope that more efficient irrigation techniques could quickly reduce water consumption on participating ranches and farms by 25-30 percent. During our first three irrigation seasons these hopes have not materialized, and we have gained a more realistic perspective on the difficulties of measuring water consumption and savings.

Between 1997 to 1998 we calculated decreases in water and energy consumption of about 8 percent and 5 percent respectively. Between 1998 and 1999 we estimated increases in water and energy consumption of 6 percent and 1.5 percent respectively. As shown above, between 1999 and 2000 we saw increases in water and energy consumption of 22.4 percent and 19.3 percent respectively. The upshot is that after three irrigation seasons, we have not yet produced convincing quantitative evidence of success at reducing water consumption. Several factors and considerations need to be kept in mind, however. Since these points include some of the most important lessons we have learned, we will spell them out in detail:

Lack of reliable data

Unlike researchers who might carry out an irrigation study under precisely controlled conditions, we work in real-life conditions that include limited control, limited understanding, a small sample size, and imperfect communication with participants. For example, not only did we fail to receive power bill information from some participants, but we've been unable to test pump efficiency every year, so we have no way of measuring changes in pump efficiency from one year to the next. This means guesswork and potentially significant errors when we use energy consumption as a basis for estimating water consumption.

Installing soil moisture sensors

The power bill information that we receive from participants also sometimes appears inconsistent or we see baffling changes from one year to another that are exceedingly difficult to track down and explain. These inconsistencies may reflect hardware changes (e.g. adding or changing pumps), billing changes that make direct comparisons from one year to another impossible, or other factors. Given the small size of our project, reporting errors on even one ranch can cause significant distortion in our calculations. For example, in 2000 we received confusing and inconsistent power bill information from a single irrigator who represented almost 20 percent of the total power consumption in our project.

Effects of weather

A major problem for measuring progress is that we have no reliable way to quantify the effects of weather on water consumption. The weather in 2000 was much drier than the weather in 1999, and this difference undoubtedly affected irrigation patterns. 2000 was a severe drought year that will long be remembered in Montana for wildfires and devastated croplands. There was very little precipitation in the fall of 1999 and very little low-elevation snow during the winter of 1999-2000. So irrigators started the 2000 growing season with extremely dry soils. Many started irrigating a full month earlier than normal, during April – which in itself probably explains part of the increase we saw in water consumption. Spring and summer 2000 were exceptionally dry. From April 16 until October 1 NCAT measured only 4.5 inches of rain in the Jefferson valley.

NCAT has developed some fairly crude methods of estimating the effects of weather on irrigation, primarily drawn from a 1989 NCAT study correlating rainfall with irrigation demand by 1500 irrigators in Montana Power Company's service territory. If we apply the results of this study, we might explain part of the irrigation increase we saw last year as resulting from the lack of precipitation. Note, however, that this kind of weather-correction does not include effects of heat, wind, or other factors. Any such calculations should be viewed cautiously and skeptically – not only because they are derived from a small sample size and fairly crude estimation techniques, but also because factors besides weather can dramatically influence water and energy consumption from one year to the next. (Some of the more obvious examples are cropping changes, hardware changes, and water availability.)

Drought Effects

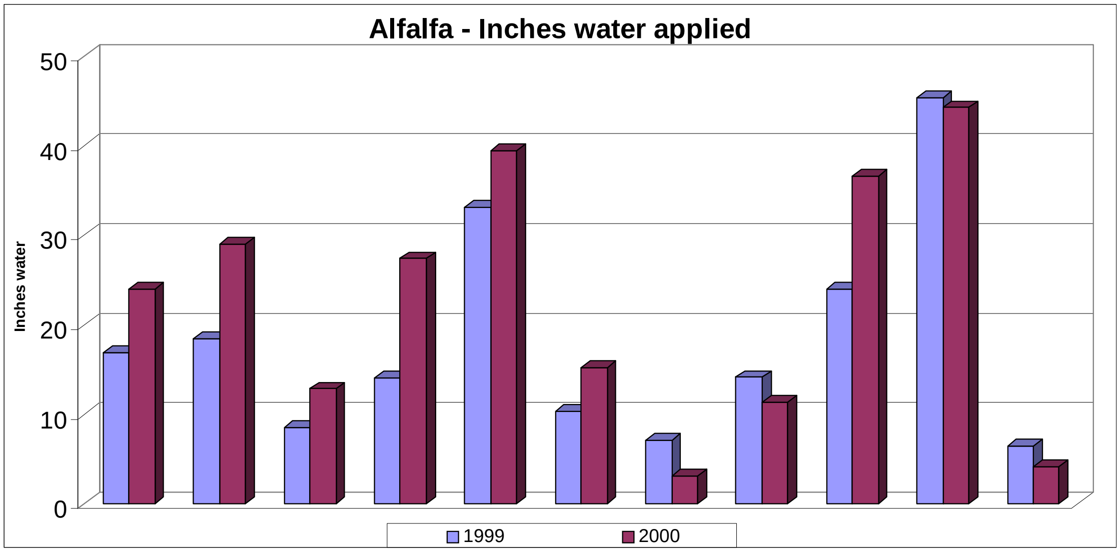
Jefferson River below Waterloo Bridge, August 2, 2000

Promoting irrigation efficiency under the conditions we experienced last summer might be compared to promoting dieting during a famine. Under extremely hot drought conditions, irrigators generally water whenever they have the chance. Irrigators told us that they lived under a constant fear that their water would be shut off. This never happened last summer on the major ditches in the Jefferson valley, and so paradoxically, we may have seen more overwatering than usual. Irrigators rarely felt secure enough to cut back on their irrigation. In the late summer the price of hay also skyrocketed, making even slight increases in production significant and increasing the value of every gallon of water that could be applied.

Difficulty of Using Evapotranspiration as a Yardstick

Even if we had a reliable and precise way to calculate total water consumption, this would mean little without some baseline or control group for comparison. One approach would be to compare actual water consumption to theoretical estimates of crop water use (evapotranspiration or ET). Irrigation that far exceeds ET rates might be viewed as a clear case of overwatering, and an irrigation efficiency project might aim to reduce water consumption to or near local ET rates.

A problem with this approach, though, is that variations in soil type or hardware can drastically affect the amount of water that needs to be pumped to meet crop needs. With these variations in mind, Dr. Jim Bauder, a Soil Scientist with Montana State University, has proposed that in the case of alfalfa – the most common crop in our project – irrigation would need to exceed 30 inches during a growing season in order to be a clear case of overwatering. On the whole, the irrigators in our project applied an average of 27 inches of water to their fields. The following chart shows inches of water applied to alfalfa fields by the producers who were in our project in both 1999 and 2000.



So if we use 30 inches as a threshold for overwatering, only three of these alfalfa fields were clearly overwatered. As we have described in earlier programmatic reports, some of the delivery systems in our project are under-designed for the size of the field. In these cases, it may be practically impossible for an irrigator to deliver adequate water, let alone overwater. The high cost of electricity also plays a role. One irrigator told us that he can only afford to budget a certain amount for his energy bills. He simply stops irrigating whenever his energy expenditures reach this point.

The upshot is that few irrigators in our project clearly exceed ET rates for their crops, but this doesn't prove that they are irrigating efficiently. The devil is in the details. Without a very thorough study of soil type, delivery system, system efficiency, operational limitations (based on the shape and size of the field, crop variety and age, planting dates, etc.) it's impossible to know the optimal quantity of water that should be applied.

Difficulty of Finding a Suitable Control Group

Another approach would be to compare the irrigators in our project to some control group that is not using the same irrigation efficiency tools and practices. Unfortunately, we have not yet found a practical way of doing this. One problem is that nearby irrigators who are not in our project are, in general, unwilling to work with us and unlikely to share their power bills with us.

Another approach would be to find a local power substation that could provide power demand information for the irrigation months. If we knew, for example, that irrigators in the entire Jefferson valley used 25 percent more power in 2000 than they did in 1999, we might view the 22 percent increase among our participants last year as typical – or even as an improvement. Unfortunately, there is no local substation that will serve this purpose, allowing us to separate power consumption by Jefferson valley irrigators from power consumption by residential and business customers in the nearby town of Whitehall.

Inexperience, Misinterpretations, and Possible Psychological Effects

It's important to keep in mind that this was the first year these irrigators had ever seen or used an AM400 monitor. Many stressed that it will take them years until they fully understand what they are seeing and learn to trust the information.

We saw evidence that some participants may have been misinterpreting the information on the AM400 in ways that would tend to encourage overwatering. When the monitor is first turned on, for example, the screen shows a range of moisture levels from 0 centibars (saturation) to 25 centibars. A 25 centibar reading is still very wet, near the water-holding capacity of most soils. A person would not ordinarily irrigate until soils had dried out to somewhere between 30 and 90 centibars, depending on soil type. On the monitor, however, a drop from 0 to 25 looks precipitous, with the graph falling from the top to the bottom of the screen. We had the impression that some participants may have experienced a panic reaction and watered more frequently.

Our conversations with irrigators definitely point to a need for ongoing training. In March 2001 we invited soil scientist Dr. Bauder to hold an irrigation workshop in the town of Whitehall. Dr. Bauder spent time giving very specific guidelines for how to use the centibar readings on the AM400 monitor in various soil types and for various crops. He specifically recommended that people never irrigate until they were seeing readings in the range of 30 to 50 centibars or higher. Project participants found this information useful, and some told us that they planned significant changes in their irrigation practices this summer.

Relatively Low Cost of Energy

Our conversations with irrigators have sometimes suggested that the cost of energy is still a relatively low priority for them. Consider these ballpark numbers: Participants in our project spent an average of $33.36 per acre on energy to pump irrigation water, ranging from a low of $10.33 to a high of $54.40 per acre. The six pivot irrigation systems in our project cost their owners $10.33 to $32.73 per acre for electricity, averaging $23.09 per acre. The twelve wheel lines in the project cost $20.27 to $54.40 per acre for electricity, averaging $37.25 per acre. These numbers suggest that energy costs are somewhat lower for pivot irrigation systems than they are for wheel line systems in our project. On the other hand, they give an indication of the relative importance of energy costs in a farm or ranch economy. For an average irrigator in our project, the energy to raise 100 acres of alfalfa last summer cost $3,336. At typical yields of 3-4 tons per acre, and a typical price of $75, these 100 acres yielded $22,500 to $30,000 worth of alfalfa. In other words, energy costs might have been 7 to 15 percent of the total value of the crop. These costs are about to change in Montana, and perhaps dramatically. In July 2002 Montana Power Company is expected to sharply increase rates for irrigators in its service territory.

Post-Season Interviews

Simple comparisons of energy and water consumption need to be viewed in the context of post-season interviews and other indicators of project effectiveness. We received a strongly favorable picture of our project success in 2000 when we spoke to our participants at the end of the year. A summary of these survey results is attached. To mention a few highlights:

- 4 of 15 respondents thought that they had "probably" or "definitely" saved water or energy. 3 didn't know, and 8 said "no" or "probably not."
- 10 of 15 respondents used the AM400 for decision-making (as opposed to merely using it for confidence or comfort).
- Many respondents reported learning important new lessons about how their soils hold water and how quickly their soils dry out.
- One person reported "reducing 100 nozzles from 9 gallons per minute to 7 gallons per minute and shutting off lines for 2-3 days at a time."
- A person who formerly ran his irrigation system for 5-6 hour "sets" in a given location, or 8 hours in hot weather, dropped to 3-hour "sets" in May and 4-5 hour sets in hot weather.
- One person who formerly ran 24-hour "sets" switched to 12-hour sets, allowing him to move across his field twice as fast. He said that this change (and the information he was seeing on the monitor) enabled him to survive the drought and keep his crop alive.
- One person shut down her irrigation system for 12 hours every night, although she had previously watered continuously for 24 hours every day.

On the whole, these comments painted a picture of producers who were paying close attention to their soil moisture readings, adjusting their operations, and learning new ways to cope with limited water supplies and drought conditions.

Mike Hansen demonstrates the first AM400 soil moisture monitor in Montana.

Objective #4: Link water savings DIRECTLY to watershed preservation

Our 1996 proposal to NFWF envisioned a strong information dissemination effort, including publications, field tours, press releases, a web page, articles in local papers, and other publicity. A primary goal of this publicity would be to remind the public of the need for better stream flows in Montana's rivers and to stress the idea that irrigation efficiency should benefit fish as well as irrigators.

The project has been very active in pursuing this objective. A partial list of our efforts follows, and copies of many of these are attached:

Articles

- *The Montana Standard* (front page stories on July 13, 2000 and April 1, 2001)
- *The Prairie Star* (stories in June 2000 and April 2001)
- *Whitehall Ledger* (numerous stories, invited columns, and editorials; NCAT's crop evapotranspiration chart and watering recommendations also appeared in the paper weekly from spring through fall 2000)
- *Farmer-Stockman* (story in the national edition, November 2000)
- *ATTRA News (*Appropriate Technology Transfer for Rural Areas) (November 2000)
- *Small Business Computing Magazine* (This national magazine interviewed two of our participants in 2000 and planned a story called "Wired Farms")
- *The Christian Science Monitor* (September 11, 1997)

Interviews

- *Whitehall Ledger*: interview on April 4, 2001
- *American News Service*: phone interview

Presentations and Meetings

- AgriBusiness Day (Butte, MT: April 9, 2001)
- Madison watershed working group (Three Forks, MT: March 8, 2001)
- Montana State University (Bozeman, MT: February 2001): Working group on "Response of Trout Habitat and Ranch Sustainability to Innovative Water Management Strategies on Montana Farms and Ranches"
- Montana Chapter of the American Fisheries Society (Butte, MT: January 22, 2001)
- Presentations to Jefferson River Watershed Council, Big Hole Watershed Committee, and Blackfoot Challenge (winter/spring 2001)
- Northwest Energy Efficiency Alliance: Scientific Irrigation Scheduling meetings in Twin Falls, Idaho (December 1999) and Richland, Washington (August 1999 and September 2000)
- Ranchers' Roundtable (Whitehall, MT: April 8, 2000)

Workshops, Tours and Field Days

- Irrigation Water Management Workshop (Whitehall, March 27, 2001)
- Irrigators' Field Day (Cardwell, May 3, 2000)
- AM400 Installation Workshops
    - Whitehall, April 2000
    - Glen (for Big Hole Watershed Committee), April 2001
    - Ovando (for Blackfoot Challenge), May 2001

Website

- Our Montana Rivers Project website (www.ncat.org/mtrivers) has been in existence since 1998.

Beyond publicity and information dissemination, NCAT's 1996 proposal to NFWF also imagined the possible creation of a "fund which would support similar types of water conservation projects in the state and region." This effort was conceived as being led by a new water conservation foundation modeled after the Rocky Mountain Elk Foundation. The mission of this foundation would be "to encourage water conservation projects, water leases, and water donations to help protect and restore our western rivers."

NCAT has not been directly involved in the creation of such a fund or organization, although a number of other organizations are at least partly filling this niche. The Western Water Project, a joint initiative of Trout Unlimited and WaterWatch of Oregon, has had a full-time staff member in Montana since 1998. A second organization, the Montana Water Trust, has held a number of organizational meetings and recently invited NCAT to serve on its board.

Objective #5: Develop a model that can be applied in other regions of the Intermountain West where agricultural water use is an issue.

The Montana Rivers Project has been unique in many ways, and no two watersheds are alike. Have we developed a model that can be applied in other parts of the Intermountain West? At the very least we've learned some lessons that may guide other similar efforts in our region:

1. Working with western ranchers requires that we be realistic about their concerns, including their understandable nervousness about privacy, water rights, and contractual entanglements.

Our 1996 proposal to NFWF stated that "Project participants will be required to sign an agreement that they will donate all conserved water for instream flows." The mental picture behind this statement was that we were taking an irrigator-by-irrigator approach that would contractually lock in instream flows one ranch at a time. We have now largely abandoned this strategy in favor of a less coercive and contractual one. Even if we could afford to provide irrigation efficiency tools and services to every ranch in the valley (which we can't), and even if we had a way to enforce such agreements (which we don't), and even if we knew what water savings would result (which we don't), the reality is that many irrigators will never sign any kind of binding agreement with an organization interested in keeping water in the rivers.

2. Except in unusual circumstances, physical constraints and western water rights law tend to defeat coercive or legal efforts to keep salvaged water in a large western river for any distance.

The reality is that one person's savings will usually be soaked up by the next thirsty irrigator downstream. This is generally legal and is implicitly encouraged by the "use it or lose it" principle that is one of the cornerstones of western water law. This is not to say that water leasing and other legal or contractual measures are useless. We have seen many examples where these approaches are very effective, especially when focused on smaller tributary streams where even a few cubic feet per second can have a dramatic impact on spawning success. There may be also be achievable legal changes that could make western water law more friendly to conservation and instream flows. In the meantime, though, we have been impressed with how much progress is possible through purely voluntary and non-coercive methods. During the past several years in Montana, we've seen repeatedly that local watershed groups can coordinate significant drought response and instream flow efforts, calling for shared sacrifice, coordination, and better communication that can make an enormous difference to the survival and health of local fisheries. Certainly the Big Hole, Blackfoot, and Jefferson are clear examples of this pattern, but there are many other examples in Montana too.

3. Progress on irrigation efficiency is most likely to come from locally-based projects that enable ranchers to experiment on their own and learn from each other.

We believe that the most promising way of promoting irrigation efficiency is to engage irrigators in a process of experimentation, learning, and communication. Advocacy groups (as well as power financial interests) will no doubt continue to pressure irrigators to reduce their water consumption. It has been crucial for the Montana Rivers Project to position itself as a cooperative and voluntary approach, one that develops partnerships with irrigators and seeks alternatives to coercion and litigation.

We believe that local control can greatly increase the effectiveness of an irrigation efficiency project. We also firmly reject what has been called the "expert-dummy model," according to which experts transfer their technical expertise to supposedly naïve subjects. We view irrigators as resourceful people who live in a world of limited control and physical and financial constraints. They cope with challenges related to weather, soils, crops, machinery, irrigation ditches, pumps, diversion structures, fences, insect pests, and economics on a daily basis, and no one will ever know as much as the producers themselves about their fields, soils, and crops. In the end we believe that irrigators need to be directly involved, making choices that fit their own unique circumstances.

Local control is important for another reason too. In the rural west, there are severe logistical problems with trying to run a centralized irrigation efficiency program. For one thing, driving distances are enormous. Moreover, agricultural producers keep a hectic schedule during the growing season, and (despite the increasing popularity of cell phones and e-mail) regular communication with them becomes nearly impossible. Before NCAT switched to the AM400 soil moisture monitor (automating the process of moisture measurement and eliminating the need for a field technician), we experienced firsthand the many practical difficulties caused by sending a field technician around to farms and ranches that were scattered over many thousands of square miles.

4. Progress on irrigation efficiency is not likely to come quickly.

When we first presented our ideas to irrigators in several Montana valleys, hardly anyone would sign up for our project. During 1997 we made initial presentations to irrigators in the Big Hole, Flint Creek, and Rock Creek basins, receiving a generally lukewarm (and sometimes downright chilly) reception. Our presentation to Jefferson irrigators also met with a mixed response, although one prominent and well-respected rancher came out strongly in favor of our project and signed up on the spot. Five of his neighbors quickly followed suit, and these six became the core of our project in the Jefferson valley.

Nonetheless, it has taken three more years to overcome initial nervousness about water rights and win the trust of most irrigators. This summer, in our fourth field season, we are finally receiving calls from several influential irrigators who are finally ready to work with us. We are also receiving phone calls from other irrigators around Montana. The keys seem to have been persistence, patience, integrity, visibility in the community, and a willingness to deliver consistently high quality services.

As explained above, it appears unrealistic to expect dramatic behavioral changes to occur in the first year or two that someone is a participant. For irrigators, time is always scarce during the growing season and they have a lot of other things to worry about. A successful approach will provide good tools, convenient technical support, ongoing training, and allow a period of years for experimentation and gradual change.

5. It is difficult to quantify the water savings or improvement in stream flows resulting from irrigation efficiency efforts alone.

It's interesting to note that NCAT's experience has not been unique. For example, in early 2001 the Northwest Energy Efficiency Alliance (NEEA) announced that it was discontinuing its scientific irrigation scheduling initiative in the four northwestern states, citing the high cost of these programs and a lack of convincing evidence of behavioral change or energy savings. At the same time, though, NEEA has expressed considerable enthusiasm for new low-cost technologies including the AM400 soil moisture monitor. It will be very interesting to see what kinds of savings the irrigators in our project are able to accomplish as they gain experience with the AM400 soil moisture monitor over the next few years.

6. An irrigation efficiency program can serve as a productive and non-threatening focus for water management discussions.

NCAT's experience has been that irrigators have plenty of reasons to become more efficient. Power rates are expected to increase to a level that will most likely put many inefficient irrigators out of business. To one degree or another, water shortages affect most river basins in the west, and inefficiency hurts farmers and ranchers just as much as it hurts fish. From a strictly economic point of view, irrigators are well aware that overwatering stunts crop growth, causes erosion, washes costly nutrients below the root zone, and in general reduces profit.

While the direct water savings from our irrigation efficiency project have been somewhat unimpressive and hard to measure, the indirect benefits have exceeded our wildest dreams. The situation in the Jefferson valley is unquestionably better than it was five years ago. There is now a vibrant local watershed group, allowing much better communication among irrigators and between irrigators and other stakeholder groups. There is a Drought Management Plan. Montana Fish, Wildlife, & Parks (MFWP) has taken a renewed interest in the fishery – with regular population surveys and a greater commitment to other studies and projects. Montana's Department of Natural Resources and Conservation has installed new flow measurement devices at key locations in the Jefferson River and the large irrigation ditches. The recent initiative by NFWF, Trout Unlimited, and the Orvis Company should provide funding for some significant habitat improvement projects, and has resulted in hiring a person to work fulltime on fisheries and water management issues in the Jefferson valley.

The Montana Rivers Project has certainly had a hand in all of these developments, although many other groups have been also involved and perhaps many of these things would have occurred on their own. What is remarkable and somewhat unique about the Jefferson valley, though, is that all of this has been achieved without any obvious sword hanging over the heads of irrigators. By contrast, the Ruby valley organized its local water management efforts after excessive reservoir withdrawals in 1994 caused a major fish kill and left irrigators threatened with fines. The Big Hole Watershed Committee was created by ranchers following the same drought year of 1994, as a direct response to the threat of listing fluvial Arctic grayling under the Endangered Species Act. One lesson we take from our experience in the Jefferson valley is that the benefits of irrigation efficiency – economic benefits, reduced social conflict, improved communication, and the good publicity that goes along with these – are powerful incentives in themselves for western irrigators to try better and more scientific irrigation practices. Locally-based water management efforts can take place and succeed without a crisis or the threat of a lawsuit or fines.

7. The cost of irrigation improvements and new technologies should be heavily subsidized initially, with decreasing subsidies over time.

Our approach has been as follows:

<u>Irrigation efficiency audits</u>: Free in 1998 and 1999 with no strings attached or requirement for further participation. Not provided in 2000 or 2001.

<u>Hardware improvements</u>: We heavily subsidized pump rebuilding and other efficiency improvements in 1998 and 1999. We provided no further subsidies or incentives in 2000 or 2001.

<u>Soil moisture monitoring and reporting</u>: We provided and installed gypsum blocks free in 1998 and 1999, sending a technician out once per week to take readings and prepare a weekly report with watering recommendations. In 2000 we switched to the AM400 soil moisture monitor, enabling irrigators to check their own soil moisture and eliminating the need for a field technician. Our role is now to assist with installations, troubleshoot problems, and download all soil moisture information at the end of the irrigation season. This information is printed out in a graph that we give to irrigators when we interview them as part of our post-season evaluation.

<u>Soil moisture hardware and installation</u>: Soil moisture sensors were free in 1998 and 1999. AM400 monitors and other hardware were free in 2000. NCAT did most of these installations, usually with some help from the irrigator. In 2001 we are providing monitors ($379 retail value) at no cost to Boulder and Jefferson valley participants, but asking them to pay for their own cable, Watermark sensors, and miscellaneous hardware. We assist with installations but do not bury cable. In the Blackfoot, Big Hole, Beaverhead valleys we are training representatives from local watershed groups to do their own installations, assisting on a limited basis with installations, and providing hardware at our cost. NCAT will provide limited troubleshooting help, download data, and perform end-of-season evaluations.

8. Progress should be measured in a variety of ways and not just by water savings.

For all the reasons described above, reductions in water consumption are extremely difficult to quantify with any confidence – at least in real-life conditions, as opposed to controlled studies on research plots. For the same reason, we have come to view dramatic reports of irrigation efficiency improvements or water savings in other parts of the country with a more skeptical eye.

This does not mean that measurable progress is impossible or that projects like this one need to proceed on blind faith. It does suggest, though, that progress should be measured in other ways. For example, we would ask questions like the following:

- Is participation in the project growing?
- Is the project winning the approval, support, and trust of local irrigators?
- Is the project creating peer pressure to irrigate more scientifically?
- Is the project generating case studies of irrigators who have succeeded in reducing their water consumption?
- Is the project learning how to identify irrigators with the strongest potential for reducing their water consumption?
- Is the project learning how water moves through the watershed, and gaining an appreciation for the most likely opportunities for improvement or conservation?
- Has the project stimulated conversation about irrigation and water management in a local watershed group or some other group?
- Has the project improved communication among water users?
- Has the project reduced secrecy and suspicion among water users, and contributed to a sense of community?
- Has the project called attention to the needs and problems of local fisheries, educated non-anglers about these needs, or attracted attention and effort to solving these problems?
- Has the project eased tensions and social conflict over water use without simply concealing or whitewashing these problems?
- Have local irrigators learned important lessons about their soils or the way their crops use water?
- Has the project caused local irrigators to become more receptive to new ideas or more open to experimentation, in their hardware, crops, or management practices?
- Has the project celebrated the achievements of innovative and responsible irrigators, and strengthened their reputation and standing in the community?
- Has the project helped non-irrigators reach a better understanding of the irrigation process, so they are better able to distinguish wasteful practices from responsible and necessary ones?

In the long term, or with a larger sample size, the effects of this project on water consumption may well become clearer. In the meantime, we remain committed to the idea that good science should win out and that more efficient irrigation will yield benefits to all water users. We've seen some dramatic cases of individual change and improvement, and we've seen some exciting examples of enthusiastic communities and local watershed groups launching their own irrigation efficiency projects.

We started this project thinking that it was an exercise in "applied science" – applying powerful and proven techniques to save water. We now view much of what we are doing as more an exercise in basic science, trying to understand some fundamental facts about how people irrigate, why they irrigate the way they do, and what kinds of change are possible for them. We also see ourselves playing a facilitating and coordinating role: bringing people together who have not traditionally talked to each other, putting on educational and training events, and creating a climate where there is more trust, support for experimentation and learning, and better communication among stakeholders.

Signs like this are now visible throughout the Jefferson valley.

A successful project needs to work patiently, one on one, with irrigators. It also needs to build local support for efficiency improvement in the community. We are optimistic about the promise of new low-cost and user friendly irrigation technologies. On the other hand, we believe that the keys to progress on irrigation efficiency are just as likely to be social and psychological as they are to be narrowly technical.