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Canal Control Training

Charles M. Burt, Ph.D., P.E.

Director, Irrigation Training and Research Center
San Luis Obispo, California

The Need

When compared to other industrial processes, irrigation processes are poorly controlled. Due to the unpredictable and uncontrollable nature of many present aspects of irrigation, a high degree of non-transferrability, or "art", is associated with irrigation. The Irrigation Training and Research Center (ITRC) at Cal Poly is dedicated to finding a retirement home for "Art".

There is a great potential for excellent on-farm irrigation water management. Many tools (center pivots, linear moves, surge irrigation, drip, laser land grading, to name a few) exist to enable farmers to distribute water evenly across their fields. Other tools (computerized irrigation scheduling programs, automated weather stations, infrared thermometers, soil moisture sensors) exist to facilitate proper irrigation scheduling, at the proper time and in the proper amount.

To implement these tools properly, and to reduce the "art" involved in on-farm irrigation, a farmer must have control of one of the essential ingredients of irrigation: WATER.

We do not have precise documentation of the state of affairs with regards to water delivery to farms, but we know some conditions have widespread occurrence:

1. Much of the world's water is delivered to farms on a rotation schedule. This means that water arrives once every week or so, for a fixed amount of time. Rotation schedules are still in wide use in the U.S.
2. More flexible delivery schedules are available in some areas, but in general a "demand" irrigation system really means that if a farmer "demands" (requests) water 24-48 hours in advance, it will be delivered at a specific (district-determined) time. Advance notice is generally also required prior to shutting off the water.
3. Canal systems are plagued with a "feast or famine" situation at the tail (downstream) ends. Due to the hydraulic nature of open channel flow, inaccuracies, and other factors, it is impossible for canal operators to precisely match deliveries to water orders. All the problems tend to show up at the tail ends.
4. Water deliveries to farms fluctuate with time due to pressure and water level changes in the delivery system.

In other words, farmers who receive water from irrigation districts are rarely, if ever, in a position where they can turn their water on and off as needed, at the desired time and for any flow rate. The conveniences of water delivery to which urban users are accustomed simply do not apply in agricultural irrigation. In order to manage this water supply which is not controllable by the user, farmers must learn the "art" of irrigation. Sophisticated on-farm irrigation process control, using advanced scheduling techniques and computer controlled equipment are not possible on most farms which receive water from irrigation districts.

Contact Person: Charles M. BurtBioResource and Agric. Engineering Dept.
California Polytechnic State University (805) 756-2379 Office; 2434 ITRC
Irrigation Training and Research Center (ITRC) www.itrc.org

These conditions do not exist because irrigation district personnel are lazy or do not care about their jobs. Instead, there are a number of inter-related factors which contribute to the current situation. These include:

1. Irrigation district operation deals with unsteady flow. Design is based upon steady flow situations.
2. Most irrigation district managers/engineers/designers have no formal education on the needs of agricultural irrigation. Most district engineers are from Civil Engineering backgrounds.
3. Agricultural Engineering (dealing with the needs of on-farm irrigation) has traditionally had a considerably low status among civil engineers in the U.S. and abroad. Therefore, recommendations by Agricultural Engineers were not given high priority. This is now starting to change, as the emphasis shifts from initial project construction to water management.
4. Changes to canal systems are expensive.
5. Typical "water conservation" activities in districts deal with sterile options such as lining canals. Those activities are easier to deal with than items such as changing delivery schedules, which require more interaction with farmers and are therefore full of headaches.
6. Most irrigation delivery systems were constructed years ago, when the primary goal was to spread water around an area. Details such as computerized irrigation scheduling and water quality issues did not exist then.
7. There are almost no classes available in universities which deal with unsteady canal control. It is even more rare to have a class dealing with control that integrates the needs of the end user (the farmer-irrigator). It is not surprising that few engineers know about the design/management solutions.
8. If people do not know of solutions, they tend to believe that their water delivery systems cannot be improved, just because they are working hard.

Recently, issues of environmental quality and scarcity of water have put the issue of flexible and reliable water delivery into the forefront. Water deliveries must be improved in order to eliminate this real bottleneck to improved irrigation water management.

Evolution of Water Delivery Training

In the early 1980's, the California Department of Water Resources (DWR) sponsored a study to examine the degree of water delivery flexibility throughout California. The inflexibility found with even the best districts would restrict the adaptation of modern on-farm irrigation management; furthermore, it was also found that there was a low awareness of solutions.

In the early 1980's, Cal Poly had contracts with the World Bank and USAID to train senior irrigation engineers from India regarding improved irrigation management. The initial scope of work was to deal with on-farm irrigation, because it was felt that since on-farm irrigation performances were so poor, farmers needed to be educated. It soon became apparent that in India, farmers were incapable or unwilling to make on-farm irrigation improvements until water was available in a more reliable and flexible manner.

When Cal Poly switched its training emphasis toward improved water deliveries, it found that bits and pieces of advanced hardware and management styles could be found throughout California and the world. Cal Poly then developed and conducted month-long tours of facilities and districts for the Indian engineers. The results were less than satisfactory. Tremendous amounts of time were spent on the road, resulting

in a high fatigue factor. In addition, it was very rare that a location could be found with an integrated, well thought out, end user-oriented water delivery policy. Sometimes a very sophisticated automated structure would be found operating in an incorrect environment. Straight lecture environments also proved unsatisfactory. It was too difficult to envision new hardware and how it performed without having access to good physical models. Finally, the nature of tours is to passively listen and observe. Ideally a training program should allow people to actively participate.

There was no single facility in the world where people could go to receive both theoretical and hands-on experience with a wide variety of water control techniques. Cal Poly decided to pursue the development of such a center.

Water Delivery Facility at the Irrigation Training and Research Center

In 1985, Pacific Gas and Electric Company (PG&E) decided to provide initial funding for a Water Delivery Facility at Cal Poly. The motivation to fund this training had two sources:

1. PG&E agricultural marketing personnel were interested in helping farmers conserve both water and power. They realized that by improving current water delivery practices, farmers would be able to utilize more sophisticated on-farm irrigation hardware and management.
2. PG&E was interested in shifting a large part of its electric pumping load out of the noon - 6:00pm time (i.e., out of the peak demand period of the day). Presently it is almost impossible for farmers who receive district supplies to do this, because the districts cannot stop the water deliveries. The districts would have tremendous control problems.

Subsequent funding and donations were received from a variety of sources. Major donors included John Merriam, the California DWR, United State Geological Survey (USGS), Southern California Edison, Southern California Gas, Waterman Industries, UMA Engineering, and dozens of manufacturers. Agricultural Engineering students were hired to do the construction, including the concrete, steel, electrical, and earth work. The result is a $1 million outdoor facility completed in December 1989, unique in the world, to teach about flexible canal and pipeline water deliveries to the farm. The Water Delivery Facility is used by Cal Poly students, and also for short courses designed on contract for water districts and engineers.

Highlights of the Water Delivery Facility include:

1. One acre reservoir for water supply and recirculation.
2. Pump teaching facility, including 12 pumps of up to 8000 GPM of various designs (axial, mixed, and centrifugal), configurations (vertical and horizontal), drives (electrical and engine), plus automation controls, priming devices, flow measurement devices, and pressure and air relief training.
3. Upstream control canal (7 CFS) demonstrating various control structures such as regular flashboards and manual underflow gates, turnouts, long crested weirs, littleman controller, electrical microprocessor control, AMIL gate, and others.
4. Downstream control (level top) canal (6 CFS) demonstrating various control structures such as AVIO and AVIS gates, micro-processor controls (several), and various hydraulic/float gate designs.
5. 7 check structure, 660 feet long scale model canal for both manual and completely automatic computerized operation. Automated with CARDD for "demand" operation at turnouts.
6. Pipeline design area, with open, closed, and semi-closed designs and turnouts.
7. Unsteady flow computer simulation modeling capability.
8. Control room for various remote data collection and control functions.

Short Courses on Water Delivery

The first short courses for California water districts were completed by March, 1990. These one day short courses were designed for irrigation district board members because board members hold the purse strings to district expenditures in California. The short courses received an "excellent" rating from participants, and some districts have already begun to make modifications based upon what they were exposed to.

The California DWR will sponsor 2.5 day short courses in 1990/91 for engineers. The short courses will cover topics ranging from philosophies of control; to how to make a better flashboard; to CARDD, a completely computerized sloping canal system developed at Cal Poly which allows water users to take water at any time and in any amount without giving advance notice.

The Irrigation Training and Research Center (ITRC) at Cal Poly

The Water Delivery Facility is part of the Irrigation Training and Research Center (ITRC) at Cal Poly. The ITRC was founded in 1989, thereby formalizing Cal Poly's history of strong irrigation training efforts. Major funding for the ITRC has come from the California DWR and PG&E.

A primary mission of the ITRC is to develop and conduct irrigation technology transfer programs. It follows the Cal Poly philosophy of developing products which can be immediately implemented to good advantage by the end user. Much of the research conducted is actually a form of operations research. For example, a new water conservation program may be developed and implemented for an agency, with immediate benefits for farmers. However, that program may also be designed to simultaneously define irrigation characteristics in a region so that the water conservation program can be quickly reshaped for maximum benefit.

On the training side, the intent of the ITRC is not to train large numbers of farmers directly, although many farmers do attend ITRC short courses. Instead, the ITRC "trains the trainers", who are familiar with local farmers and local farming techniques. The local trainers come to the ITRC to receive tools to enhance their local work. Expert computer systems have been developed for both landscape and on-farm irrigation management. One expert system, AGWATER, a revolutionary tool for the transfer of on-farm irrigation efficiency and scheduling knowledge, has been provided along with training and computers to over 50 irrigation districts throughout California.

The strong theoretical and practical irrigation backgrounds of the staff, together with their philosophy of training, allows them to develop short courses which get right to the point. The short course atmosphere is generally a combination of practical problem solving, hands-on outdoor experiences, and sessions dealing with strategies and philosopies of irrigation design and management.

Conclusion

Improved flexibility and reliability of water deliveries to the farm have been identified as essential ingredients in the conversion of irrigation from an "art" to a well controlled industrial process. The California DWR and PG&E, among others, have recognized the need for improved technology transfer, and have supported the development of the Irrigation Training and Research Center (ITRC) at Cal Poly. The Water Delivery Facility, a part of the ITRC, is a unique facility which allows engineers and water district personnel to rapidly become familiar with practical water control solutions.

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