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Irrigation District Modernization for the Western U.S.

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OVERVIEW

Many irrigation districts throughout the western U.S. have been actively engaged in modernization efforts. In most cases, the modernization improves the level of water delivery service (flexibility and reliability) provided to farmers. In many cases, the impetus and/or funding has come from external sources. These external sources include persistent droughts, an opportunity to sell water which is conserved and transferred, the need to increase in-stream flow rates by reducing diversions from rivers, and the need to improve downstream water quality by decreasing the drainage outflows.

The Irrigation Training and Research Center (ITRC), located within the BioResource and Agricultural Engineering Department at California Polytechnic State University in San Luis Obispo, has been actively involved in assisting irrigation districts for many years. This assistance has taken many forms. One has been the offering of numerous short courses for district personnel on topics such as SCADA (Supervisory Control and Data Acquisition), flow measurement, canal automation, and canal modeling. These courses have typically been funded by organizations such as the U.S. Bureau of Reclamation (USBR), the California Energy Commission, California Department of Water Resources, or individual districts. ITRC also provides troubleshooting and brainstorming consulting services to many water districts. Regardless of the initial motivation for modernization which a district may have had, ITRC consistently works with the districts to achieve better water delivery service to farmers while also meeting or exceeding the original goals.

STATUS AND NEEDS SURVEY

At the start of a new multi-year effort on behalf of the Mid-Pacific Region of the USBR, ITRC gathered data from 61 agricultural districts by interviewing irrigation district personnel and studying their Water Conservation Plans to complete a "Status and Needs Survey" (Burt et.al., 1996). These districts cover 902,000 hectares, comprising about 90% of the irrigated acreage in Mid-Pacific Region districts. Data were analyzed to determine general demographic information, the degree of water delivery flexibility provided to farmers, and the extent of existing and planned district modernization. The interview process defined needs for direct technical assistance and training.

This paper summarizes some of the results of the Status and Needs Survey, and gives a brief overview of what is being done by some of the districts.

FLEXIBILITY INDICES

Urban homeowners are accustomed to receiving water from the tap "on demand" (i.e., without providing advance notice), with unlimited flexibility in frequency (when), duration (how long), and flow rate. In the Mid-Pacific Region, agricultural water users (i.e., farmers) receive water with a high degree of equity (not measured in this study) and with much more flexibility than most of their counterparts in other areas of the world. Nevertheless, the flexibility of water deliveries in the Mid-Pacific Region does not compare with the "demand" flexibility provided to homeowners.

Frequency Flexibility

835,500 hectares have policies which allow farmers to receive water on an unlimited frequency schedule (Table 1), as long as they order water in advance. For farmers who have an unlimited frequency schedule, the mean advance notice time was 26 hours, and the mean number of times a farmer cannot get water on his requested day is once per season.

63,800 ha (7% of the total area) use a form of rotation schedule. Of these, 56,100 ha use a fixed rotation with trading turns between farmers, and 7700 ha use a modified rotation schedule. None of the districts surveyed use a strict fixed rotation (no trading turns) or a fixed rotation during peak water use periods.

Table 1. Analysis of Districts with Various Frequency Policies* (n=61)

Type of Schedule	Total Hectares	% Total	Number of Districts
Fixed Rotation (with trading turns)	56,100	6	1
Modified Rotation	7,700	1	1**
Unlimited Frequency	835,510	93	60

* "Frequency" pertains to a farmer choosing the day he receives water.

** One district had unlimited frequency on most of the district area, but had a modified rotation on other areas.

Flow Rate Flexibility

Only one district responded that farmers could not receive different flow rates for each irrigation - although this district allows farmers to receive several different flow rates throughout the season. The remaining districts have policies allowing farmers to receive different flow rates at each irrigation.

Similarly, 56 districts have no restrictions on changing a flow rate *during* an irrigation event; the average advance notice before changing flow rates during an irrigation is 13 hours. Three districts do not allow any flow rate changes during an irrigation. Seventeen districts have a policy of 0 advance notice required before a flow rate change. Overall, farmers receive a high degree of flow rate flexibility.

Duration Flexibility

Thirty-four districts have policies allowing farmers to receive water for any duration. The remaining districts allow delivery durations of 12 hours, 24 hours, or other fixed increments. The advance notice required before farmers can shut off water ranged from 0 to 24 hours, and averaged 6 hours; seven districts do not require advance notice to shut off.

Duration flexibility is important for all forms of on-farm irrigation, but it is very difficult for irrigation districts to allow farmers to shut water off unannounced or at odd times - canals and pipelines with conventional control hardware can overflow if this happens. Farmers would like more duration flexibility to reduce over-irrigation, and avoid unnecessarily high bills and deep percolation of water and nutrients. Drip and microirrigation systems are easily automated to provide the correct amount of water to replace evapotranspiration (ET) plus losses due to evaporation and non-uniformity, so they are ideally suited for management with unlimited duration flexibility. Since soil infiltration rates change through the season with surface irrigation, farmers rarely know exactly when they will complete an irrigation. Since an irrigation could be finished at any hour of the day or night, farmers can prevent over-irrigation if they can shut off their water with no advance notice.

Farmers want a high degree of flexibility in irrigation delivery duration; ideally farmers operation their own turnouts. If the district requires that a district employee operate the turnouts, the farmer's ability to automate an on-farm irrigation system disappears. Farm employees must wait until the ditchrider arrives to begin irrigation.

Most irrigation districts have areas of their distribution system with limited capacity. When farmers request water orders, district personnel must check the pipeline/canal capacity to ensure there is enough capacity to supply that order without adversely affecting other users.

Flexibility Index (District Level)

The above mentioned aspects of district delivery policies regarding frequency, flow rate and duration were indexed to quantify the "extent" of flexibility within each district. Each parameter (frequency, flow rate and duration) has a rating from 0-5, with 5 as the most flexible score. The sum of these individual indices gives the "Flexibility Index". A flexibility index of 15 is the highest score possible.

The Flexibility Index defined in Table 2 was developed as a performance index that can be used in future studies. The average indices for frequency, flow rate, and duration were 3.3, 4.3, and 4.0. The average total flexibility index (i.e., the sum of the frequency, flow rate, and duration indices) was 11.6 out of a possible 15. Overall, the flexibility indices were high - all districts had flexibility ratings greater than 10. The overwhelming majority of districts (54) had flexibility ratings less than 13; one district received a perfect score of "15".

Table 2. Definitions of the Flexibility Index

Points	Condition
	FREQUENCY
1	Always a fixed rotation
2	Fixed rotation with trading, or limited frequency, or fixed rotation during peak season only
3	24 hours or more advance notice required before delivery is made
4	Less than 24 hours advance notice required before delivery
5	Farmer does not need to notify district before delivery
	FLOW RATE
1	Same flow rate must always be delivered
2	Several flow rates are allowed during the season
3	A different flow rate is available each irrigation, with up to 2 changes per irrigation allowed
4	Flow rate can be changed any time, provided advance notice is given to the district
5	Flow rates can be different and changed by the farmer without giving advance notice to the district
	DURATION
1	District assigns a fixed duration of irrigation
2	District assigns a fixed duration, but allows some flexibility
3	Farmers must select a duration with a 24 hour increment
4	Farmers can choose any duration, but must give notice before changing
5	Farmers can have any duration, with no advance notice required before changing

ON-FARM IRRIGATION METHODS

Recognizing the types and acreage using different irrigation methods helps in understanding the degrees of supply flexibility required by farmers. Farmers vary in their need for technical and educational support depending on their irrigation method; drip systems require frequent, flexible water deliveries. Over half the total acreage represented by the Survey used surface irrigation methods (i.e., furrow, border strip, or basin). Sprinkler and drip irrigation represented 19% and 13% of the total acreage, and is expected to increase. The remaining acreage irrigate rice or used combination irrigation methods (i.e., hand-move sprinkler and drip on row-crops) (Table 3).

Table 3. On-farm Irrigation Methods Used Within District Service Areas (n=61)

Irrigation Method	Hectares	Percent of Total
Furrow	325,700	38
Border Strip or Basin	130,300	15
Hand Move or Side Roll Sprinklers	89,900	11
Center Pivot or Linear Move	1,200	<1
Permanent Sprinklers (trees or vines)	24,000	3
Rice	49,200	6
Drip on Row Crops	7,500	1
Microspray or Drip (trees and vines)	98,600	12
Solid Set Sprinklers on Row/Field Crops	34,800	4
Combination	82,900	10
TOTAL	**844,100**	**100**

WATER PRICING

The majority of interviewed districts (45 districts representing 666,100 ha) charge for water on a volumetric basis. The mean price is $398/ha-m ($47.80/AF). Twelve districts representing 225,100 ha use a fixed pricing structure; seven districts charge different prices depending on the crop type.

DELIVERED WATER

The water supply allotted to the districts is highly variable, by both district and year. Districts that experience wide fluctuations in water supply almost always see ground-water recharge as a major concern, and their policies may emphasize recharge during wet years rather than flexible deliveries during average or dry years. On average, districts had .76 m gross water available for deliveries during the last ten years, including both surface and groundwater supplies.

ITRC/USBR ASSISTANCE

The Status and Needs Assessment determined what types of structures, communication systems, flow measurement devices, conveyance facilities, etc. were in use at the present, and what the districts plan to invest in for future improvements. As a result of those findings, ITRC and USBR embarked on an aggressive program of technical assistance to districts. This program is offered to districts on a cost sharing basis, and only upon the request of the districts.

Key components of this assistance include:

- Rapid appraisals of the district modernization needs. A 1-2 day survey is conducted with district personnel, and recommendations are then given.
- Improvement of flow measurement and flow control techniques. This includes assistance with the selection and design of structures, as well as training.
- Development of RFQs (Request for Qualifications) and RFPs (Request for Proposals) for SCADA systems. These documents provide detail of the required hardware and software for the district. The development of these documents is an important learning

opportunity for the district personnel, as they must develop a master plan for modernization in order to properly specify the SCADA needs.

- Design of improvements for drainage or irrigation water recirculation and storage facilities, to reduce surface discharges and to increase delivery flexibility.
- Technical assistance in selecting proper structures for flow control and water level control (upstream or downstream), or for improvements in delivery through pipelines.
- Development of improved PI (Proportional Integral) algorithms for upstream control, and demonstration of the Begemann gate for upstream water level control.

The response by the districts to this technical assistance has been strongly enthusiastic.

REFERENCE

Burt, C.M., K. O'Connor, S. Styles, M. Lehmkuhl, C. Tienken, and R. Walker. 1996. Status and Needs Assessment: Survey of Irrigation Districts. USBR Mid-Pacific Region. Irrigation Training and Research Center. Cal Poly, San Luis Obispo, CA 93407.