Status and Needs Assessment:

Survey of Irrigation Districts

USBR Mid-Pacific Region

on behalf of

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Water Conservation Office

Prepared by

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Executive Summary

ITRC gathered data from 61 agricultural districts in the U.S. Department of the Interior Bureau of Reclamation's (USBR) Mid-Pacific Region by interviewing irrigation district personnel and studying their Water Conservation Plans. These districts comprise 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. These needs varied by district and area in California. The Irrigation Training and Research Center concluded that training programs should incorporate some common classes using the Water Delivery Facility and other resources at California Polytechnic State University, San Luis Obispo, in addition to small specialized training efforts customized for single or small groups of districts.

This report summarizes the results and provides brief comments on various aspects of those results.

Background

Purpose

In the spring of 1995, the Mid-Pacific Region of the United States Bureau of Reclamation (USBR) contracted with the Irrigation Training and Research Center (ITRC) of California Polytechnic State University at San Luis Obispo (Cal Poly) to provide technical assistance to irrigation and water districts. As a first step and before designing a complete technical assistance program, ITRC conducted a Status and Needs Assessment Survey (Survey) of districts within the Mid-Pacific Region.

The purpose of the Survey was to:

- Identify the extent of flexibility of water delivery presently offered by irrigation and water districts to farmers; and
- Identify where improvements can be made and what types of technical assistance districts will require to make those improvements.

Survey

The Status and Needs Assessment Survey was developed at ITRC by June 1995. Some of the information requested by the Survey was available in Water Conservation Plans submitted to USBR by many districts.

Initial beta testing was conducted on the initial Survey before using it throughout the Mid-Pacific Region. Four districts in the Klamath Region were visited, data was collected, and results were compiled in this trial testing. Beta testing showed that streamlining the Survey was necessary to reduce the time involved in conducting an interview. The final, modified Survey contained the following general categories:

- Information to describe the present degree of water delivery flexibility offered by districts;
- District characteristics such as size, water reliability, water prices, various irrigation methods, control hardware, etc.;
- Current and future district sponsored programs;
- Delivery system characteristics; and
- District needs and areas requiring assistance.

The Survey also contained a water balance of individual districts, which used information from existing district Water Conservation Plans.

A copy of the Survey is located in Appendix A. The Survey contained over 250 questions. It was designed to

be completed during a face-to-face interview with a knowledgeable person from each district.

District Selection

The initial list of Mid-Pacific Region water districts consisted of 117 agencies. Table 1 shows the number of districts in each state and the acreage those districts represent.

Table 1. *Water Districts Within the Mid-Pacific Region*

State	**No. of Districts**	**Acres**
California	110	2,253,612
Nevada	3	102,200
Oregon	4	166,000
TOTAL	117	2,521,812

Very small districts were not interviewed to minimize Survey costs yet still cover large and representative acreage. Districts in California and Oregon servicing more than three thousand acres of agricultural land were visited by one of three interviewers. Some districts servicing fewer than three thousand acres of agricultural land were contacted by phone for quick interviews focusing on districts' needs. Table 2 shows the number of districts interviewed and the acreage represented.

Table 2. *Water Districts Interviewed and Acreage Represented*

State	**No. of Districts Interviewed**	**Acreage Represented**
California	63	2,237,492
Nevada	0	0
Oregon	2	94,000
TOTAL	65	2,331,492
Total used	61	2,290,192

Interviewing 55% of the districts in the region covered about 90% of the irrigated acreage in the Mid-Pacific Region. Four districts were either drainage districts or urban districts without the characteristics described in the Survey. Therefore, data from a total of 61 districts were used. A listing of the participating districts is included in Appendix B.

Water Conservation Plans (WCP's)

Water Conservation Plans have been submitted by many districts to comply with Section 3405(C) of the CVPIA (PL102-575). Plans contain data on some technical information requested by the Survey. Examples include:

- Number of customers, turnouts, and turnout measurement devices;
- Total and irrigated acres;
- Breakdown of irrigation methods by acre;
- Existing facilities - miles of canals and pipes; and
- Basic information on the district delivery schedule (i.e., arranged, fixed rotation, or modified rotation).

WCP's from 33 interviewed districts were used to supply some Survey information. The intent during Survey development was that the WCP's would be examined before districts were visited. To visit the districts as early as possible, most WCP's were instead used as a supplemental source of data after interviews had been conducted. When WCP's were available before an interview, they were very useful in reducing the time needed to conduct the interview.

Contacting Districts

Interview appointments were made with district managers, or other district personnel with a good understanding of district operations and plans. Districts were divided between three interviewers by size and location. One interviewer met with the large districts north of Fresno; another interviewer met with districts south of Fresno; the third interviewer met with remaining small districts.

The districts were located on maps and visiting schedules were made according to district location. Interviews required two to four hours at each district office. Traveling time between districts limited visits to two per day.

Interviews

Before conducting interviews, districts were contacted with a letter from USBR and another letter from ITRC. Those letters were followed up with a phone call to arrange the interview, and a subsequent confirmation letter. District managers were also informed of the Survey at various meetings.

Interviews were generally held in district offices, usually with the general manager. In some cases the interviews were held with knowledgeable district engineers or field personnel. Districts were very cooperative and managers and engineers took valuable time to participate in a lengthy personal interview.

The time required for the interview varied from one and a half to four hours. The degree of elaboration interviewees gave on the districts' structure and operational questions decided time required to conduct an interview. Although the Survey often required only best estimates to identify district trends, some questions required precise answers to complete the Survey form.

Feedback (questions of needs and opinions) sections of the Survey were well received by the interviewees. Persons interviewed were willing to discuss their views, opinions, and interests. Responses to this section varied greatly and depended on the size, location, and age of the districts.

Follow-up

Where technical questions could be answered from WCP's, limited interview time was better directed at discussion of district training needs. When missing technical information could not be collected from WCP's, unanswered questions were organized for each district.

A cover letter, which updated the districts on the current status of the project and encouraged questions or further responses, was faxed to the districts. The districts were asked to look over the questions before they were contacted by phone by ITRC two days later. Managers usually had time to finish the interviews over the phone. If not, the fax sheets were faxed or mailed back to the ITRC office.

Collection of Survey data was completed in August 1995.

District Status

Introduction

Answers from the Status and Needs Assessment Survey (Survey) were compiled to characterize the present status of districts. Items of primary interest include: general demographic information, level of service provided to water users, and types and numbers of water delivery structures.

The information in this section is provided by topic and describes the characteristics of districts and their customers. Significant figures vary throughout the report as the nature of data varies; the totals generally reflect reported totals, and are not rounded off.

General Information

The following information helps determine the Survey's scope and can be compared to USBR or California Department of Water Resources (DWR) data for consistency and accuracy. Table 3 describes general district demographics (i.e., district size, acreage, customers, and turnouts).

Table 3. *General District Characteristics* (n=61)

Description	Total Number	Min.	Max.
Number of Districts Participating	61	N/A	N/A
Total Number of Customers	17,158	4	1,300
Total Acreage in District Boundaries	2,791,944	2,400	614,000
Total Acreage Serviced by District	2,290,192	1,900	500,000
Number of Turnouts	35,520	8	5,300
Amount of Water Delivered	2,033,049	6,885	191,957

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.

Farmers are requesting more flexible deliveries, and the data below show that the degree of water delivery flexibility is high in many cases. As later sections of this report show, irrigation districts are implementing a wide range of procedures to improve the level of service they provide to farmers. Improvements are hampered by high initial costs, plus the lack of technical knowledge of engineering options related to water delivery control.

Frequency Flexibility

2,122,192 acres have policies which allow farmers to receive water on an unlimited frequency schedule (Table 4), 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 (Table 5).

162,000 acres (7% of the total acreage) use a form of rotation schedule. Of these, 142,500 acres use a fixed rotation with trading turns between farmers, and 19,500 acres 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 (Tables 4 and 5).

Table 4. *Analysis of Districts with Various Frequency Policies* (n=61)*

Type of Schedule	Total Acreage	% Total	Number of Districts
Fixed Rotation (no trading turns)	0	0	0
Fixed Rotation (with trading turns)	142,500	6	1
Fixed Rotation (during peak periods only)	0	0	0
Modified Rotation	19,500	1	1**
Unlimited Frequency	2,122,192	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 (Table 6). The remaining districts have policies allowing farmers to receive different flow rates at each irrigation.

Table 5. *Common Characteristics of the Delivery Schedules (n=61)*

Type of Schedule and Characteristic	Average	Std. Dev.	Num. of Districts
Fixed Rotation (no trading turns)			0
Days between turns	N/R		
Fixed Rotation (with trading turns)			1
Days between turns	15		
Percentage of farmers trading turns once per year	40		
Percentage of irrigations during the season which farmers trade turns	25		
Fixed Rotation (during peak periods only)			0
Days between turns	N/R		
Modified Rotation			1
Days of deviation from fixed rotation	2		
Number of days between standard rotation	14		
Advance notice required	24		
Unlimited Frequency			60
Advance notice required	26	10.27	
Number of times a turn-out cannot get water on the day requested, per year	1	3.07	

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 (Table 7). Seventeen districts have a policy of 0 advance notice required before a flow rate change (Table 8). Overall, farmers receive a high degree of flow rate flexibility.

Table 6. *Flexibility of Delivery Flow Rate Selection (n=60)*

Number of Responses	Response
0	Essentially the same flow rate must be delivered for each irrigation
1	The farmer can request several different flow rates through the season
59	Can have different flow rates each irrigation

Table 7. *Flexibility of Changing*

Flow Rate Selection (n=59)

Number of Responses	Response
3	No times - no changes allowed
0	One time
0	Two times
56	There are no restrictions

Table 8. *Advance Notice Required Before a Flow Rate Change is Made During an Event* (hours) (n=57)*

Average hours	13
Maximum	25
Minimum	0
Standard deviation	11

* 17 districts do not require any advance notice.

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 (Table 9). The advance notice required before farmers can shut off the water ranged from 0 to 24 hours, and averaged 6 hours; seven districts do not require advance notice to shut off (Table 10).

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 overirrigation if they can shut off their water with no advance notice.

Table 9. *Flexibility in Duration of an Irrigation Event (n=58)*

Number of Responses	Response
34	Unlimited - any duration is allowed
4	12 hour increments
15	24 hour increments
5	Other fixed, district-determined increment

Table 10. *Advance Notice Required by the District Before Farmers Can Shut Off Water* (hours) (n=58)*

Average hours	6
Maximum	24
Minimum	0
Standard deviation	10

* 7 districts require no advance notice prior to shutoff.

Farmers want a high degree of flexibility in irrigation delivery duration; ideally farmers operate 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.

Many water conveyance systems, delivery canals and pipelines are not designed with adequate control systems to permit farmers to operate turnouts. Often, when one farmer makes a flow rate change, the ditchrider must move along the complete length of the supply canal or pipe to readjust the flows of other open turnouts.

On average, district personnel must be present to open and close farm turnouts nearly 50% of the time (Table 11). On average, district personnel operate gates within one hour of the prescribed time (Table 12). When there is not enough flow to match a water order, 22 districts pro-rate the order and 27 districts postpone the water (Table 13).

Table 11. *Percentage of Time District Personnel Must Be Present to Open and Close Farm Turnout Gates (n=57)*

Number of districts responding 100%	16
Number of districts responding 0%	21
Average	49
Maximum	100
Minimum	0
Standard deviation	46

Table 12. *How Closely to the Prescribed Time Turnout Gates are Operated by District Personnel (hours) (n=35)*

Average	1
Maximum	2
Minimum	0
Standard deviation	.5

Table 13. *Procedure if There is Not Enough Capacity or Flow Availability to Match a Turnout Order (n=54)*

Number of Responses	Response
22	Pro-rate: farmers receive a portion of their order
27	Postpone: farmers must wait to receive any water
5	Other (combination)

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. Table 13 describes procedures used by various districts in the case of a capacity limitation, which generally occurs during the peak of summer.

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. A farmer able to turn on water on "demand" without providing advance notice to the district is the most flexible condition within the "Frequency Index" and is assigned a score of "5". A district which allows a farmer to change flow rates during an irrigation event without notifying the district is the most flexible condition within the "Flow Rate Index" and is assigned a score of "5". A district which allows farmers to receive water for any length of time and does not require advance notice to change the duration is the most flexible condition within the "Duration Index" and is assigned a score of "5". Table 14 outlines the guidelines for indexing flexibility.

The Flexibility Index defined in Table 14 was developed as a performance index that can be used in future studies to determine how district operations have changed.

The average indices for frequency, flow rate, and duration were 3.3, 4.4, 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 (Table 15). For each category, there were districts achieving the highest rating (i.e., 5), which indicates that some districts provide extremely flexible water supplies in terms of frequency, flow rate, or duration.

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 16).

Table 14. *Definition 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

Table 15. *District Flexibility Index Summary (n=57)*

Parameter	Average	Max.	Min.	Std. Dev.
Frequency	3.3	5	2	.6
Flow Rate	4.4	5	3	.6
Duration	4.0	5	3	.7
Flexibility Index	11.6	15	10	1.3

Table 16. *Flexibility Index Frequencies (n=57)*

Flexibility Index	Number of Districts
< 11	18
11 - 11.9	15
12 - 12.9	15
13 - 13.9	7
14 - 15	2

Flexibility Provided by District Supplier (USBR)

Flexibility in water delivery provided to farmers is affected by the flexibility of water supplies provided to districts. District personnel were asked to characterize this flexibility.

The percent unannounced flow rate change at a district turnout allowed by USBR ranges from 0 – 100%; the weighted and unweighted means are 40% and 56% (Table 17). A change of 100% means that if a district is diverting 50 cubic feet per second (cfs) at a particular time, that diversion can be changed to 100 cfs without providing advance notice. The percent unannounced flow rate change for the whole district allowed by USBR ranges from 0 – 100%; the weighted and unweighted averages are 35% and 50% (Table 18). Advance notice prior to USBR flow rate changes ranges from 10 to 24 hours; weighted and unweighted averages are 19% and 17% (Table 19). On average, 1,850 acre-feet (AF) are delivered to districts regardless of district need (probably for flood control). The amount of water delivered to districts, which was not ordered, ranges from 0 – 30,900 AF (Table 20). On average, the districts report that the USBR is unable to deliver the requested flow rate 10% of the time, although the maximum value is as high as 80%.

Table 17. *Unannounced Flow Rate Change Allowed by Supplier (USBR) at Any Single District Turnout (Percent) (n=51)*

Unweighted average	56
Weighted average (weighted by acres)	40
Maximum	100
Minimum	0
Standard deviation	44

Table 18. *Allowable Unannounced Flow Rate Change for Whole District, Allowed by USBR (Percent) (n=51)*

Unweighted average	50
Weighted average (weighted by acres)	35
Maximum	100
Minimum	0
Standard deviation	45

Table 19. *Hours of Advance Notice Required by USBR Before a Scheduled Flow Change Occurs (n=55)*

Unweighted average	17
Weighted average (weighted by acres)	19
Maximum	24
Minimum	0
Standard deviation	11

Table 20. *Amount of Water Delivered to Districts Regardless of Need* (AF) (n=55)*

Unweighted average	1,124
Weighted average (weighted by acres)	1,850
Maximum	30,900
Minimum	0
Standard deviation	3,434

* Water that districts were required to accept even though they did not need the water. One possible reason is for flood control.

District personnel were asked if the USBR was ever unable to provide the flow rates the districts needed. The responses (Table 21) show that constraints exist. However, the question was not worded in a way that one can determine the cause of the problem; it may be due to a lack of storage, or it may be a conveyance capacity limitation.

Table 21. *Percent of Time Supplier (USBR) Is Unable to Provide Required Flow Rate* (n=57)*

Unweighted average	10
Weighted average	12
Maximum	80
Minimum	0
Standard deviation	23

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 irrigated acreage, and is expected to increase. The remaining acreage irrigated rice or used combina-tion irrigation methods (i.e., hand-move sprinkler and drip on row-crops) (Table 22).

Table 22. *On-farm Irrigation Methods Used Within District Service Areas (n=61)*

Irrigation Method	**Total Acreage**	**Percent of Total**
Furrow	827,370	38
Border Strip or Basin	330,928	15
Hand Move or Side Sprinklers	228,377	11
Center Pivot or Linear Move	3,140	<1
Permanent Sprinklers (trees or vines)	60,891	3
Rice	125,076	6
Drip on Row Crops	18,916	1

Microspray or Drip (trees or vines)	250,402	12
Solid Set Sprinklers on Row/Field Crops	88,351	4
Combination	210,500	10
TOTAL	2,143,951	100

Note: The data in Column 3 do not exactly match the total acreage given in Column 2.
This suggests that either:

1. Clear records on acreage and irrigation method are not maintained; or
2. These numbers change from year to year resulting in ambiguous information.

Groundwater and Private Well Pumping

Of the total acres serviced by the districts, 53% have land with private wells. Eleven districts, representing 25% of the total serviceable acres in the Survey, access private wells on 100% of their service areas. Nearly 600,000 agricultural acres can use either groundwater or surface water for irrigation. Table 23 describes the character-istics of districts with privately owned wells. Improving district flexibility could possibly reduce groundwater pumping (but not consumptive use) on more than 1.8 million acres of irrigated land. Approximately one-third of the interviewed districts own wells; nearly two-thirds of the districts rely *exclusively* on surface supplies to deliver. Table 24 summarizes the extent of district owned wells and energy costs.

Water Pricing

The majority of interviewed districts (45 districts representing 1,691,826 acres) charge for water on a volumetric basis. Of these, only three districts (43,986 acres) use a tiered pricing structure (Table 25). The mean price for tiered and non-tiered water was 28.27 and 48.35 dollars per acre-foot ($/AF) (Table 26).

Twelve districts representing 571,852 acres use a fixed pricing structure; seven districts charge different prices depending on the crop type (Table 25). Average water

***Table 23.** Characteristics of Acreage with Privately Owned Wells (n=54)*

Characteristics of districts which have privately owned wells to augment surface supplies	
Number of districts having private wells	54
Total acreage supplied partially by private wells	1,228,718
Average pumping depth for wells (weighted by acreage), feet	220
Characteristics of districts in which 100% of the customers have access to groundwater from privately owned wells as well as from surface deliveries	
Number of districts	11
Total acreage	587,991

***Table 24.** District Power Costs* (n=23)*

Information	**Value**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
Total number of district owned wells	209				
Number of districts reporting ownership of wells	23				
Number of districts which provided data on both pumping costs and rates**	35				
Total pumping bill for these districts, $/yr		384,200	717,000	7,500	4,000,000
Cost of electricity for these districts, $/kW-Hr		.088	.038	.004	.17

* Includes power for both lift and groundwater pumps owned by district. ** Includes pumping from well and/or lift pumps.

price for fixed price structures was 9.44 $/AF and prices ranged from 3.54 – 59.33 $/AF (Table 26). Table 27 summarizes normalized water prices using ten year historical deliveries ($/acre).

***Table 25.** Water Pricing Policies (n=57)*

Methods of Water Pricing	**Number of Districts**	**Acreage**
Volumetric ($/AF)		
Tiered	3	43,986
No Tier	42	1,647,840
Fixed price per acre ($/acre)		
Price varies by crop	7	260,289
Price does not vary by crop	5	311,563

***Table 26.** Water Prices per Acre-Foot* ($/AF) (n=57)*

Methods of Water Pricing	**Mean Price**	**Min. Price**	**Max. Price**
Volumetric			
Tiered	28.27	22.09	48.00
No Tier	48.35	6.56	124.92
Fixed price per acre	9.44	3.54	59.33

* Based on current price structure and approximate historical ten year deliveries. Includes standby and service charges.

***Table 27.** Water Prices per Acre* ($/acre) (n=57)*

Methods of Water Pricing	**Mean Price**	**Min. Price**	**Max. Price**
Volumetric			
Tiered	61.73	48.60	96.00
No Tier	103.35	27.00	299.80
Fixed price per acre	33.41	17.00	89.00

* Based on current price structure and approximate historical ten year deliveries. Includes standby and service charges.

Delivered Water

The water supply allotted to the districts is highly variable, by both district and year. This makes it difficult to establish uniform applicable water management guidelines for all districts. 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 2.5 AF per acre gross water available for deliveries during the last ten years (Table 28). These values include both surface and groundwater supplies.

Table 28. *Average Gross Water Available for Delivery During the Last Ten Years (AF) (n=60)*

Unweighted average	2.7
Weighted (by acres) average	2.5
Maximum	5.0
Minimum	0
Standard deviation	1.5

Facilities

Reservoirs

Three percent of the service acres represented in the Survey have farmer turnouts with privately owned reservoirs (approximately 84,000 acres). Table 29 describes the status of acreage with on-farm reservoirs. This information suggests that few farmers have the ability to store surface deliveries (i.e., they must irrigate when they receive water from the district, regardless of whether it is the best time to irrigate). Limited flexibility in deliveries combined with little to no on-farm storage affect a farmer's options for maximizing on-farm water management with sophisticated irrigation systems. In areas with excellent delivery flexibility, reservoirs may still be needed to remove silt from water (for drip systems) or for farmers to take advantage of time-of-use (TOU) electric power rates.

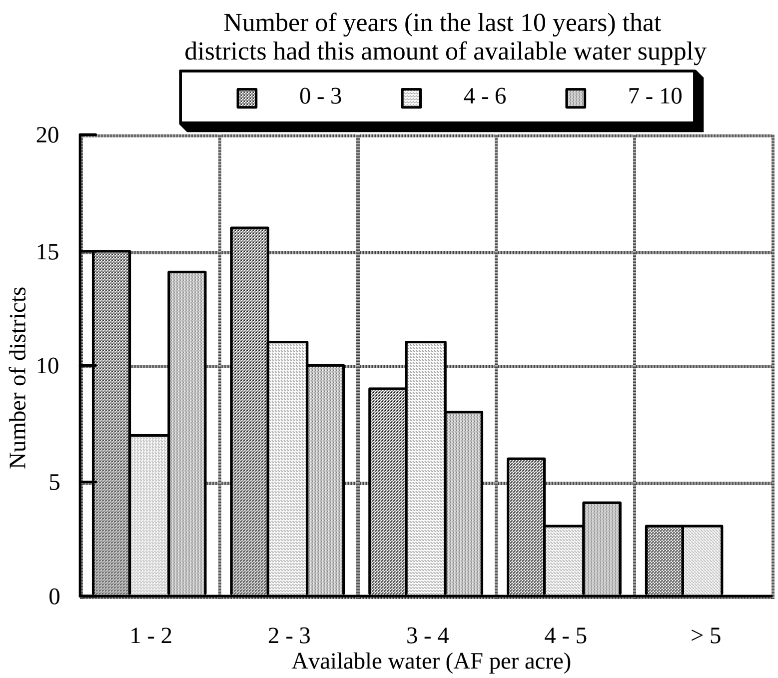

Figure 1. *Gross Water Supply Available for District Distribution During the Last Ten Years (n=60)*

Table 29. *Turnouts Equipped with Farmer Owned Reservoirs (n=19)*

Percent of Total Turnouts with Farmer Owned Reservoirs	Number of Districts*	Acreage with Reservoirs
< 5%	9	4,000
5% – 25%	6	27,900
25% – 50%	0	0
50% – 75%	2	44,800
> 75%	2	7,300
TOTAL	19	84,000

* For example, nine districts had farmer owned reservoirs on less than 5% of the total turnouts - this land represents 4,000 acres.

Drainage

Nearly half (30) of interviewed districts have subsurface drainage water leaving the district; this represents 76 outlets. 92,710 acres have on-farm tiles, and there are 2,427 miles of district operated drains. Table 30 describes drainage characteristics of these districts.

Table 30. *Drainage Characteristics of Districts with Drainage Systems*

Characteristic	Number of Districts Reporting Values > 0	Total for All of These Districts, Combined
District drainage outlets exiting the district	30	76 outlets
On-farm tiles	19	92,710 acres
District drains	22	2,427 miles

Water Conveyance and Delivery Systems

District personnel were asked about the characteristics of their delivery systems, including the age. A single district may have canals and pipelines of varying ages. Old systems may require that a large percentage of the operating budget be allocated for repairs; old systems are often associated with small fields and small conveyance capacities. Old systems with small capacities represent an expensive combination to improve.

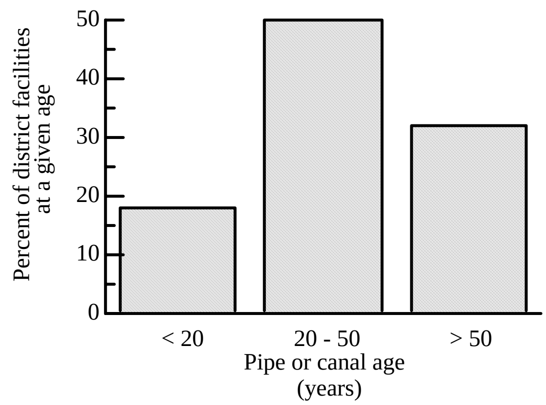

Figure 2. *Age of District Distribution and Conveyance Facilities in the Mid-Pacific Region*

Table 31. *Canal Distribution System Demographics (n=39)*

Canal Type	Total Miles
Mains	1,098
Laterals	3,926

Table 32. *Percentage of Time Flow Rate Is at Maximum Capacity in Distribution Systems (n=61)*

Percentage of Time the Flow Rate is at Maximum Capacity	Frequencies (i.e., Number of Districts Responding)	
	Mains	**Laterals**
No response	7	7
0	10	38
1 - 25	29	32
26 - 50	12	9
51 - 75	2	2
76 - 100	1	3

Flow Measurement

Conversations with district personnel showed that accurate flow measurement at farm turnouts and volumetric billing of water are stated policy objectives in the Mid-Pacific Region. Some districts have old facilities which did not originally have accurate measurement devices; many districts have already installed or are studying the use of improved measurement devices. Traditional propeller meters, while very practical in some areas, are frequently plugged by weeds in other districts. These districts are looking for alternative flow rate measurement devices. The costs of installing new flow meters varies depending upon the nature of the turnout design, the available pressure, and the water quality. Table 33 depicts the devices currently in use.

Propeller meters and Armco-type metering gates were the most commonly used turnout flow measurement devices with 44% and 30% of the total customers (Table 33). Undershot gates and weirs/flumes were the least used turnout measurement devices representing 2% and 4% of the total customers. Thirteen percent of the total customers do not have flow measurement devices. Many districts use more than one type of measurement device.

Table 33. *Types of Turnout Flow Measurement Devices (n=61)*

Turnout Flow Measurement Device	Total # of Turnouts with Device	Percent of Total Customers	Number of Districts
No flow measurement device	4,767	13	8
Armco-type metering gate	11,15 7	30	10
Undershot orifice (slide gate)	805	2	3
Weir or flume device without a contin-uous record	1,527	4	6
Propeller meter	16,11 3	44	43
Other	2,275	7	8

Many flow rate measurement devices do not totalize the volume which has passed through a turnout. The standard procedure is to assume that once a turnout has been adjusted for the desired flow rate, that flow rate will remain constant, and that the volume can be computed (Volume = Flow Rate × Time). In fact, flow rates can change if water levels (or pressures) either upstream or downstream of the turnout change, as often happens. Turnouts with a low head (a small difference in water level on both sides of a turnout) are sensitive to slight water level fluctuations on either side of the turnout. The tables below indicate responses to questions about this sensitivity.

Turnout flow rate changes over time present three problems: (1) the farmer has difficulty managing a constantly changing water supply, (2) irrigation district personnel are reluctant to allow farmers to make flow rate changes since those changes can upset the previously adjusted flows of other users, and (3) a farmer may receive more or less water than estimated (although these differ-ences tend to even out with time).

Potential solutions include new turnout designs and better control of water surfaces or pressures in irrigation district distribution canals or pipelines. These practices are generally expensive and often require specialized technology and designs.

Tables 34 – 36 depict water level changes, flow rate changes and head variations at farm turnouts. These values are district personnel estimates and represent average conditions. Water level fluctuations are typically more extreme at the tail ends of canals and pipelines.

Table 34. *Difference in Head Across On-Canal Farm Turnouts* (n=23)*

Change in Head	Average (inches)
Average	18
Maximum	32
Minimum	7

* This is the average elevation change from the canal water surface to the water surface downstream of the turnout.

Table 35. *Variation in Canal Water Level at Turnouts During a Single Day (n=24)*

	Variation (inches of head)
Average	4
Standard deviation	3

Table 36. *Change in Flow Due to Change in Canal Water Level (Percent) (n=20)*

	Change in Flow (%)
Average	10
Standard deviation	7

Physical Infrastructure

Modernization of water control and water delivery flexibility is closely related to improvements in physical infrastructure. A portion of the Survey was dedicated to determining what types of structures and control systems are currently in place. Furthermore, questions were asked regarding spending in the immediate future on various physical infrastructure needs. The results are tabulated in Table 37.

Table 37. *Present Physical Infrastructures and Anticipated Changes in the Near Future (n=61)*

Item	**Present Number in all Districts**	**Number of Districts**	**Number of Future Additions**
Miles of each of the following pipelines			
Monolithic concrete pipe (poured in place) - miles	909	7	5
Closed Pipeline - no pumps (miles)	1,563	21	1
Closed Pipeline - pumps (miles)	1,406	21	44
Semi-Closed Pipeline (miles)	0	2	40
Open Pipeline (no overflows) - no pumps (miles)	124	3	18
Open Pipeline (no overflows) - pumped inlet (miles)	5	2	2
Open Pipeline with overflows - no pumps (miles)	205	3	0
Number of sites with remote monitoring at tail end	0	1	0
Number of sites w/o remote monitoring at tail end	0	1	0
Open Pipeline with overflows - pumped inlet (miles)	0	0	0
Number of sites with remote monitoring at tail end	0	0	0
Number of sites w/o remote monitoring at tail end	0	0	0
Special control devices on canals			
Regulating reservoirs	181	24	7
Lateral interceptors	1	5	0
Flow measurement devices in the canals			
Weir/flume, flow rate only	365	4	0
Weir/flume, totalized	12	4	11
Other, totalized	4	1	0
No device, but gate rating tables	1,176	5	0
Local water level automation - upstream control			
Amil gates	3	2	0
Littleman	8	3	0
PI (computer)	0	0	2
Other hydraulic	0	0	0
Long crested weirs	10	1	50
Other automatic	5	1	0

Table 37 continued...

Table 37. *Present Physical Infrastructures and Anticipated Changes in the Near Future (continued)*

Item	Present Number in all Districts	Number of Districts	Number of Future Additions
Manual gates			
Flashboards	617	9	0
Vertical gates - non-motorized	639	6	0
Vertical gates - motorized	3	1	0
Radial gates - non-motorized	6	1	0
Radial gates - motorized	0	0	0
Comb. gates - overflow plus underflow	25	1	0
Underflow gates with weirs on the side	215	2	0
Overshot gates - (UMA type)	0	0	1
Local water level automation - downstream control			
Hydraulic gates	1	1	4
PI	2	2	0
Littleman	40	1	20
SCADA Systems			
Remote monitoring package for the main office: • w/ PC windows	4	7	2
• with a big display board	1	4	1
• with a small display board	5	7	0
Alarms (phone, beeper) on ______ sites	157	18	40
Radios/cellular phones for ditchriders.	285	34	0
Remote monitoring on ______ spill sites	12	4	10
Remote monitoring on ______ other locations	49	6	34
Automated/ remote flow rate control at heads of canals	0	0	0
Local PI with flume/weir - no remote change	0	0	0
Local PI w/o flume/weir - no remote change	0	0	0
Remote manual	0	0	0
Local PI with remote over-ride	16	2	23
Littleman with flume	0	0	0
Wireless transmission network for SCADA (# of systems)	17	8	7
Hard wire transmission network for SCADA (# of systems)	3	3	0
Miscellaneous			
Lined canals (miles)	472	21	4
Recirculation of district spill/drainage (number of sites)	99	16	4
Recirculation of on-farm spill/drainage by district (number of sites)	77	12	1
Number of lift stations (from one canal to another canal)	393	37	6
VFD on lift stations to canals or pipes	14	18	5
Other automation on lift stations (into canals)	12	3	0

District Organization, Functions, and Programs

Flexibility

Identification of district managers' attitudes towards flexibility helps determine the degree of understanding and commitment which districts have towards various improvements. The majority (31 districts) believe that there is little need to improve the current flexibility in the delivery system; thirty percent of the districts believe that improving the district's flexibility is very important (Table 38). Half of the responding districts prefer improving district flexibility with structures only; one-third of the respondents prefer improving flexibility with new concepts and limited hardware (Table 39). Sixty-one percent of the districts responded that district flexibility has been addressed at board meetings on fewer than six occasions in the last five years (Table 40). Overall, managers believe that farmers have a relatively low desire for improved district flexibility (Table 41).

Table 38. *District Managers' Rating of Need to Improve Flexibility of Present Delivery System (n=61)*

Number of Responses	Response Rating of 0 to 9 (9 = very important)
31	0 - 3
12	4 - 6
18	7 -9
	Average value = 4.0

Table 39. *District Managers' Preference of Means to Improve Flexibility (n=54)*

Number of Responses	Response
27	Improve district flexibility with new structures
18	Improve flexibility with new management concepts and limited new hardware
9	Combination of both

Table 40. *Number of Times During Last Five Years the Subject of Improving District Delivery Flexibility Has Been Addressed at Board Meetings (n=57)*

Number of Responses	Response
35	0 - 5
14	6 - 10
8	10 - 15
0	> 15
	Average = 7.0

Table 41. District Managers' Rating of Average Farmer's Desire for Improved District Flexibility (n=61)

Number of Responses	Response On a Scale of 1 to 9 (9 = very high)
26	0 - 3
18	4 - 6
17	7 - 9
	Average = 4.0

Organization

The average number of registered professional engineers on staff is 0.5; major design work is completed entirely by outside engineers for 60% of the districts (Table 42, Table 44). On average, the district has 4.2 ditchriders and the manager has worked in one district for 11.5 years (Table 43, Table 45). One-third of the responding districts fill managerial positions by promoting from within (Table 46).

Table 42. *Type of Personnel Responsible for Completing Districts' Major Design Work (n=60)*

Number of Responses	Response
4	Entirely district personnel
37	Entirely outside engineering
7	Mostly district, some outside
12	Mostly outside, some district

Table 43. *Number of Ditchriders in Districts (n=61)*

Average	4.2
Maximum	30
Minimum	0
Standard deviation	5

Table 44. *Number of Registered Professional Engineers on Permanent Staff (n=61)*

Average	.5
Maximum	7
Minimum	0
Standard deviation	1

Table 45. *Number of Years Manager Has Worked for District (n=58)*

Average	11.5
Maximum	32
Minimum	0
Standard deviation	8

Table 46. *Methods for Filling Top District Management Position (n=59)*

Number of Responses	Response
20	Working up through the ranks
39	Other

Functions

Sixty-four percent of the managers do not consider groundwater recharge to be a *major* district function; however, managers frequently responded that canal seepage and on-farm deep percolation are beneficial uses of water (Tables 47 – 49).

Table 47. *Is Groundwater Recharge a Major Function of the District? (n=61)*

Number of Responses	Response
22	Yes
39	No

Table 48. *Is Canal Seepage Considered a Beneficial Use of Water? (n=61)*

Number of Responses	Response
30	Yes
12	No
18	N/A

Table 49. *Is On-farm Deep Percolation Considered a Beneficial Use of Water? (n=61)*

Number of Responses	Response
27	Definitely yes
16	Possibly
8	Probably not
10	Definitely not
0	Do not know

Water Conservation Programs

Managers estimated that potential reduction in district deliveries ranges from 0 to 72,000 AF per year. On average (weighted), managers believe that deliveries could be reduced by 6,337 AF per district during a normal year, which is about 0.1% of the total delivered volume. Thirty-nine districts responded that there is no potential for reduced deliveries during a normal year (Table 50). Twenty districts believe they might transfer or sell the conserved water and no districts would expand their service area or irrigated area (Table 51). Thirty-seven districts believe that there is no potential to reduce district groundwater pumping during a normal year. The extent of potential groundwater pumping reductions range from 0 – 100% and average at approximately 10% (Table 53).

The questions were asked for both average years and dry years, since the districts may experience a wide range of water supply depending upon the weather.

Table 50. *Manager Estimate of Potential Reduction of District Deliveries (n=55)*

Statistic	Average Year	Dry Year
Number of districts responding “0”	39 districts	41 districts
Unweighted Average	4,111 AF	438 AF
Weighted Average	6,337 AF	349 AF
Maximum	72,000 AF	10,000 AF
Minimum	0 AF	0 AF
Standard deviation	13,781 AF	1,734 AF

Table 51. *Potential Use of Reduced Diversions (n=42)*

Number of Responses	Response
0	Expand service area/irrigated area
6	Groundwater recharge
20	Transfer/sell
10	Nothing
6	Other

Table 52. *Potential for Reducing Groundwater Pumping in the District (n=57)*

Statistic	Average Year	Dry Year
Count of “0” Responses	37 districts	45 districts
Unweighted average	10 %	5 %
Weighted average	7 %	3 %
Maximum	100 %	100 %
Minimum	0 %	0 %
Standard deviation	25 %	20 %

District Identification of Desired Assistance

Technical Support

One of the purposes of the Survey was to assess districts' technical assistance requirements in the Mid-Pacific Region. The Survey contained specific questions about types of short courses and hardware items. The questions were answered "off-the-cuff" by district managers. Although answers should not be considered comprehen-sive, they do indicate areas of interest. The results are shown in Table 53. Fourteen districts expressed interest in irrigation short courses for farmers; they also indicated a need for educational and technological packets for water users.

Table 53. *Technical Assistance Needs Defined by Districts (n=61)*

District Defined Need	Number of Districts Expressing Interest
Short Courses	
For Farmers	
Fertigation	2
Irrigation Scheduling	14
Drip	2
General	7
For Irrigators	
General	8
For Ditchriders	
General	8
Seasonal ditchriders training	1
For Employees	
Automation - general	5
Water measurement	3
SCADA	5
General Information for Water Users	
Educational packet	5
Articles on technology	3
Outreach program	7
Design/Technical Assistance Topic	
Efficiency study in area	5
Salinity study in area	4
Mobile lab	4
VFD pumps	3
Develop tiered water pricing	3
Automation of laterals	5
Pumping plant efficiency study	2
Billing software	2
Improvement of delivery program by SLWD	2
Examine SCADA for pumps	2

Table 53 continued...

Table 53. *Technical Assistance Needs Defined by Districts (continued)*

District Defined Need	Number of Districts Expressing Interest
Redesign of lift station pumps	2
Remote monitoring	1
Pipe leaks	1
Regional water study	1
City Water meter accuracy	1
Flow rate measurement	1
Operation of low head pipes	1
Groundwater assessment study	1
Meter Calibration facility study	1
Replogle flume turnout design	1
Portable power units for pumping	1
Water user survey to determine needs	1
Sizing/locating reg. reservoir.	1
Pipeline pressure regulation	1
Develop a Master Plan	1
Seepage loss reduction	1
Landscape irrigation	1
Study of early shutoff of deliveries	1
District-wide study for automation	2
Off-peak pumping study	1

Table 54. *Information Needs Regarding Physical Infrastructure Items*

Physical Infrastructure Needs	Districts Requesting Information
Open pipeline design w/o pumps or overflows	1
Regulating reservoirs	4
Totalizers on weirs or flumes in main canals	2
Upstream control structures	
Amil gates	3
Littleman controllers	3
PI controllers	3
Other hydraulic gates	3
Long crested weirs	3
Improved flashboard design	1
Non-motorized vertical gates	1
Motorized vertical gates	1
Radial gates	2
Combination gates	1
Underflow gates with side weirs	1
Overshot gates	1
Downstream control structures	
Hydraulic gates	1
PI controllers	1
Littleman controllers	1
SCADA systems	
Remote monitoring at the main office with PC windows	11
Remote monitoring with a big display board	8
Remote monitoring with a small display board	9
Alarms on critical sites	8
Radio/cellular phones for ditchriders	9
Remote monitoring on spill sites	9
General remote monitoring	9
Automated/remote flow control at heads of canals	4
Local PI with flume/weir - no remote change	3
Remote manual operation of gates	3
Local PI of gates with remote over-ride	3
Littleman controller on a flume	3
Wireless transmission network for SCADA	4
Hard wire transmission network for SCADA	4
Recirculation of district spill/drainage	2
Recirculation of on-farm spill/drainage by the district	1

Eleven districts expressed interests in general remote monitoring, remote monitoring of spill sights, alarms, and communication with ditchriders (Table 54). There was moderate interest in information on regulating reservoirs, upstream control structures, and downstream control structures.

Observations and Conclusions

Sixty-four water/drainage districts were interviewed in the Mid-Pacific Region of the USBR. They comprised approximately 2,290,000 acres, or 90% of the irrigated acreage which receives USBR in the Region. Sixty-one districts had characteristics that were consistent with agricultural irrigation supply districts; data from these districts were used to characterize the Status and Needs of these districts.

Observations

The data gained from the Survey were discussed in the previous sections. Some observations and comments are included with the tables and figures, and most of those will not be repeated here. Some observations of the data include the following:

1. The on-farm irrigation methods used in the surveyed districts are very similar (in percent of acreage represented) with statewide averages reported by DWR in Bulletin 160-93.
2. Eighty-eight percent of the districts report private well ownership. The acreage served by supplemental wells is approximately 57% of the total district acreage (Table 23). These figures indicate the importance of determining the relationship between water conservation and groundwater management.
3. There is an average annual pumping bill of $384,000 for the 35 districts with significant pumping. Power rates vary by location. If power rates increase over time, there will be a major impact on practices and costs of water in some districts with low power rates.
4. Reservoirs (either on-farm or within the district distribution system) can improve flexibility of water delivery. Only a small percentage (4%) of farm turnouts are reported to have reservoirs. However, districts report the existence of 181 regulating reservoirs in their distribution systems. ITRC believes that this is a major increase over historical numbers.
5. Districts report having significant capacity problems during periods of peak flow rates (Table 32). Better water level and pressure control systems would allow them to safely increase their capacities.
6. Forty-four percent of customers have turnout flow rates recorded with propeller meters. ITRC believes that this indicates a major increase over the last 10-15 years.

7. Irrigation district personnel manually open and close turnouts in about half of the districts. They arrive at the turnouts within about an hour (plus or minus half an hour) of their designated time. This is a constraint on improved, automatic on-farm irrigation.

8. Main canals (operated by the USBR or Water Authorities) now allow large unannounced flow rate changes by the districts (Tables 17 and 18) in many cases. ITRC believes that this is a relatively new policy.

9. Districts do not always receive the flow rates they need from their suppliers. A small amount of water (average of 1,100 acre-feet per year (AFY) per district) must be accepted for reasons such as flood control, even though there is no district request for water. The supplier cannot supply enough water to match requests about 10% of the time (Tables 20 and 21).

10. ITRC believes that districts have a better understanding of the need for flexibility than in the past, but that a significant number of district managers still do not recognize the quickly changing service needs of on-farm irrigation.

11. Sixty-four percent of the districts believe that water management will not decrease demand during a normal water year. Sixty-seven percent of the districts believe that district deliveries cannot be reduced during a dry year (Table 50).

12. The average gross surface water supply delivered to users is 2.5 AFY per acre on average over the last ten years.

13. District managers have a relatively high level of interest in improvements to their distribution system which involve remote monitoring, Supervisory Control and Data Acquisition (SCADA), and selective automation of key structures. They also would like more informa-tion on this type of modernization.

14. Requests for information and technical assistance vary between various districts (Tables 54 and 55). The combination of hydrology, type of infrastructure, size, education background of employees, etc., of each district is unique. This creates a difficulty in developing a few short courses which appeal to all districts.

Conclusions

1. ITRC believes that districts have made notable improvements in providing flexible water deliveries (although historical “Flexibility Index” values were not available for comparison). However, significant challenges remain to improve flexibility even more, as farmers rapidly shift toward more advanced and improved on-farm irrigation management.

2. District managers have a medium interest level in further improving flexibility, but the present flexibility of water delivery must be improved to reduce groundwater pumping and support on-farm irrigation methods such as micro-irrigation. Presently only 13% of the acreage irrigates with drip. ITRC expects that acreage using micro-irrigation will more than double in the next decade; this increase will strain district capabilities to provide water with the needed flexibility.

3. Training efforts are needed, including annual classes on topics such as flow measurement and automation. Manager responses indicate that per class attendance may be low. Nevertheless, numerous small attendances can impact significant acreage. A few topics, such as Supervisory Control and Data Acquisition (SCADA), appear to have a fairly large appeal.

4. This Survey revealed a need for specialized, regional training and assistance courses. Many districts receiving water from the Friant-Kern canal deliver water through pipelines and have different questions and needs than districts using canals. Many short classes (one-half day to two full days) at the districts may be needed to properly address technical issues.

5. Automation has historically consisted of placing controllers on a few key structures. As the districts are required by their customers to improve service, they will need solutions involving integrated automatic control systems.

6. Many specific individual technical assistance needs have been defined by various districts

(Table