Benchmarking of Flexibility and Needs

2002

Survey of Non-Federal Irrigation Districts

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Executive Summary

ITRC interviewed irrigation district personnel from 17 agricultural districts throughout California.

Data were analyzed to determine the degree of water delivery flexibility provided to farmers and the extent of existing and planned district modernization. This is the third such report the Irrigation Training and Research Center (ITRC) has published for irrigation districts in California. The first two reports were conducted on behalf of the Mid-Pacific Region of the U.S. Bureau of Reclamation and included irrigation districts that had long-term federal contracts. This report was conducted on behalf of the California Department of Water Resources (DWR) and did not include irrigation districts with long-term federal contracts. The first survey was conducted in 1996 and can be downloaded at http://www.itrc.org/reports/S&N/S&N.html. The second survey was conducted in 2000 and can be downloaded at http://www.itrc.org/reports/Benchmarking/BenchmarkingNeeds.pdf.

The interview process defined needs for direct technical assistance and training. These needs varied by district and region throughout California. The ITRC concluded that training programs should incorporate some common classes using the Water Delivery Facility and other resources located on campus at California Polytechnic State University, San Luis Obispo. In addition, some districts acknowledged interest in small, specialized training efforts customized for single or small groups of districts at local facilities. The data also indicated that more Rapid Appraisal Process (RAP) visits are needed to determine possible physical and managerial improvements (modernization and efficiency) for districts to accommodate the ever-changing needs of their consumers. Direct technical assistance to individual districts has been and will continue to be a key element of continuing success in modernization.

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

Background

Purpose

In the summer of 2002, the Irrigation Training and Research Center (ITRC) of California Polytechnic State University, San Luis Obispo (Cal Poly) conducted, as part of the technical assistance program, interviews of selected irrigation districts throughout California. This Benchmarking Survey was similar to the Benchmarking of Flexibility and Needs Survey conducted 2 years earlier by ITRC for the Mid-Pacific Region of the U. S. Bureau of Reclamation (USBR).

The purpose of this Survey was to:

- Identify the extent of flexibility of water delivery presently offered by irrigation and water districts to farmers;
- Identify educational programs in which districts currently participate or have accomplished; and
- Identify improvements that can be made in regards to technology and water conservation, as well as what types of assistance districts will require in the future to make those improvements.

Survey

The Survey contained over 200 questions included in the following general categories:

- Information to describe the present status of water delivery flexibility offered by districts;
- Specific district characteristics such as water reliability, water prices, various irrigation methods, water conservation programs, modernization, etc.;
- Current and future district sponsored programs; and
- Request for technical assistance from ITRC.

The Survey questions can be found in Appendix A.

District Selection

In order to provide an accurate survey of status and needs, districts were selected based on diversity in location, size, and delivery characteristics. In addition, no districts that are part of the USBR Mid-Pacific Region were selected for this survey. A total of 17 districts with a total cropped acreage of approximately 1,760,000 acres were chosen for this survey. Refer to Figure 1 for a map showing the location of the 17 districts.

No. of Districts Interviewed	Cropped Acreage Represented
17	1,759,942

Interviews

Before conducting interviews, districts were contacted by phone call to explain the purpose of the Survey and invite their participation. The Survey was sent to the district via email prior to the interview.

Interviews consisted of an in-person meeting with district managers and/or other district personnel with a good understanding of district operations and plans. Districts were very cooperative and managers and engineers took valuable time to participate in a lengthy personal interview.

Feedback (questions of needs and opinions) sections of the Survey were well received by the interviewees. Persons interviewed were very willing to discuss their views, opinions, and interests.

Collection of Survey data was completed in August of 2002.

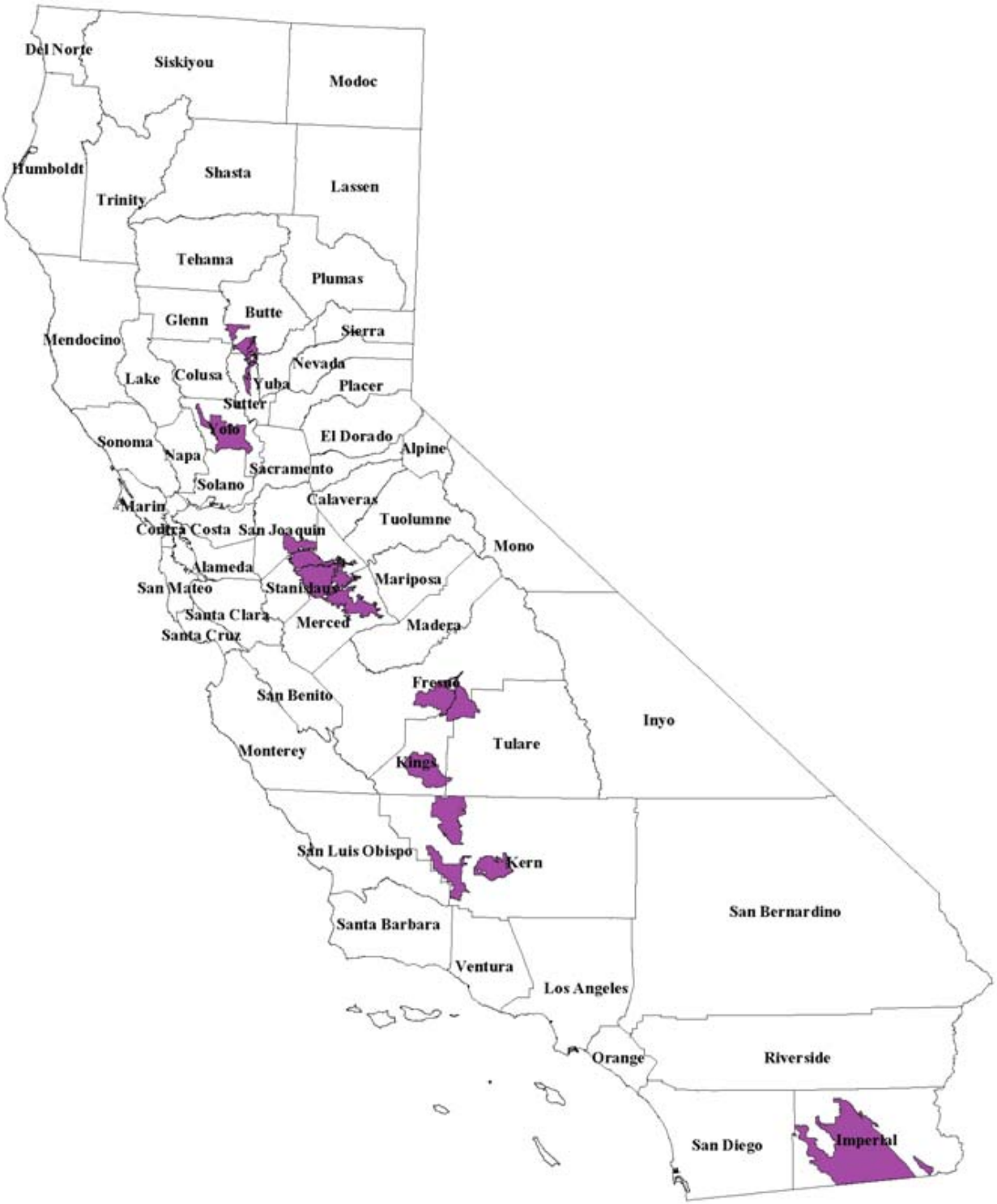

Figure 1. *Map showing the location of the 17 districts surveyed for this report.*

District Flexibility

Introduction

Answers from the Benchmarking of Flexibility and Needs Survey were compiled to characterize the present status of districts as well as future needs for technical assistance.

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.

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 up to system capacity. In California, most 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 throughout California does not compare with the "demand" flexibility provided to homeowners.

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

Frequency Flexibility

Advance ordering of water on an unlimited frequency schedule is utilized on the majority of acreage in surveyed districts (Table 1). For those farmers, the mean advance notice time was 30 hours and the mean number of times a farmer cannot get water on the requested day is less than once per season.

Of all the districts surveyed, five use a strict fixed rotation (no trading turns) or a fixed rotation during peak water use periods on some percentage of their acreage (Table 1). A modified rotation schedule is utilized over 85% of the acreage in one district and 3% of another.

Table 1. *Common Characteristics of the Delivery Schedules*

Description	*(n = 16)*
Districts Reporting Fixed Rotation	5
Average Percent of these Districts' Acreage	32%
Acreage	134,919
Number of days between standard rotation	14
Districts Reporting Modified Rotation	2
Average Percent of these Districts' Acreage	44%
Acreage	59,465
Days of deviation from fixed rotation	2
Number of days between standard rotation	11
Hours of advance notice required	42
Districts Reporting Unlimited Frequency	15
Acreage	1,565,558
Average hours of advance notice required	30
Average number of times in a year a turnout cannot get water on the day requested	0.62

Flow Rate Flexibility

Only three districts responded that farmers could not receive different flow rates for any irrigation (Table 2). Two other districts responded that farmers could receive different flow rates throughout the season, though not every irrigation. The remaining districts have policies allowing farmers to receive different flow rates at each irrigation.

During an irrigation event, 11 districts have no restrictions on changing a flow rate whereas 4 districts do not allow a flow rate change (Table 3). One district has a limit of 2 changes per irrigation event. All 12 districts that allow a flow rate change during an irrigation event require advance notice with an average notice time of 19 hours (Table 4).

Table 2. *Flexibility of Delivery Flow Rate Selection at Each Event*

Response	Number of Responses *(n = 16)*
Essentially the same flow rate must be delivered for each irrigation	3
The farmer can request several different flow rates through the season	2
Can have different flow rates each irrigation	11

Table 3. *Flexibility of Changing Flow Rate Selection during an Event*

Response	Number of Responses *(n = 16)*
No change is allowed	4
One time	0
Two times	1
There are no restrictions	11

Table 4. *Advance Notice required before a Flow Rate Change is made during an Event*

Response	*(n = 10)*
Average required hours	19
Number of districts that require no advance notice before flow rate change	0

Duration Flexibility

Duration flexibility is important for all forms of on-farm irrigation, but it can be 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 energy and water bills and deep percolation of water and nutrients. Drip and micro irrigation 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. As soil infiltration rates change throughout 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 are allowed to receive water for any duration in 12 districts. The remaining districts allow durations of some other fixed hourly increment for delivery (Table 5). These increments generally ranged from 6 to 12 hours in duration. The average advance notice required before farmers can shut off the water was 13 hours; four districts do not require advance notice to shut off (Table 6).

Table 5. *Flexibility in Duration of an Irrigation Event*

Response	*(n = 16)*
Unlimited - any duration is allowed	12
12 hour increments	2
24 hour increments	0
Other fixed, district-determined increment	2

Table 6. *Advance Notice Required by the District before Farmers Can Shut Off Water*

Response	*(n = 16)*
Average required hours	13
Number of districts that require no advance notice prior to shutoff	4

In order to achieve a high degree of flexibility in irrigation delivery duration, farmers ideally ought to be able to 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 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 62% of the time (Table 7). In addition, district personnel operate gates within an average of less than one hour (Table 8). When there is not enough flow to match a water order, 4 districts pro-

rate the order and 11 districts postpone the water delivery (Table 9).

Table 7. *Percentage of Time District Personnel Must Be Present to Open and Close Farm Turnout Gates (n = 15)*

Number of districts responding 100%	3
Number of districts responding 0%	1
Average percentage	62

Table 8. *How Closely to the Prescribed Time Turnout Gates are Operated by District Personnel (n = 15)*

Average time (hours)	0.54

Table 9. *Procedure if There is Not Enough Capacity or Flow Availability to Match Turnout Order (n = 15)*

Pro-rate: farmers receive a portion of their order	4
Postpone: farmers must wait to receive any water delivery	11

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 previously mentioned aspects of district delivery policies regarding frequency, flow rate and duration were indexed to quantify the degree of water delivery flexibility provided by each district. Each parameter (frequency, flow rate, and duration) has a rating from 1 - 5, with 5 as the most flexible score. The sum of these individual indices gives the “Flexibility Index,” the highest possible score amounting to 15, and the lowest possible equaling 3. A district that allows farmers to obtain 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 that allows a farmer to change flow rates during an irrigation event without notifying the district has the most flexible condition within the “Flow Rate Index” and is assigned a score of 5. If no advance notice is required to alter the duration of an irrigation, thereby allowing farmers to receive water for any length of time, a score of 5 is assigned in the "Duration Index".

Guidelines for indexing flexibility, outlined in the table below were developed to provide benchmarking that can be used in future studies to determine how district operations have changed and to compare districts with each other.

The average sub-index values for frequency, flow rate, and duration were 3.5, 3.1, and 4.3, respectively. The average total flexibility index (i.e., the sum of the frequency, flow rate, and duration indices) was 10.9 out of a possible 15 (Table 11). In each category, there were districts achieving the highest rating (i.e., 5), indicating that some districts provide very flexible water supplies in terms of frequency, flow rate, or duration.

Table 10. *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	More than 24 hours advance notice required before delivery is made
4	24 hours or less 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; must give at least 24 hour notice before altering; and the district operates the gates ≥ 80% of the time
4	Farmers can choose any duration; must give at least 8 hours of notice before altering; and the district operates the gates < 80% of the time
5	Farmers can have any duration, with no advance notice required before changing

Table 11. *Average Flexibility Index Summary (n = 16)*

Parameter	Index
Frequency	3.5
Flow Rate	3.1
Duration	4.3
Flexibility Index	**10.9**

Table 12. *Flexibility Index Frequencies (n = 16)*

Flexibility Index	Number of Districts
<11	7
11-11.9	4
12-12.9	4
13-13.9	0
14-15	1

Flexibility Provided by District Supplier

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.

Average required advance notice time prior to flow rate changes was 17 hours (Table 13). In some cases, the district is their own water supplier. These districts were left out of the average so that the result was not skewed.

Table 13. *Hours of Advance Notice Required of the District Supplier Before a Scheduled Flow Change Occurs (n = 16)*

Average	17

Only one district was required by its supplier to take water even though it did not have a demand. On average over the last 10 years, this district was required to accept about 1000 acre-feet per year for flood control purposes. Other districts also obtained floodwater, however these districts requested the water so it could be utilized for groundwater recharge.

On-Farm Irrigation, Costs, and Pricing

On-Farm Methods

Degrees of supply flexibility required by farmers can be understood by recognizing the types of different irrigation methods utilized and the acreage associated with those methods. Over three quarters of the total acreage represented by the Survey utilized surface irrigation methods (i.e., furrow, border strip, or basin). Sprinkler and drip irrigation represented only 2.6% and 7.6%, respectively, of the total irrigated acreage. Drip and micro irrigation is on the increase, according to most district representatives. The remaining acreage consisted of irrigated rice or was a combination of irrigation methods (i.e., hand-move sprinkler and furrow irrigation on row crops).

A large portion of districts interviewed do not track acreage by irrigation method, therefore some of the values in Table 14 were estimated by district representatives.

Table 14. *Estimated On-Farm Irrigation Methods Used within District Service Areas*

Irrigation Method	Total Acreage	Percent of Total
Furrow	762,658	43.3%
Border strip or basin	618,039	35.1%
Hand-move or side-roll sprinklers	18,800	1.1%
Center pivot or linear move	980	0.1%
Permanent sprinklers (trees or vines)	21,090	1.2%
Rice	112,157	6.4%
Drip on row crops	10,960	0.6%
Microspray or drip on trees or vines	122,338	7.0%
Solid set sprinklers on row crops	4,020	0.2%
Combination	88,900	5.1%
TOTAL	1,759,942	100.0%

Power Costs

Throughout the districts surveyed, a total of 547 district well pumps were listed, resulting in an average of over $558,500 per year in district pumping costs. The average cost for electricity to operate these pumps was found to be $0.107 per kilowatt-hour ($/kW-hr), as shown in Table 15.

Clearly there is a need to examine energy efficiency improvements as a possible alternative to reduce costs for some districts.

Table 15. *District Power Costs* (n=6)*

Total number of district well pumps	547
Average pumping power bill ($/yr)	$558,500
Average pumping power bill ($/kW-hr)	0.107

* Includes only groundwater pumps owned by the district.

Water Pricing

The majority of interviewed districts (9 districts representing 1,392,942 acres) charge for water on a volumetric basis (Table 16). Of these, four districts reported using a "tiered" pricing structure. Tiered pricing means that the district charges a different price for water depending either on: (i) the amount used (for example, the district charges one price per acre-ft for the first 3 feet of water used by the water user and another price for each additional acre-ft), (ii) the district charges one price for each acre-ft of water used in one area of the district and another price in a different area of the district (for example, in one area of the district the water does not have to be lifted using booster pumps, therefore the water is less expensive compared to other areas were water has to be lifted). The mean price for tiered and non-tiered water was $24.78 and $24.56 per acre-foot, respectively (Table 17).

A fixed pricing structure is employed in six districts representing 367,000 acres, wherein three districts vary prices by acre depending on the crop type (Table 16). The average water cost for fixed price structures was $7.14 per acre-ft and ranged from $2.70 – 8.65 per acre-ft (Table 17). Normalized water prices are summarized in Table 18 using five-year historical deliveries.

Table 16. *Water Pricing Policies (n = 15)*

Method of Water Pricing	Number of Districts	Acreage
Volumetric ($/AF)		
Tiered	4	468,841
No Tier	5	924,101
Fixed price per acre ($/acre)		
Price varies by crop	3	77,000
Price does not vary by crop	3	290,000

Table 17. *Water Prices per Acre-Foot* ($/AF)*

Method of Water Pricing	Mean Price	Min. Price	Max. Price
Volumetric			
Tiered	$24.78	$9.89	$48.45
No Tier	$24.56	$4.00	$54.58
Fixed price per acre	$7.14	$2.70	$8.65

* Based on current price structure and approximate historical five-year deliveries (*n=15*). Includes standby and service charges. Mean prices are weighted by irrigated acreage.

Table 18. *Water Prices per Acre* ($/acre)*

Method of Water Pricing	Mean Price	Min Price	Max Price
Volumetric			
Tiered	$76.84	$40.51	$114.74
No Tier	$87.17	$20.04	$123.47
Fixed price per acre	$19.04	$15.00	$29.00

* Based on current price structure and approximate historical five-year deliveries (*n=15*). Includes standby and service charges. Mean prices are weighted by irrigated acreage.

Delivered Water

The water supply available to the districts is highly variable, by both district and year. Districts that experience wide fluctuations in water supply view groundwater recharge as a major concern, and their policies usually emphasize recharge during wet years rather than flexible deliveries during average or dry years.

On (weighted) average, districts had 5.08 acre-ft per acre per year gross water available for deliveries during the last five years (Table 19). These values include both surface and groundwater supplied by the district.

Table 19. *Average Gross Surface Water Available for Delivery during the Last Five Years (AF/acre/ year) (n = 15)*

Unweighted average	3.89
Weighted average (by irrigated acres)	5.08
Maximum	6.72
Minimum	1.47
Standard Deviation	1.93

Facilities - Present and Future

Regulating Reservoirs

Turnouts with privately-owned reservoirs occur in 7 of the districts included in the Survey. All of those districts have such reservoirs on less than 25% of their total turnouts (Table 20). 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, will impact 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.

Table 20. *Turnouts Equipped with Farmer Owned Reservoirs*

Percentage of Total Turnouts with Farmer-Owned Reservoirs	**Number of Districts** *(n = 7)*
<5%	5
5% - 25%	2
25% - 50%	0
50% - 75%	0
>75%	0

Water Conveyance and Delivery Systems

District personnel were asked about the characteristics of their delivery systems particularly in regards to the amount of time the systems are at capacity (maximum flow rate). Table 21 shows that capacity problems occur relatively frequently.

Table 21. *Percentage of Time Flow Rate is at Maximum Capacity in Distribution Systems*

Percentage of Time the Flow Rate is at Maximum Capacity	**Number of Districts** *(n = 14)*	
	Mains	Laterals
0%	1	1
1 - 25%	8	6
26 – 50%	4	5
51 – 75%	1	2
76 – 100%	0	0
Average Percentage	**22%**	**28%**

Flow Measurement

The type of flow measurement devices currently in use are depicted in Table 22. The majority of turnouts did not have any flow measurement device. Of the turnouts that did have flow meters, the undershot orifice gate was the most common, and the Armco-type metering gates were the second most commonly used turnout flow measurement devices. Propeller meters and weirs/flumes were the least used turnout measurement devices. Many of the districts use more than one type of measurement device.

Many flow rate measurement devices do not totalize the volume that has passed through a turnout. Instead, 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 then 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.

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 alterations 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 differences tend to even out with time).

Potential solutions include new turnout designs and better control of water levels or pressures in irrigation district distribution canals or pipelines. The ITRC continues to work with districts and others to seek proper solutions for individual cases.

Anticipated Physical Infrastructure Changes

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. Districts were also asked whether they were interested in obtaining more information on such improvements. The results are recorded in Table 23.

Table 22. *Type of Turnout Flow Measurement Devices*

Turnout Flow Measurement Device	Total # of Turnouts with Device	Percent of Total Customers	Number of Districts
No flow measurement device	15,079	46.0%	9
Armco-type metering gate	5,574	17.0%	5
Undershot orifice (slide gate)	10,793	32.9%	4
Weir or flume device without a totalizer	56	0.2%	2
Propeller meter	1,303	4.0%	6
Other	8	0.0%	2
Total	32,813	100.0%	

Table 23. *Present Physical Infrastructures and Anticipated Changes in the Near Future*

Item	Total Quantities Present	Additional Quantities Planned Between 2002-2005	Number of Districts that WILL Add an Undefined Quantity by 2005	Number of Districts that MAY Add an Undefined Quantity by 2005	Number of Districts Interested in Additional Information
Special control devices on canals					
Regulating reservoirs	23	15	1	2	8
Lateral interceptors	16	9	1	1	4
Flow measurement devices in canals					
Weir/flume, flow rate only	20	10	0	2	4
Weir/flume, totalized	59	21	2	2	7
Other, totalized	38	33	0	1	7
No device, but gate rating tables	543	0	1	0	4
Local water level automation upstream control					
Amil gates	2	1	0	0	6
Electromechanical (Littleman)	0	0	0	0	4
Computerized	105	27	0	3	8
Long crested weirs	206	61	0	3	10
ITRC flap gate	38	35	0	5	9
Other	150	0	1	0	1
Local water level automation downstream control					
Hydraulic gates	0	0	0	0	1
Electromechanical	0	0	0	0	1
Computerized	0	43	0	0	1
Other	0	0	0	0	1
Other	0	0	0	0	0
SCADA Systems					
Remote monitoring package for the main office	7	5	0	1	10
Remote monitoring at spill sites	137	14	3	2	10
Remote monitoring at other locations	161	179	3	1	11
Network for SCADA communications	8	4	1	1	8
Alarms (phone, beeper) on sites	206	0	5	0	7
Automated/remote flow rate control					
On check structures along the canal	103	27	2	3	8
On pumps	53	15	1	0	6
Radios/cellular phones for ditchriders.	223	8	0	0	2

Table 23. *Present Physical Infrastructures and Anticipated Changes in the Near Future (continued)*

Item	Total Quantities Present	Additional Quantities Planned Between 2002-2005	Number of Districts that WILL Add an Undefined Quantity by 2005	Number of Districts that MAY Add an Undefined Quantity by 2005	Number of Districts Interested in Additional Information
Miscellaneous					
Hand-held data recorders with download software	24	0	0	3	9
Field data management software	4	1	0	1	8
Water ordering software	2	1	0	0	6
Billing software	4	1	0	0	4
Lined canals (miles)	1571	69	0	0	6
Recirculation of district spill/drainage (# of sites)	61	7	1	2	6
Recirculation of on-farm spill/drainage by district (# of sites)	29	0	2	1	3
Number of lift stations (from one canal to another canal)	21	35	0	1	4
Other automation on lift stations (into canals)	2	0	0	1	1
Other physical improvements	12	3	1	0	0

Management Perceptions

It may be helpful to note some perceptions of the management level district personnel who assisted in providing the Survey information. The answers noted in these tables were often given "off-the-cuff" and may not reflect official district policy.

Flexibility

The majority of management personnel interviewed believes that there is some need to improve the current flexibility in the delivery system (Table 24). Three of the responding persons prefer to improve district flexibility with structures only. The overwhelming majority of districts are in favor of a combination of new hardware and management concepts (Table 25). It was reported that in 40% of the districts, district flexibility has been addressed at board meetings on fewer than six occasions (Table 26) during the last 5 years. Overall, managers believe that farmers have a intermediate desire for improved district flexibility (Table 27).

Table 24. *Rating by Senior Personnel of the Need to Improve Flexibility of the Present Delivery System*

Response Rating of 0 to 9 (9 = very important)	**Number of Responses** *(n = 15)*
0 – 3	6
4 – 6	4
7 – 9	5
Average	**4.8**

Table 25. *Senior Personnel Preference of Means to Improve Flexibility*

Response	**Number of Responses** *(n = 15)*
Improve district flexibility with new structures	3
Improve flexibility with new management concepts and limited new hardware	0
Combination	12

Table 26. *Number of Times during the Last Five Years the Subject of Improving District Delivery Flexibility has been Addressed at Board Meetings*

Response	**Number of Responses** *(n = 15)*
0 – 5	6
6 – 10	1
11 – 15	3
> 15	5
Average	**12.9**

Table 27. *Senior Personnel Rating of the Average Farmer's Desire for Improving District Flexibility*

Response Rating of 0 to 9 (9 = very important)	**Number of Responses** *(n = 15)*
0 – 3	6
4 – 6	5
7 – 9	4
Average	**4.6**

Functions

Groundwater recharge is considered a major district function by nearly 70% of the managers. In addition, managers more frequently than not responded that canal seepage and on-farm deep percolation are beneficial uses of water (Tables 28 to 30).

Table 28. *Is Groundwater Recharge a Major Function of the District?*

Response	**Number of Responses** *(n = 16)*
Yes	11
No	5

Table 29. *Is Canal Seepage Considered a Beneficial Use of Water?*

Response	Number of Responses *(n = 15)*
Yes	10
No	4
N/A	1

Table 30. *Is On-farm Deep Percolation Considered a Beneficial Use of Water?*

Response	Number of Responses *(n = 15)*
Definitely yes	7
Possibly	3
Probably not	3
Definitely not	2
Do not know	0

Water "Conservation" Potential

Water conservation, as it pertains to this report, is a reduction in water delivered to the district at the districts' diversion point(s). It does not represent a reduction in consumptive use (i.e. evaporation, transpiration, and non-beneficial losses to a salt sink).

Managers believe, on (weighted) average, that district deliveries could be reduced as much as 65,378 acre-ft during a normal year. However, five districts observed no potential for reduced water deliveries during a normal year (Table 31). Four of the districts believe they might transfer or sell the conserved water. In addition, two of the districts would expand their service area or irrigated area. Over half of districts believe that there is no potential to reduce groundwater pumping during a normal year (Table 33). The majority of districts that believe there is potential to reduce groundwater pumping believe it is necessary to increase surface deliveries to accomplish this task.

In view of the fact that the districts may experience a wide range of water supplies, depending upon the weather, the Survey questions were asked for both average years and dry years.

Table 31. *Manager Estimate of Potential Reduction of District Deliveries (AF/year) (n = 14)*

Statistic	Avg. Year	Dry Year
Number of districts responding "0"	5	10
Unweighted Average	22,714	19,357
Weighted Average	65,378	64,422

Table 32. *Potential Use of Reduced Diversions*

Response	Number of Responses *(n = 12)*
Expand service area/irrigated area	2
Groundwater recharge	4
Transfer/sell	4
Nothing	0
Other	2

Table 33. *Potential for Reducing Groundwater Pumping in the District (n = 15)*

Statistic	Avg. Year	Dry Year
Number of districts responding "0"	9	13
Unweighted Average	17%	2%
Weighted Average	16%	2%

District Identification of Desired Technical Assistance

One of the purposes of the Survey was to assess districts' needs with regards to technical assistance programs. The Survey contained not only specific questions about the types of short courses and hardware items, but also questions regarding special assistance from ITRC. The questions were often answered informally by district managers and are listed in Tables 34 and 35. Districts indicated a very strong need for irrigation short courses for staff. Technical assistance from ITRC in the areas of Supervisory Control and Data Acquisition (SCADA) systems, remote monitoring, flow measurement, gate automation, and rapid appraisals proved to be popular interests as well.

***Table 34**. Current and Future District Programs*

Item	Number of Districts Active in these Programs	Number of Districts Planning to be Active in these Programs Between 2002-2004	Number of Districts Interested in Further Information
On-Farm Improvements			
Low interest loans	1	2	1
Mobile Labs	5	6	3
Irrigation Evaluations	4	5	4
Other	5	7	1
Water Delivery Service			
Allow earlier shutoff of water	2	2	1
Reduce carry-overs	0	0	0
Education			
District Newsletter	12	12	3
Seminars/training for the staff			
Water measurement	9	15	14
SCADA	6	15	13
Automation	6	16	13
On-farm irrigation	2	6	7
Other	5	9	8

***Table 34.** Current and Future District Programs (continued)*

Item	Number of Districts Active in these Programs	Number of Districts Planning to be Active in these Programs Between 2002-2004	Number of Districts Interested in Further Information
Education			
Short courses for water users			
Irrigator classes	4	9	9
Irrigation scheduling	4	9	9
Salinity	2	6	7
Drainage	0	6	7
Specific irrigation methods	2	4	3
Other	2	3	2
ET scheduling information for water users	3	6	3

***Table 35**. Specific Requests for Technical Assistance*

District Defined Need	Number of Interested Districts
Education assistance	
Staff short courses	15
GIS-GPS short course	7
Short course on Pipeline Hydraulics	1
Continuing education required for Water Distribution and Water Treatment	1
Water conservation coordinator workshop	1
Short Course Designed for Board Members including district tours to show new technology and improved service	1
New short courses advancing past current course material	3
Correspondence courses	5
On-site Irrigator/Farmer short courses	3
Staff and Farmer short course - basics in TMDL (water quality), salinity, leaching, drainage	5
Short course for Dairies to minimize nitrate seepage	1
Landscape audit classes	1
Educating districts on water saving technology via newsletter, e-mail, etc.	1
HHDR/Data Management implementation	3
On-farm assistance	
On-farm irrigation evaluations	2
Mobile labs	2
Implementing drip from open canals	2
District infrastructure	
Tour/review district and offer improvement options or review projects or designs and offer opinions about the concept and functionality (example - Rapid Appraisal)	7
Automatic upstream control gates	9
Canal modeling and gate algorithm development	2
Canal or pipeline system modifications/consolidation	8
Filtration	1
SCADA systems/enhancements/assistance	10
Remote monitoring	10
Weir/flume design and or best installation location	8
Identifying best flow measurement device for a given situation	8
Canal weed control options or methods of changing flow rate coefficient over delivery season	4
Addition of regulating ponds or capacity buffering pumps	5
Efficiency evaluations: Pumps, VFDs, or canal losses	1
Developing solutions to flow meter problems	7
Ground water banking/recharge or management	4
Water quality issues	3
Managing saline water and or saline soils	2
Other	
GIS assistance	2
Help with Water Management Plan	1
Grant writing	1
Funding	2

Observations and Conclusions

Seventeen water agencies were interviewed throughout California. Together these districts comprised approximately 1,760,000 acres of irrigated cropland in California. The districts have characteristics that are consistent with non-federal irrigation supply districts and the obtained data was used to characterize the Status and Needs of this category of districts.

Observations

Some key observations of the data presented in this report include the following:

1. Reservoirs within the district distribution system can improve flexibility of water delivery. Districts report the planning of an additional 15+ regulating reservoirs in their distribution systems (Table 23), indicating a movement towards increased district flexibility and improved water management efforts.

2. There is an average annual deep well pumping bill of $558,500 for the six districts with significant pumping (Table 15). With the increased power costs in recent years, most of these districts are participating in incentive programs that provide grants to increase pump efficiencies.

3. Some districts reported having significant capacity problems during peak flow rate periods (Table 21). Enhanced water level and pressure control systems would allow them to safely increase their capacities.

4. Irrigation district personnel manually open and close turnouts in a majority of the districts (Table 7). In addition, they arrive at the turnouts within approximately an hour of their designated time (Table 8). This is a constraint on improved, automatic on-farm irrigation.

5. The ITRC believes that districts have a better understanding of the need for flexibility than in the past, but that a significant number of senior district personnel still do not recognize the importance of rapidly changing water delivery service to meet the needs of modern on-farm irrigation.

6. Thirty one percent of the districts believe that improved water management will not decrease demand during a normal water year. Sixty-three percent of the districts believe that district deliveries cannot be reduced during a dry year (Table 31).

7. The weighted average gross surface water supply available to users is 5.08 acre-ft per acre per year over the last five years (Table 19).

8. District managers have a relatively high level of interest in technical assistance and information from ITRC in the areas of remote monitoring, Supervisory Control and Data Acquisition (SCADA), gate automation, canal flow measurement, rapid appraisals, and short courses for district staff (Table 35).

Conclusions

1. The ITRC believes that districts are making notable improvements in providing flexible water deliveries. However, significant challenges remain to improve flexibility even more, as farmers rapidly shift toward more advanced and improved on-farm irrigation management.

2. The present state of water delivery flexibility must be improved in order to reduce the volume of groundwater pumping that supplies on-farm irrigation methods such as micro irrigation. However, 40% of district senior personnel have a low interest level in further improving flexibility (Table 24). Presently, only about 7.6% of the acreage is irrigated with drip or microspray. The ITRC expects that the acreage of micro irrigation will more than double in the next decade, increasing the strain on district capabilities to provide water with the needed flexibility.

3. Training efforts are needed for both farmers and staff, including annual short courses on topics such as Supervisory Control and Data Acquisition (SCADA), irrigation scheduling, remote monitoring, flow measurement, automation, and GIS mapping (Tables 34 and 35).

4. This Survey revealed some need for specialized, regional training and assistance courses. Many short classes (one-half day to two full days) at the districts may be needed to properly address technical issues. A major issue that some districts identified is water quality leaving the district boundaries. These districts wish to have an understanding of the new laws, as well as learn about possible solutions to existing problems.

5. Integrated automatic control systems will need to be installed to improve the level of service provided by the district.

6. Many specific individual technical assistance needs have been defined by various districts (Table 35).

Appendix A

Benchmarking Survey

Section 1. Please answer in the space provided or on additional paper as needed.

What can the ITRC do through the DWR technical assistance program to help improve your water management efforts?
a.
b.
c.

What examples of recent water (or energy) conservation or modernization have you implemented and would like to publicize? ITRC, DWR, and the California Energy Commission may be able to help you promote your successful efforts.
a.
b.
c.

Is ITRC allowed to publicize these recent efforts? _____

Section 2. Questions or Descriptions for	**Participated in or Accomplished since 1995 (Y/N)**	**Planned Participation Before 2005 (Y/N)**	**Want more information? (Y/N)**
CURRENT AND FUTURE PROGRAMS			
On-Farm Improvements			
Low interest loans			
Mobile Labs			
Irrigation Evaluations			
Other _____			
Other _____			
Water Delivery Service			
Allow earlier shutoff of water Explanation: _____			
Reduce carry-overs Explanation: _____			
Other _____			
Other _____			
Education			
District Newsletter			
Seminars/training for the staff			
Water measurement			
SCADA			
Automation			
On-farm irrigation			
Other _____			
Other _____			
Short courses for water users			
Irrigator classes			
Irrigation scheduling			
Salinity			
Drainage			
Specific irrigation methods _____			
Other _____			
Other _____			
ET scheduling information for water users			
Other _____			
Other _____			

Section 3. Questions or Descriptions for	**Present Quantities (#)**	**Quantities Planned for Addition Before 2005 (#)**	**Want more information? (Y/N)**
CURRENT AND FUTURE CANAL IMPROVEMENTS			
*Please answer these questions for the following **CANAL** devices*			
Regulating reservoirs			
Lateral interceptors			
Flow measurement devices in the canals			
Weir/flume, flow rate only			
Weir/flume, totalized			
Other, totalized			
No device, but gate rating tables			
Local water level automation - upstream control			
Amil gates			
Electromechanical (Littleman)			
Computerized			
Long crested weirs			
ITRC flap gate			
Other _____			
Local water level automation - downstream control			
Hydraulic gates			
Electromechanical			
Computerized			
Other _____			
Other _____			
SCADA Systems			
Remote monitoring package for the main office			
Remote monitoring for _____ spill sites			
Remote monitoring for _____ other locations			

Section 3. Questions or Descriptions for	**Present Quantities (#)**	**Quantities Planned for Addition Before 2005 (#)**	**Want more information? (Y/N)**
***SCADA Systems** Continued*			
Automated/remote flow rate control			
On check structures along the canal			
Pumps			
Network for SCADA communications			
Alarms (phone, beeper) for _____ sites			
Radios/cellular phones for ditchriders			
Miscellaneous			
Hand held data recorders with download software			
Field Data management software			
Stock program name: _____			
Custom program name and point of contact: _____			
In-house program name and point of contact: _____			
Water ordering software			
Program name and point of contact: _____			
Billing software			
Program name and point of contact _____			
Lining canals (miles)			
Recirculation of district spill/drainage (# of sites)			
Recirculation of on-farm spill/drainage by district (# of sites)			
Lift stations to canals or pipes			
Other automation on lift stations (into canals) Explanation _____			
Other physical need/option			
Other physical _____			
Other physical _____			

Section 4. Questions or Descriptions for	**Answer**	**Units**
GENERAL DISTRICT CHARACTERISTICS		
What is the GROSS irrigation water available to the district, on the average, for the last 5 complete water years? (This should not include any well water that is pumped by farmers that stays on the farm)		acre-ft
What is the acreage used by the following irrigation methods? a. furrow		ac
b. border strip or basin		ac
c. hand move or side sprinklers		ac
c. center pivot or linear move		ac
e. permanent sprinklers (trees or vines)		ac
f. rice		ac
g. drip on row crops		ac
h. microspray or drip on trees or vines		ac
i. solid set sprinklers on row crop		ac
j. combination		ac
RESERVOIRS		
What percentage of turnouts are equipped with farmer owned reservoirs?		%
WATER PRICING		
Volumetric Billing		
Average cost of water for tier 1 water		$/af
Tier 1 limit		af/ac
Average cost of water for Tier 2 water		$/af
Tier 2 limit		af/ac
Average cost of water for Tier 3 water		$/af
Tier 3 limit		af/ac
Average cost of water for Tier 4 water		$/af
Tier 4 limit		af/ac
Fixed Price Billing		
Average cost of water		$/ac-yr
Does the fixed rate vary by crop type? 1 = yes, 2 = no		#

Section 4. Questions or Descriptions for	**Answer**	**Units**
Non-Water Charges		
Assessment Charges		$/ac-yr
Standby Charges		$/ac-yr
DELIVERY SYSTEM CHARACTERISTICS		
General		
Percentage of time the flow rate is at maximum capacity for: 1. District mains		%
2. Laterals		%
FLOW MEASUREMENT AT FARM TURNOUTS		
# of customers serviced by each of the following devices at farm turnouts? 1 = No flow measurement devices		#
2 = Armco-type metering gates		#
3 = Undershot orifice (slide gate)		#
4 = Weir or flume device without a continuous record		#
5 = Propeller meters		#
6 = Other (describe)		#
FACILITIES AND UPGRADES		
Number of district well pumps		#
Total (ave) Annual Power Bill		$
Cost of electrical power		$/kW-hr
DISTRICT FLEXIBILITY		
FREQUENCY		
Rotation		
Percentage of district acreage using a Fixed Rotation Schedule - with no trading of turns?		% acres
How many days between water turns?		days

Section 4. Questions or Descriptions for	**Answer**	**Units**
Percentage of district acreage using a Fixed Rotation Schedule—with farmers trading turns occasionally		% acres
Number of days between water turns as official district policy (even though some farmers actually trade turns between themselves).		days
Percentage of farmers who trade turns at least once a year.		%
Average percentage of irrigations during a season that these farmers trade turns.		%
Percentage of district acreage using a Fixed Rotation during peak water use period only		% acres
Number of days between water turns during that time. (Answer questions below to explain frequency policy during non-peak).		days
Limited Frequency—Modified Rotation		
Percentage of district acreage using a Limited Frequency (plus or minus a few days from a fixed).		% acres
Days of deviation from fixed rotation allowed by district.		days
Number of days between standard rotation.		days
Advance notice required by district before schedule change.		hours
Unlimited Frequency		
Percentage of district acreage using a Unlimited Frequency (any day requested).		% acres
Advance notice required by district before delivery		hours
Number of times a turnout cannot get water exactly the day desired during a year		times/yr

Section 4. Questions or Descriptions for	**Answer**	**Units**
FLOW RATES		
Which of the following 3 choices best describes the flexibility of flow rate availability? 1. Essentially the same flow rate is delivered to each field for every irrigation 2. The farmer can request several different flow rates throughout the season 3. The farmer can have a different flow rate each irrigation if he/she requests it		#
How many times can a farmer change a flow rate while an irrigation is in progress? 1 = No times 2 = 1 time 3 = 2 times 4 = There are no restrictions		#
If a farmer can change flow rates during an irrigation, how many hours advance notice must be given before the change is made?		hours
DURATIONS		
What is the flexibility in duration? 1 = Unlimited 2 = 12-hour increments 3 = 24-hour increments 4 = Other fixed, district determined duration		#
Advance notice required before shutting off the water? (0 can be a possible answer)		hours
Percentage of the time district personnel open and close farm turnout gates?		%
When district personnel operate gates, how close do they come to the prescribed time.		hours
If there is not enough capacity/flow availability to match a turnout order, what do you do? 1 = Pro-rate 2 = Postpone		#
Flexibility from Water Supplier		
Allowable unannounced % flow change per supplier turnout? (Actual)		%

Section 4. Questions or Descriptions for	**Answer**	**Units**
Allowable unannounced % flow change for the whole district? (Actual)		%
Hours of advance notice required by the supplier before a scheduled flow change occurs		hours
How many acre-feet of water per year, on the average over the last 10 years, did you have to take even if you didn't need it?		ac-ft
What percent of the time is the supplier unable to provide the flow the district requires?		%
If there is an inability, is it the result of 1) Lack of storage 2) Conveyance capacity limitations 3) Other _____		#
What percent flow must the district then accept?		%
DISTRICT FUNCTIONS		
GENERAL		
On a rating of 0 to 9 (9 being very important), rate the need to improve the flexibility of the present delivery system.		#
Which of the following is more preferable? 1 = Improve district flexibility with new structures 2 = Improve flexibility with new management concepts and limited new hardware 3 = combination		#
How many times during the last 5 years, has the subject of improving district delivery flexibility been brought up at board meetings?		#
On a scale of 0 to 9, rate the desire of the average farmer in his district for improved flexibility (9 is a very strong desire).		#
FUNCTIONS		
Is ground water recharge a major function of the district? 1 = yes 2 = no		#

Section 4. Questions or Descriptions for	**Answer**	**Units**
Is canal seepage considered a beneficial use? 1 = yes 2 = no 3 = n/a		#
Is on-farm deep percolation considered beneficial? 1 = definitely yes 2 = possibly 3 = probably not 4 = definitely not 5 = do not know		#
WATER CONSERVATION PROGRAMS		
General		
What is the potential for reducing district deliveries in your District? a. average year		acre-ft/yr
b. dry year		acre-ft/yr
What would you do with the saved water? 1. expand service area/irrigated acres 2. ground water recharge 3. transfer/sell 4. nothing 5. Other _____		#
What is the potential for reducing ground water pumping in the District? a. average year		%
b. dry year		%

Appendix B

Interviewed Districts

No.	District	Address	City	State	Zip	Phone
1	Kern Delta Water District	501 Taft Highway	Bakersfield	CA	93307	(661) 834-4656
2	West Kern Water District	800 Kern Street	Taft	CA	93268-0024	(661) 763-3151
3	Semitropic Water Storage District	PO Box Z	Wasco	CA	93280	(661) 758-5113
4	Alta Irrigation District	289 N. L St.	Dinuba	CA	93618	(559) 591-0800
5	Consolidated Irrigation District	PO Box 209	Selma	CA	93662-0209	(559) 896-1661
6	Tulare Lake Basin Water Storage District	1001 Chase Ave	Corcoran	CA	93212	(559) 992-4127
7	Merced Irrigation District	812 W 18th Street	Merced	CA	95344	(209) 722-5761
8	Modesto Irrigation District	1231 11th Street	Modesto	CA	95352	(209) 526-7562
9	Turlock Irrigation District	333 E Canal Drive	Turlock	CA	95381	(209) 883-8316
10	South San Joaquin Irrigation District	11011 E Highway 120	Manteca	CA	95336-9750	(209) 823-3101
11	Eastside Water District	PO Box 280	Denair	CA	95316-0280	(209) 491-0371
12	Yolo Co. Flood Control & Water Conservation District	34274 State Highway 16	Woodland	CA	95695	(530) 662-0265
13	Western Canal Water District	PO Box 190	Richvale	CA	95974	(530) 342-5083
14	Sutter Extension Water District	4525 Franklin Road	Yuba City	CA	95993-9316	(530) 673-7138
15	Butte Water District	735 Virginia St	Gridley	CA	95948	(530) 846-3100
16	Biggs-West Gridley Water District	1713 West Biggs Gridley Rd.	Gridley	CA	95948	(530) 846-3317
17	Imperial Irrigation District	333 E Barioni Blvd	Imperial	CA	92255	(760) 339-9083

Appendix C Quantifiable Objectives Survey

Quantifiable Objectives Survey

Addendum to the Benchmarking of Flexibility and Needs Survey 2002 for Non-Federal Irrigation Districts

In May 2003, the seventeen non-federal irrigation districts that were interviewed by the Irrigation Training and Research Center (ITRC) for the Benchmarking of Flexibility and Needs Survey 2002 were given a questionnaire by the ITRC regarding CALFED Quantifiable Objectives. Fourteen of the seventeen districts completed the questionnaire and their responses are summarized in this addendum.

Along with the questionnaire, each district was given a summary of the Target Benefits outlined for the Quantifiable Objective (QO) Region that encompassed the majority of their district.

The district familiarity with CALFED QO's before the questionnaire was given, ranged from no familiarity to other districts that actually met with CALFED personnel while the QO's were being classified and were therefore very familiar.

Table A1. *District Familiarity with CALFED Quantifiable Objectives*

Response	Number of Responses *(n = 14)*
Familiar	11
Not Familiar	3

Even though not every district was familiar with QO's most districts have past, current, or future projects that would help meet one or more (out of four) generalized target benefits included in the questionnaire. In order to obtain comparable data, districts were asked if they had past, current or future modernization efforts, planned or completed, that would help achieve one or more of the following generalized QO's:

1. Increased District flexibility through physical and operational improvements allowing water users to convert to more uniform irrigation methods such as drip and microspray irrigation
2. Reduction in operational spill keeping water at the source so it can be used to meet QO's
3. Conjunctive use program
4. Increased District flexibility through physical and operational improvements encouraging water users to use surface water as opposed to groundwater

The following table shows the district's yes, no, maybe, or not applicable answer to this question.

Table A2. *Past, Current, or future modernization efforts planned or completed that will help achieve one of four generalized quantifiable objectives.*

Generalized QO Number	Number of Responses *(n = 14)*			
	Yes	No	Maybe	N/A
1	11	0	1	2
2	6	5	2	1
3	10	1	3	0
4	9	0	2	3

Most of the districts currently have projects, completed or planned that will help achieve one of more of the general QO's. Improving the service to water users through improved water delivery flexibility seemed to be a high priority to the majority of districts surveyed. Increasing the level of service to water users is important so that water users have the ability to improve irrigation management while using surface water supplies. Irrigation scheduling and drip/microspray irrigation require a high level of water delivery flexibility (flexibility in flow rate, duration, and frequency) to be use effectively. Districts must respond to this demand though modernization of infrastructure and operations.

The majority of irrigation district interviewed were interested in receiving grant funding for modernization improvements that would benefit the State by helping to meet quantifiable objectives as well as their district through improved water delivery service.

Table A3. *District interested in receiving grant funding to improve their distribution system while helping to achieve QO's*

Response	Number of Responses *(n = 14)*
Yes	11
No	1
Maybe	2