Potential Water Savings from Improvements in Irrigation Districts and On-farm Irrigation in the Lower Rio Grande Valley of Texas

Progress Report and Initial Estimates

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EXECUTIVE SUMMARY

This report summarizes progress in determining the potential water savings in irrigation districts of the Lower Rio Grande Valley of Texas. Support for this study has been provided by three sources:

1). the Bureau of Reclamation,

2). the Lower Rio Grande Development Council through Perez, Freese and Nichols, Inc., as part of the Lower Rio Grande Integrated Water Resources Plan, Phase II (IWRP) project, and

3). Irrigation Districts as part of the DMS (District Management System) program.

To date, we have been able to assemble attribute data (sizes, capacity, etc.) on only 39% of the lined and 50% of the unlined canals comprising the main water distribution network of the districts. We have no information on the existing condition of these canals and have limited information on the secondary/tertiary networks (laterals). Thus, we were not able to directly assess the water saving potential from improvements in the distribution networks of the districts. As an alternative, estimates on the potential water savings are provided based on conveyance efficiency improvements.

Preliminary analysis indicate a potential water savings of **54,000 to 223,000 ac-ft/yr** could result from improvements in the conveyance efficiency of 28 districts through renovations such as canal lining and pipeline replacement:

- a water savings of **54,000 to 112,000 ac-ft/yr** could be achieved by bringing the conveyance efficiencies of the districts from current levels up to 80%.
- a water savings of **105,000 to 223,000 ac-ft/yr** could result from bringing efficiencies up to 90%.

The 90% goal would require significant investment in the districts, but would have the added benefit of solving the "head" problem experienced on about half the irrigated fields (insignificant volume and/or water pressure at the field outlet). Insufficient head prevents good water management and causes low on-farm irrigation efficiency. Poor head and related poor water management also can reduce potential crop production and yields.

We measured the seepage losses in 5 canals. The two earthen canals had seepage rates similar to those reported in the scientific literature. But, the three concrete canals had very high seepage loss rates, indicating problems with their construction or maintenance. It should be noted that most districts do not have good data on sources of water losses that affect efficiency. In addition, questions have been raised on the accuracy of the basic information districts use to determine conveyance efficiency.

Implementing a combination of on-farm practices of metering, gated pipe water delivery, and improved water management and/or technology could result in a water savings of between **98,000 and 217,000 ac-ft/yr**. To achieve these on-farm water savings, an intensive technical assistance and education program would also be needed. Additional on-farm savings would result from a correction of the head problem as discussed above.

Funding is being sought for a more intensive effort that would provided the detailed information necessary for direct assessment of potential water savings. A description of this proposed program is included.

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BACKGROUND

About 98% of all the water used in the Lower Rio Grande Valley, in both Texas and Mexico, is from the Rio Grande River. The region is undergoing rapid population and industrial growth. The Texas Water Development Board projects that by the year 2050, the population in the Valley will more than double, and municipal and industrial water demand will increase by 171% and 48%, respectively (Table 1; note: these projections do not include expected increases in Mexico).

However, the lower Rio Grande River is over appropriated; that is, there are more water right permits than firm yield. Agriculture holds about 90% of the water rights and, depending on the year, accounts for about 80% of total withdrawals from the river. Thus, water to meet future demand will likely come from agriculture. The purpose of this study is to determine how much water could be "freed-up" by making improvement in the irrigation systems of the region.

Table 1. Population and water demand projections in the Lower Rio Grande Region of Texas[(1)]. Water demand is expressed in acre-feet per year.

Category	1990	2010	2030	2050	% of Change 1990-2050
Population	919,505	1,598,851	2,403,624	3,020,871	228.5%
Municipal Water Use	187,839	312,439	415,970	508,814	170.9%
Industrial Water Use	11,036	13,132	15,047	16,355	48.2%
Irrigation Water Use	1,358,284	1,354,031	1,254,706	1,162,737	-14.3%
Irrigation Adjustment[(2)]	0	(188,366)	(194,992)	(208,040)	-29.8%
Total Water Use	1,557,159	1,491,236	1,490,731	1,479,866	-4.9%

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DESCRIPTION OF THE IRRIGATION DISTRICTS

This study examines 28 water districts in Hidalgo, Cameron and Willacy Counties. These districts hold authorized agricultural water rights totaling 1,468,314 ac-ft (Table 2). Based on water rights holdings, the districts vary greatly in size, with the smallest district having 625 ac-ft of water rights and the largest district 174,776 ac-ft. The 4 largest districts (Mecedes, Delta Lake, San Benito, and San Juan) account for 44% of the all agricultural water rights, and the largest 8 districts (adding Harlingen, Donna, Edinburg, and Santa Cruz) account for 69% of the total.

Generally, these districts classify their water distribution networks into two categories: the "mains" and "laterals." Figure 1 shows the Regional GIS District Map which illustrates our current understanding of the district boundaries and the extent of the main irrigation water distribution networks ("mains"). In producing this map, the DMS Team[(3)] began with a distribution network map obtained from University of Texas, Bureau of Economic Geology. This map contained canal lines, but no attribute information (such as canal size, lining material, etc.) With assistance from the irrigation managers, we corrected and expanded the original map and developed a database with information on canal sizes, lining materials, etc. The district boundaries shown in Fig. 1 were determined by the IWRP Project Team[(4)] and mapped by TAES - Mapping Sciences Laboratory.

The total miles of canals, pipeline and resacas comprising the main irrigation water distribution networks (as shown in the Regional GIS) are summarized in Tables 3 and 4. Table 3 lists the total miles of the main canals by size (based on top width) and lining status. We have no size information on 39% of the lined main canals and about 50% of the unlined main canals. Table 4 provides the overall summary the extent of the main distribution networks which include 641.9 miles of canals, 9.7 miles of pipelines, and 44.6 miles of resacas.

Along with the main canals, districts have an extensive network of smaller canals and pipelines which carry water from the mains to individual fields ("laterals"). For example, Figure 2 shows the entire distribution system, including the laterals, for Delta Lake Irrigation District. Individual water account/field boundaries for HCID#6 are shown in Fig. 3, color-coded by the number of times each filed was irrigated in 1997. Currently, we are working with 6 additional districts in mapping their laterals and account boundaries as part of the DMS Program. This level of detail is needed on districts for a proper analysis of water saving benefits.

Table 2. The official and common names of 28 irrigation and water supply districts in the Hidalgo, Cameron and Willacy Counties and their authorized agricultural water rights.

Official Name	**Common Name**	**Authorized Water Right (ac-ft)**
Adams Gardens Irrigation District No. 19	Adams Garden	18,737
Bayview Irrigation District No. 11	Bayview	17,978
Brownsville Irrigation and Drainage District No. 5	Brownsville	34,876
Cameron County Irrigation District No. 3	La Feria	75,626
Cameron County Irrigation District No. 4	Santa Maria	10,182
Cameron County Irrigation District No. 6	Los Fresnos	52,142
Cameron County Water Improvement District No. 10	Rutherford-	10,213
Cameron County Water Improvement District No. 16	Cameron #16	3,913
Cameron County Water Improvement District No. 17	Cameron #17	625
Cameron County Water Improvement District No. 2	San Benito	151,941
Delta Lake Irrigation District	Delta Lake	174,776
Donna Irrigation District Hidalgo County No. 1	Donna	94,063
Engleman Irrigation District	Engleman	20,031
Harlingen Irrigation District No. 1	Harlingen	98,233
Hidalgo and Cameron Counties Irrigation District No. 9	Mercedes	177,151
Hidalgo County Improvement District No. 19	Sharyland	11,777
Hidalgo County Irrigation District No. 1	Edinburg	85,615
Hidalgo County Irrigation District No. 2	San Juan	147,675
Hidalgo County Water Irrigation District No. 3	McAllen #3	9,752
Hidalgo County Irrigation District No. 5	Progreso	14,234
Hidalgo County Irrigation District No. 6	Mission #6	42,545
Hidalgo County Irrigation District No. 16	Mission # 16	30,749
Hidalgo County Irrigation District No. 13	Baptist Seminary	4,856
Hidalgo County Water Control and Irrigation District No.	Monte Grande	5,505
Hidalgo County Municipal Utility District No. 1	MUD	1,120

Santa Cruz Irrigation District No. 15	Santa Cruz	82,008
United Irrigation District of Hidalgo County	United	69,491
Valley Acres Water District	Valley Acres	22,500

TOTAL 1,468,314

Figure 1 - The 28 irrigation districts and main irrigation water distribution networks in Hidalgo, Cameron and Willacy Counties.

Table 3. Canal sizes and lining material for the main irrigation water distribution networks as shown on the Regional GIS map (Fig. 1).

Top Width (feet)	**Canal Type (or lining material) (miles)**	
	concrete	**earth**
< 10	41.6	1.0
10 - 20	98.0	11.9
20 - 30	25.2	52.2
30 - 40	3.8	35.1
40 - 50	1.1	60.1
50 - 75	1.4	30.9
75 - 100	0	11.1
> 100	0	9.7
Unknown Widths	99	134.5
Total Miles	270.1	346.4

Table 4. Miles of canals, pipelines and resacas for the main irrigation water distribution networks as shown on the Regional GIS Map (Fig. 1).

canals	**pipelines (miles)**	**resacas (miles)**	**unknown (miles)**	**total**

(miles)				(miles)
641.9	9.7	44.6	0.1	696.3

Figure 2 - The entire water distribution network, including mains and laterals, of Delta Lake Irrigation District.

Figure 3 - Hidalgo County Irrigation District # 6's main distribution network and water account/field boundaries color coded by the number of times each field was irrigated in 1997.

Table 5 provides the total extent of the distribution networks (mains and laterals) of each district based on all information available, including data obtained from our GIS analysis, IWRP project questionnaire, and direct contact with district managers. The dash lines on Table 5 indicate only that we have no information for that category. Three districts provided incomplete or no information concerning their distribution systems, and are not included in Table 5.

Table 5. Extent of the distribution networks of 25 irrigation districts based on survey responses and GIS analysis. Little or no information has been provided for 3 districts[1].

District	Canals (miles)			Pipelines (miles)	Resacas (miles)
	Total	**Lined**	**Unlined**		
Adams Garden	23.5	15.6	7.9	3.0	--
Bayview	16.7	7.1	9.6	76	14.5
Brownsville	2	--	2	122	--
CCID#2	204.7	1.2	203.5	34.7	13.9
CCID#16	3.5	--	3.5	--	--
Los Fresnos	100	25	75	25	11.8
Delta Lake	292	250	42	173.98	--
Donna	32.3	28.3	4	--	--
Engleman	10.4	10.4	--	2.7	--
Harlingen	74	28	46	157.3	--
Edinburg	111	87	22.7	80	--
HCID#2	71.3	26.5	41.9	218.5	--
HCMUD	--	--	--	200	--

HCWID#3	17	12	5	--	--
HCID#5	0.5	--	0.5	--	--
HCID#6	45.5	45	.5	95	--
Mercedes	76.3	56.3	20	250	--
HCID#13	--	--	--	3.5	--
HCID#16	17.2	17.2	--	1.7	--
HCWCID#18	0.5	0.5	--	7	--
HCWCID#19	4.7	2.3	2.4	--	--
La Feria IDCC#3	43.8	22.5	21.3	120	--
Santa Maria	3.5	--	3.5	--	--
United ID	53.1	18.5	34.6	88	--
Valley Acres	7.0	5.0	2	20	--

[1] *CC#10, CC #17; Santa Cruz*

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SEEPAGE AND CONVEYANCE LOSSES

LITERATURE REVIEW

The DMS Team conducted a review of the scientific literature on canal seepage losses and improvements in district efficiencies from rehabilitation projects. We only found a few articles that reported seepage rates for different lining materials and soil types. Seepage rates from these studies are summarized in Tables 6 and 7. Table 7 is of particular interest and gives seepage rates measured in five irrigation districts in South Texas, including the United and San Benito Irrigation Districts. Details of the literature search will be given in a later report.

Table 6. Canal seepage rates reported in published studies.

Lining/Soil Type	**Seepage Rate (gal/ft^2 /day)**
plastic	0.08 - 3.74
concrete	0.06 - 3.22
gunite	0.06 - 0.94
compacted earth	0.07 - 0.6
clay	0.37 - 2.99
loam	4.49 - 7.48
sand	9.34 - 19.45

Sources: Bureau of Reclamation (1963); Nofziger, D.L. 1979. The influence of canal seepage on groundwater in Lugert Lake irrigation area. Oklahoma Water Resources Research Institute, OSU.

FIELD RECONNAISSANCE

Our original plans were to use portable open channel flow meters, including velocity and doppler meters, to determine seepage loss rates in representative canals throughout the area. However, after two days of testing these flow devices against a calibrated weir structure, we concluded that their accuracy (± 5%) was not good enough for us to determine seepage losses in canal sections.

Table 7. Canal seepage rates reported in the Lower Rio Grande Valley.

Soil Type	**Seepage Loss Rate** (gal/ft^2 /day)
clay	1.5
silty clay loam	2.24
clay loam	2.99
silt loam earth	4.49
loam	7.48
fine sandy loam	9.35
sandy loam	11.22

Source: Texas Board of Water Engineers. 1946. Seepage Losses from Canals in Texas, Austin. July 1.

As an alternative, the DMS Team measured seepage losses in five canals and one pipeline network using the ponding method. This testing was conducted in and with assistance from four districts. The results of the ponding tests are summarized in Table 8. The three lined canals had very high seepage loss rates compared to the scientific literature, indicating problems with their construction or maintenance. The seepage rates of the two unlined canals fell in the ranges reported in the scientific literature (Tables 5 and 6). The pipeline network measurements took place in the Brownsville Irrigation District and showed very little seepage during the 24 hour test.

For the IWRP Project, a questionnaire form was sent to all 28 districts. On the form, only five districts reported areas of known seepage losses: Harlingen (West main canal), Mercedes (East-side main canal, siphon at Bus. 83), Santa Maria (Disdor), United (Mission main, Nbryan) and Hidalgo#1 (Penitas and East).

Table 8. Seepage rates measured by the DMS Team in 5 irrigation canals in the Lower Rio Grande Valley.

Test #	**Canal Type**	**Top Width (ft)**	**Length (ft)**	**Seepage Rate** (gal/ft^2 /day)	**Total Loss in Canal** (ac-ft/mile) per day------------------per year*
1	concrete	19	2557	4.28	0.81-------------------243

2	earth (clay)	38	3342	1.62	0.82------------------246
3	earth (sandy clay loam)	45	6336	1.69	1.05------------------315
4	concrete	12	2583	2.12	0.20-------------------60
5	concrete	12.5	9525	2.49	0.25-------------------75

*based on 300 days per year.

SOIL SERIES AND SEEPAGE RATES

Figure 4 shows a general soil map of the region. The DMS Team created this map with the GIS software *ArcView* from NRCS soil survey maps. Soil types are color coded by possible seepage rates based on soil type (Tables 6 and 7). Smaller, unlined canals in the more permeable areas are likely to have significant seepage rates. Once the laterals of districts are mapped, unlined canals in these areas can be identified for further investigation.

However, the Valley is an alluvial region, and soils type can very dramatically over small distances. In addition, actual seepage loss depends on many factors in addition to soil type, including construction techniques, maintenance, distance to the shallow water table, and silt deposits. Thus, canals need to be evaluated on an individual basis to determine seepage losses and potential benefits from lining or pipeline replacement.

CONVEYANCE EFFICIENCY AND WATER DUTY

The term *conveyance efficiency* (or *water duty*) is a measurement of all the losses in an irrigation distribution system from the river (or diversion point) to the field. Conveyance efficiency is calculated from the total amount of water diverted in order to supply a specific amount of water to a field (usually 6 inches).

Conveyance efficiency is expressed as efficiency, the percent of water lost, or amount of water pumped (in feet). For example, District A must pump 8 inches from the river in order to deliver 6 inches to the field. District A's losses can be expressed as a:

- conveyance efficiency of 75%,
- water duty of 25%, or
- water duty of 0.67 ft.

Conveyance loss includes a number of factors besides seepage and evaporation. Table 9 shows my classification system for conveyance losses which is composed of Transportation, Accounting, and Operational losses.

The conveyance efficiencies as reported to us by 19 districts are listed in Table 10. The remaining 9 districts did not respond to survey and telephone requests for this information. The highest efficiencies are reported in smaller districts with extensive pipeline systems, while the lowest efficiencies are in larger districts which have undergone little rehabilitation. Seven districts reported major renovations programs since 1960 (Table 11). These districts also had better than average conveyance efficiency estimates.

It should be pointed out that most districts do not have good data on their current conveyance efficiencies, and more work is needed to quantify these losses in order to target renovation programs.

Figure 4 - General soil map for Hidalgo, Cameron and Willacy Counties color coded by possible canal seepage rates based on soil type.

Table 9. Classification of the sources of water loss in irrigation districts.

Transportation	Accounting	Operation
seepage in main, unlined canals	accuracy of field-level deliveries (estimates of canal riders/irrigators)	charging empty pipelines and canals
seepage in secondary territory unlined canals (laterals)	unauthorized use	spills (end of canals)
leakage from lined canals	metering at main pumping plant	partial use of water in dead-end lines
leakage from pipelines	water rights accounting system	
evaporation (canals and storage reservoirs)		

Table 10. Estimated conveyance efficiency as supplied by 19 districts.

District	Conveyance Efficiency (%)	District	Conveyance Efficiency (%)
Adams Garden	85	HCMUD	90
Bayview	85	HCWID#3 (McAllen)	90
Brownsville	90	HCWID#5 (Progresso)	92
CCID#2 (San Benito)	40	HCCID#9 (Mercedes)	75
CCID#6 (Los Fresnos)	60	HCID#16 (Mission)	85
Delta Lake	75	HCWCID#18	95
Donna	58	La Feria IDCC#3	75
Harlingen	85	Santa Cruz ID#15	75
HCID#1 (Edinburg)	80	Santa Maria IDCC#4	75
HCID#2 (San Juan)	77		

Table 11. Major renovations since 1960 as reported by 7 districts.	
Irrigation District	**Renovations since 1960**
Hidalgo County #2	1980 Bureau of Reclamation Rehabilitation project that lasted 8.5 years Spent $20.6 million New river pumping plant 1800 acre-feet reservoir Concrete lined earthen canals and placed smaller canals in reinforced concrete pipelines
Brownsville	All canals were put underground with the exception of 1.5 miles of canal from the river
Harlingen	(no details provided)
La Feria	Rehabilitate its facility from 1961-1965 Improvements were the pumping plants, increase reservoir capacity to 2000 acre-feet, 22.5 miles lined canals, and 120 miles of pipeline
HCMUD #1	(no details provided)
Hidalgo County #1	Canals into pipeline and old mortar joining pipe into new pipeline
Hidalgo and Cameron County #9	Bureau of Reclamation: major canal renovation and pipeline installation In House: new river pumping plant, and reservoir renovation and construction

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POTENTIAL WATER SAVINGS FROM DISTRICT IMPROVEMENTS

CONVEYANCE EFFICIENCY IMPROVEMENTS

Due to the limited amount of data we were able to assemble regarding the extent, sizes, and condition of the irrigation water distribution systems, I was not able to perform direct assessment of seepage losses and potential water savings through improvements. As an alternative approach, we looked at the difference between the existing conveyance efficiencies and the efficiencies that which could reasonably be achieved by the districts through renovation projects.

Table 12 lists the conveyance efficiencies for 12 irrigation districts in the Western United States which range from about 60 to 95%. For the present analysis, I assumed that an efficiency of 80 to 90% was obtainable for most districts.

Starting with the conveyance efficiency estimates provided by the 19 districts (Table 10), I calculated the potential water savings if all districts were brought up to 80 and 90% conveyance efficiency. For the

9 districts not reporting efficiencies, I assumed a present value of 75%. The results are presented in Tables 13a and 13b. **The total potential water savings from conveyance efficiency improvement for all districts (adding Tables 13a and 13b) is 54,000 to 223,000 ac-ft/yr**.

In Table 13, water saving potentials are provided for low water use years and high water use years. A low water use year is defined as diversion of 35% of the authorized water right and a high water use year as 80%. Since water-short districts use a higher percentage of their water rights, 45 and 90% were used for low and high water use years, respectively. These portions are based on an analysis of water diversions by each district during the period 1989 - 1997.

UNCERTAINTY IN CONVEYANCE EFFICIENCY ESTIMATES AND POTENTIAL WATER SAVINGS

There is some question about the accuracy of the basic information used to estimate conveyance efficiency, particularly:

1). the amount of water pumped or diverted into the system, and

2). the actual amount of water delivered to the field.

The doppler flow meters currently used at many river pumping plants were "calibrated" for each site based on estimates of the current pumping rates and/or pumping plant capacity, and on engine/motor and pump performance. Due to the physical layout of the pumping plants, it is difficult to independently verify these rates. Likewise, little metering is done at the field turn-out, and the amount delivered is also an estimate in most districts.

Table 12. Conveyance efficiencies of 12 irrigation districts in the Western US.

Irrigation Division or District	Irrigated Area (acres)	Diversion (ac-ft)	Farm Delivery (ac-ft)	Per Acre Delivery (ac-ft/ac)	M&I Delivery (ac-ft)	Conveyance Efficiency (%)
Arizona						
Wellton-Mohawk Div.	60324	442140	397836	6.6	1080	90.2
Mesa Unit	17454	290747	273927	15.69	2018	94.9
North Gila Valley Unit	6319	51163	44483	7.04	0.00	86.9
South Gila Valley Unit	9628	59595	56551	5.87	0.00	94.9
Salt River Valley	54174	840921	333859	6.16	291149	74.3
Yuma Valley Division	45761	360020	263048	5.75	19564	78.5
Yuma Auxiliary	2717	33745	28904	10.64	0.00	85.7
California						
Coachella Valley WD	61052	299237	260060	4.26	0.00	86.9
Imperial ID	463030	2974647	2654689	5.73	26223	90.1
Bard Reservation	6689	40642	36046	5.39	0.00	88.7

Unit						
Indian Reservation Unit	6541	49661	42562	6.51	0.00	85.7
Nevada						
Newlands	64637	270228	163407	2.53	0.00	60.5

Notes:

(1) A portion of the irrigated area within CVWD receives its entire water supply from groundwater. Additionally, some of the area that receives Colorado River water also receives supplemental groundwater. Because of these conditions, the total actual per-acre delivery is greater than the reported 4.26 acre-feet per acre.

(2) The Newlands Project area has a growing season of approximately six months with a much lower

Source: Imperial Irrigation District Report: History of Water Conservation within the Imperial Irrigation District, April 28, 1998

Table 13a. Potential water savings in 19 districts by increasing the conveyance efficiency to 80% and 90%. Savings is calculated for low and high water use years*, and the increases in efficiency are based on conveyance efficiencies supplied by each district (Table 10).

District	Potential Water Savings (ac-ft/yr)			
	80% Conveyance Efficiency		90% Conveyance Efficiency	
	Low	High	Low	High
Adams Garden**	0	0	422	843
Bayview	0	0	315	719
Brownsville	0	0	0	0
CCID#2**	27349	54699	34187	68373
CCID#6**	4693	9386	7039	14078
Delta Lake**	3932	7864	11797	23593
Donna	6255	14298	9547	21823
Harlingen	0	0	1719	3929
HCID#1	0	0	2997	6849
HCID#2	1551	3544	6719	15358
HCMUD	0	0	0	0
HCWID#3	0	0	0	0
HCID#5	0	0	0	0
HCCID#9	3100	7086	9300	21258
HCID#16**	0	0	692	1384
HCWCID#18	96	220	289	661
La Feria**	1702	3403	5105	10210

Santa Cruz	1435	3280	4305	9841
Santa Maria	178	407	535	1222
TOTALS	**50291**	**104187**	**94968**	**200135**

* low water year = 35% of authorized water right; high water use year = 80% of authorized water right

** water short districts, calculations based on 45% for low water use year and 90% for high water use year

Table 13b. Potential water savings in 9 districts not supplying estimates of present conveyance efficiency. Savings are calculated for low and high present water use years* using an assumed present efficiency of 75%.

	Potential Water Savings (ac-ft/yr)			
	80% Conveyance Efficiency		**90% Conveyance Efficiency**	
District	**Low**	**High**	**Low**	**High**
CCWID#10	179	409	536	1226
CCWID#16	68	157	205	470
CCWID#17	11	25	33	75
Engleman	351	801	1052	2404
HCID#6	745	1702	2234	5105
HCID#13	85	194	255	583
HCWCID#19**	265	530	795	1590
United	1216	2780	3648	8336
Valley Acres	394	900	1181	2700
TOTALS	**3314**	**7498**	**9939**	**22489**

* low water year = 35% of authorized water right; high water use year = 80% of authorized water right

** water short district, calculations based on 45% for low water use year and 90% for high water use year

The total savings as given in Tables 13a and 13b provide a good estimate of the **regional water saving potential** from district improvements. However, the estimates for individual districts are provided here for the sole purpose of documenting how I arrived at these numbers. A more detailed analysis is required to produce estimates that have a reasonable level of confidence.

SHARING, COMBINING AND CONSOLIDATING IRRIGATION DISTRICTS AND DISTRIBUTION SYSTEMS[(5)]

The advantages of sharing or combining main distribution canals include reducing evaporation, seepage losses, and the operation and maintenance costs of districts. Important factors that must be considered include the capacity of the canal systems and pumping plants as related to the daily, weekly, monthly and seasonal water demand in the districts under consideration. Major limiting factors include the capital costs, as well as the regulatory and permitting difficulties in constructing new canals to interconnect districts or to substantially increase the capacity and sizes of existing canals.

There is only one current situation in which sharing main canals may be feasible which would not involve new construction. Hidalgo County #6 and United Irrigation Districts' main canals cross in the segment leading from the river pumping plant to the districts (Fig. 1). Combining the segments would reduced about 8 to 10 miles of a large earthen canal. However, more detailed study is required before I can make this recommendation.

In the future, increased opportunities for sharing of canals will occur, particularly due to the urban growth patterns along Hwy 83 corridor. This growth pattern will leave most large districts essentially split into north and south irrigated areas separated by municipalities. Possible sharing of distribution systems in the northern areas would require the expansion of existing canals and construction of new canals. Consolidation of distribution systems may become feasible in two groups of districts, one group includes Delta Lakes, Mercedes, Engleman and Donna, the other group includes the western districts of HC#16, HC#6, HC#1, United and Santa Cruz.

Consolidating administrative functions of districts has already occurred. Recent examples include Adams Garden and Harlingen Irrigation Districts, and Hidalgo County #16 and United Irrigation Districts; both involving a small district and a much larger district with a large support staff. Such consolidations improve the economics and often the level of services that districts can provide. Individual board of directors can still exist providing for the current levels of property owner representation. Future consolidations are likely, particularly among the smaller districts in Hidalgo County, as these districts continue to lose land and fragment due to municipal growth.

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ON-FARM POTENTIAL WATER SAVINGS

On-farm irrigation efficiency is defined as the ratio of the amount of water needed to grow the crop to the amount of water delivered to a field. The amount of water needed to grow a crop is usually estimated from ET (evapotranspiration) data as adjusted for beneficial rainfall and leaching requirements.

Generally, surface irrigation systems, such as found in the Lower Rio Grande Valley, have low efficiencies. For example, Table 14 lists the average on-farm irrigation efficiencies measured in 11 districts in the Western United States. On-farm irrigation efficiency ranges from 30 to 80%. Generally, we expect on-farm surface irrigation efficiencies of 60 - 70%. Various practices and field improvements can increase this efficiency to 70 - 80%, or even higher with good management and improved technology.

Table 14. Average on farm irrigation efficiencies measured in 11 districts in the Western United States.

District	Average On-Farm Irrigation Efficiency (%)

Imperial Irrigation District	78
Coachella Valley Water District	52
Reservation Division	52
Yuma County Water User Association	71
Yuma Mesa Irrigation and Drainage	31
Unit "B" Irrigation District	33
Yuma Irrigation District	61
North Gila Irrigation District	39
Wellton-Mohawk Irrigation District	58
Colorado River Indian Tribes	65
Palo Verde Irrigation District	43

Source: Imperial Irrigation District Report: History of Water Conservation within the Imperial Irrigation District, April 28, 1998. Unpublished data collected by the Bureau of Reclamation.

Table 15 provides the observed water savings reported in 4 districts (Bayview, Brownsville, Delta Lakes, San Benito) from recent experiments with layflat tubbing replacement of siphon tubes and on-farm metering. In some cases, improved technology or water management were also implemented. The numbers reported for Donna and La Feria are for metering only. It should be noted that hard data to support many of these observations do not exist.

Table 15. Water savings observed or estimated from metering and poly pipe experiments during the 1990s in the Lower Rio Grande Valley.

district	**water savings observed**
Bayview	36 %[1]
Brownsville	33 %[1]
Donna	20 %[2]
La Feria	10 %[2]
Delta Lakes	33 %[1]
San Benito	40 %[1]

[1] may include additional benefits from implementing improved on-farm water management practices or due to changes in irrigation technology

[2] metering only

These observations and supporting information show that significant water savings at the farm level are possible in the Lower Rio Grande Valley. However, one major limiting factor is that in about half of the area, water is delivered to the field with inadequate "head" (insufficient volume and/or pressure) to allow for efficient furrow irrigation. Without improvements in the distribution systems, on-farm water saving potential in about half the irrigated land will be limited.

For the analysis used in the IWRP project, we classified potential on-farm water savings into three components:

1). metering,

2). gated pipe replacement of field ditches and siphon tubes, and

3). high water management and/or improved irrigation technology.

Table 16 gives the expected range of water savings for each practice and the factor used in this analysis. Table 17 summarizes the assumptions used in applying these factors to this region. For example, the first two factors (metering and gated pipe) were not applied to the area currently under the practice. In addition, benefits from high water management were not applied to the half of the area with head problems. Increased on-farm efficiency can only be achieved in these areas by improvements in the distribution systems and/or adoption of pumped and pressurized irrigation systems such as drip and sprinkler irrigation.

On-farm water saving potential were calculated for high and low water use years as discussed above. **The results are a potential on-farm water savings of 98,000 to 217,000 ac-ft/yr**. However, an intensive technical assistance and education program would be needed to achieve such savings.

Table 16. Factors used for calculation of on-farm water saving potential in the IWRP Project.

technique	**expected water savings**	**factor used**
metering	0 - 15 %	10 %
poly/gated pipe replacement of field ditches/siphon tubes	5 - 20 %	10 %
high management/improved irrigation technology	10 - 30 %	20 %

Table 17. Assumptions for applying water savings factors in Table 16 to the Lower Rio Grande Valley.

technique	**assumptions for calculations**
metering	- adopted Valley-wide by 2010 - 20% of land area is assumed to be metering - factor applied to remaining 80%
poly/gated pipe	- adopted by 90% of Valley by 2010 - approximately 50% of Valley already using gated/poly pipe - factor applied to remaining 40% of Valley not currently using poly/gated pipe (0.9 - 0.5 = 0.4)
high management/improved irrigation technology	- adopted on half of Valley by 2010 - approximately 20% of area currently under high management or using improved technologies

	- factor applied to 30% of area (0.5 - 0.2 = 0.3)

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PROJECT AND FINANCIAL SUPPORT

Support for the work summarized in this report is from three sources as discussed below.

District Management System Program

Since 1995, I have been working with a number of irrigation districts in modernizing their accounting systems and in developing a District Management System (DMS). The DMS is composed of GIS-based maps and databases of district distribution networks and water accounts. The DMS is designed to aid in the day-to-day management of districts. Various computer tools and software are under development to expand the capabilities of the DMS, and to improve its capability for conservation planning and the analysis of alternatives in regional water resources planning projects.

Direct funding and in-kind services are currently being provided by 8 districts who are implementing the DMS: Harlingen, Mercedes, Brownsville, San Benito, San Juan, Delta Lakes, HCID#1 and HCID#6.

The term *"DMS Team"* is used in this report to refer to individuals that work under my supervision on this program, as well as on the two projects discussed below.

LRGV Integrated Water Resources Plan - Phase II Project

In November 1997, funding was provided to the Texas Agricultural Experiment Station (TAES) as part of the LRGV Integrated Water Resources Plan - Phase II (IWRP) Project. These funds were provided to TAES by the LRGV Development Council through the IWRP prime contractor, Perez-Freese and Nichols, Inc.

The IWRP is a regional water planning project that is examining various options for meeting the expected increases in water demand for municipal and industrial growth. My assignment on the project was to conduct the engineering analysis of the potential water savings in irrigated agriculture. The draft final report for the project is currently out for public comment, and will be completed in early 1999.

Some information included in this study were obtained by Perez-Freese and Nichols, or one of its subcontractors, as a part of the IWRP project. Most of this information derived from a questionnaire developed by the project team, including TAES. Various subcontractors were responsible to retrieving the forms from the water districts. Such material is identified in the text of this report "as obtained by the *IWRP Project Team*," or by similar language.

Bureau of Reclamation

I received a grant from the Bureau of Reclamation through the Texas Water Resources Institute, TAES, for a project entitled "Characterization of Conveyance Losses in Irrigation Distribution Networks in the

Lower Rio Grande Valley of Texas." Funding on this project is for the period June 1998 - September 1999.

BUDGET DETAILS

The following expenditures were used to support this effort during the period December 1997-December 1998. Indirect costs, cost-sharing by the Texas Agricultural Extension Service and expenditures by irrigation districts are not included.

LRGV Integrated Water Resources Plan - Phase II Project

(initial allocation: $87,176)

Expense Category ------------------------------Expenditures 12/97 - 12/98

Personnel --$74,732

(salary, wages, fringe)

Travel --$19,444

Supplies, Materials and Other Direct Costs -------------$ 5,495

TOTAL ---$99,671

Bureau of Reclamation Project

(total grant amount: $60,000)

Expense Category -----------------------------------Approx. Expenditures 12/97-12/98

Personnel --$27,373

(salaries, wages, fringe)

Supplies, Materials and Other Direct Costs --------------$ 3,500

TOTAL --$30,873

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ACKNOWLEDGMENTS

DMS TEAM

Assisting me on this analysis was the DMS (district management system) team of:

- Craig Pope, Graduate Research Assistant
- Dr. Jalal Basahi, Research Associate (former)
- Kyle Chelik, Student Technician (former).
- Shad McDainel, Student Technician (former)

INTEGRATED WATER RESOURCES PLAN PROJECT - PHASE II (IWRP)

(1) TAES - Texas Agricultural Experiment Station project team members contributing to this report and analysis:

- Dr. Jason Johnson, Assistant Professor and Extension Agronomist
- Dr. John Ellis, Research Associate
- Dr. Robert Maggio, Professor and Director, TAES Mapping Sciences Laboratory

(2) Some data collected by Perez-Freese and Nichols, Inc. and subcontractors was used in this report, as indicated in the text by *IWRP Project Team* or similar language.

IRRIGATION DISTRICT MANAGERS

Invaluable assistance and was provided by the water district managers and the LRGV Water District Managers Association, without whom this study could not have taken place.

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APPENDIX: WORK PLAN FOR AN INTENSIVE STUDY OF

WATER SAVING POTENTIAL IN IRRIGATION DISTRICTS

Complete GIS-mapping of irrigation distribution systems, including the laterals. Where necessary, digitize and geo-reference existing maps. Assemble as much information on distribution attributes as possible. Using various District Management System tools, extrapolate attributes data from known segments to other segments. Refine the Regional Soil Series map for localized variations in canal construction earthen material.

Conduct pounding studies on representative segments and collect additional soil samples and hydrological data needed to accurately determine seepage rates. Use the District Management System to calculate directly seepage losses in distribution network. Working with districts, determine the ranges of other components of conveyance lost (transportation, accounting, operational) such as monitoring spell recovery, targeted deliveries, etc. Analyze past rehab projects to document any district-wide water savings. Conduct a detailed analysis of existing metering data.

Review estimates on current technologies, field sizes, and adequacy of water deliveries for the irrigation districts. Determine the extent of water delivery problems and refine estimates of existing usage of improve irrigation methods. Adjust factors used to determine potential savings as necessary.

Document benefits of existing on-farm metering, pricing and incentive programs by reviewing district records.

OUTLINE OF MAJOR TASKS

A. Complete GIS maps of districts including:

- mains
- laterals - canals and pipelines
- drain canals
- canals no longer in use.

Obtain existing maps of districts, digitize and geo-reference or redraw using DOQQ as a base.

B. Obtain attributes of distribution systems (sizes and materials). Develop a Condition Rating Procedure to classify the condition of all segments. In cooperation with district personnel, conduct field reconnaissance to obtain attribute data and rate the condition of segments.

C. Refine exiting general soil map and expand to include remainder of region. Conduct field reconnaissance to verify canal construction material in relation to surrounding soils.

D. Conduct seepage loss measurements in representative canal and pipeline segments though ponding tests. Contract earth moving equipment/crews for sealing off canal sections for tests. Extrapolate results from tested segments to similar segments

E. Quantify losses in distribution system through valves, gates and spills though direct monitoring and metering.

F. Conduct an analysis of losses through distribution system management.

G. Select and work with representative districts to complete mapping of water accounts and tie-in with district databases. Use district records to determine water balance as a check on reported water duty. Analyze potential water saving through conversions to alternate technologies based on actual field sizes and practices. Extrapolate results to other districts.

ADDITIONAL PERSONNEL REQUIREMENTS

(1) Field Teams: (2 teams, 2 person each + 1 GIS specialist) to collect and help process district data and maps - headquartered in Region M.

(2) 2 GIS Specialists: develop maps and databases, and conduct analysis - headquartered at Texas A&M.

1. Cameron, Hidalgo, Maverick, Starr, Val Verde, Webb, Willacy

2. Irrigation water use adjustment reflects estimated levels of ground water availability.

Source: Water for Texas, Texas Water Development Board, August 1997

3. The DMS (district management system) Team refers to individuals that work under my direct supervision.

4. IWRP Project Team refers to Perez-Freese and Nichols, or their subcontractors, on work performed as part of the LRGV Integrated Water Resources Plan - Phase II Project.

5. This discussion was required for the IWRP and is based on only a cursory examination of the major distribution networks. It is mean to present the more obvious issues involved in the consolation of districts.

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