Potential Water Savings in Irrigated Agriculture for the Rio Grande Planning Region (Region M)

2005 Update

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by

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SUMMARY

This report updates the information provided to the Region M Planning Group in December 2000 and details the potential water savings in irrigated agriculture which are shown below. County estimates are also included in this report.

WATER SAVING POTENTIAL IN IRRIGATION DISTRICTS AND ON-FARM IN ACRE-FEET PER YEAR

Water Supply Condition	District Conveyance Efficiency Improvement	On-farm Practices and Methods	
		With district improvements	Without district improvements
drought	154,393	172,612	96,296
normal	243,092	274,033	125,194

Conveyance Efficiency Improvements are water savings from the reduction of transportation, operation and accounting water losses in irrigation districts, and the increase of conveyance efficiencies from current average of 69.7 to 90%.

On-farm Practices and Methods are water savings from the expansion of water measurement/metering, replacement of field ditches with poly pipe, and adoption of improved water management practices and irrigation technologies

Other findings and conclusions are as follows.

Description of Districts

- The main distribution networks of irrigation districts consist of 795 miles of canals, 192 miles of pipeline, and 76 miles of resacas.
- The secondary and tertiary networks (“laterals”) consist of about 673 miles of canals and 1755 miles of pipelines.
- There are a total of 699 miles of lined canals (lined with concrete of similar materials), 712 miles of unlined canals, and about 57 miles of canals which we do not know their lining status.
- The 9 largest districts (out of 28) hold 74% of all agricultural water rights.

Conveyance Efficiency

- Canals are in poor condition with an average condition rating of 6.4 (on a 10 point scale).

- Measured seepage loss rates in 10 lined canals (concrete or related lining type) ranged from 0.6 to 8.8 gal/ft^2/day. The smaller canals had the highest seepage loss rates. The annual projected water loss from these canal segments ranges from 61 to 494 ac-ft/mi/yr.

- High seepage losses in lined canals indicate that improper construction methods and materials are being used in the region, and that some districts have inadequate maintenance programs.

- When classified by soil type, seepage loss rates measured in 9 unlined canals were similar to those reported in the scientific literature, and ranged from 0.15 to 13.85 gal/ft^2/day. The annual projected water loss from these canal segments ranges from 23 to 1690 ac-ft/mi/yr.

- Total loss rate tests results in lined canals ranged from 0.6 to 164 gal/ft^2/day or annual projected losses of 45 to 1520 ac-ft/mi/yr. These total losses include seepage and leaks through gates and valves.

- Total loss rate tests results in unlined canals ranged from 0.6 to 8.5 gal/ft^2/day or annual projected losses of 45 to 1213 ac-ft/mi/yr.

- Total loss test results indicate that leaks though valves and gates is a significant loss of water.

- There are at least 219 miles of concrete pipelines with mortar joints. Inflexible pipeline joints are likely to have high leakage rates. We have no information on the type of joints in 1327 miles of concrete pipelines.

- Four spill loss and recovery sites previously monitored had spill rates ranging from 28 to 4684 ac-ft/yr. There are at least 64 major spill sites in the region.

On-farm

- At 50% of the area experiences frequent head problems, causing insufficient water volume at the field turn-out to allow for efficient furrow irrigation.

- Currently, 54% of the water delivered in the region is under consistent water measurement or metering programs by districts.

- On-farm, about 36% of the water applied in the region is through “poly” (or gated) pipe, and 30% is applied with high water management and/or improved irrigation technology.

General

- Questions have been raised on the accuracy of the information districts use to estimate conveyance efficiency (or “water duty”) including metering at the river pumping plants.

- Uniform database formats and software are needed among districts to help promote district accounting system modernization and integration with GIS, as well as supporting water measurement and district rehabilitation programs.

- To achieve the projected water savings, a comprehensive and integrated program is needed that addresses all aspects of water supply and use in districts. The Imperial Irrigation District’s program with the Municipal Water District is one model to use in designing a program for the Rio Grande Planning Region.

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ABOUT THIS REPORT

This report was completed for the Region M Water Planning group by the Irrigation Technology Center (ITC), Texas A&M University under the direction of Dr. Guy Fipps. Funding was provided through Texas Cooperative Extension under a contract with NRS Engineering, Inc.; dates of the contract are March 28, 2005 – May 31, 2005.

This report updates the information presented in the December 22, 2000 report: ***Potential Water Savings in Irrigated Agriculture for the Rio Grande Planning Region (Region M)*** (referenced here as REPORT 1). Complete text of REPORT 1 was included in the appendix of the Region M 2001 water planning report under *Technical Memorandums*; it is also posted at http://idea.tamu.edu under the "reports" section of the website.

No new information was collected for this report. Instead, we updated the data, conclusions and water savings estimates based on data that the ITC has collected over the last 5 years as a part of our Irrigation District Engineering and Assistance program. For more information, see our website: http://idea.tamu.edu. Only those tables in REPORT 1 that are relevant to the current water saving potential analysis have been updated and/or included in this report. The original table numbers from REPORT 1 are also included on each table.

LITERATURE REVIEW

Very little information has been reported in the scientific literature on canal seepage and reduction from district rehabilitation projects. What data is available was discussed in REPORT 1 and is summarized in Table 1.

For REPORT 1, we also investigated Imperial Irrigation District's (IID) program with the Municipal Water District (MWD). IID received $109 million to save 100,000 ac-ft/yr of water which was then leased to the MWD for a period of about 40 years. IID's program is summarized in Table 2. Key points relevant to Region M are:

- This is an integrated program that includes elements aimed at improving both the conveyance efficiency and on-farm irrigation.

- The program includes elements that are resulting in large water savings, as well as those needed to improve the overall operation of the district.

- About 16% of the total budget was spent on program verification which saves no water. However, program verification is important in order to develop confidence in achieved water savings among all parties, including the growers of the district. This program also produced the data needed in various lawsuits questioning the success of the program.

DESCRIPTION OF THE DISTRICTS

Water Rights

The names and authorized water rights of 28 water districts in Hidalgo, Cameron, Willacy and Maverick Counties are listed in Table 7. This information was obtained from the Rio Grande Watermaster office. Figure 1 shows the irrigation district boundaries in the LRGV, and Figure 4 shows Maverick ID.

These districts hold authorized agricultural water rights totaling 1,562,932 ac-ft, a decline of 40,282 ac-ft since 2000. Based on water rights, the districts vary greatly in size, with the smallest active district having 3,773 ac-ft and the largest district 174,776 ac-ft.

- The 5 largest districts (Mercedes, Delta Lake, San Benito, Maverick and San Juan) account for 49% of all agricultural water rights.
- The largest 9 districts (adding Harlingen, Donna, Edinburg, and Santa Cruz) account for 72% of the total.

Water Distribution Networks

The main irrigation distribution networks of the LRGV districts are shown in Figure 2. Figure 4 shows both the mains and laterals for Maverick ID. Figure 3 shows both the mains and laterals for the LRGV districts.

Distribution Networks of Districts (miles)

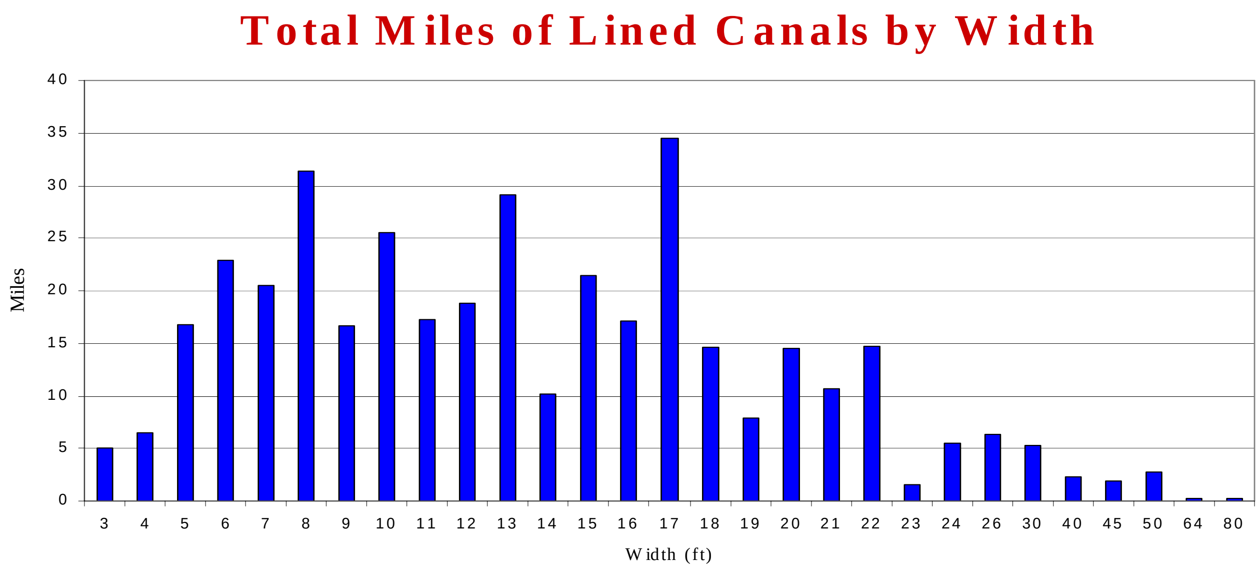
	Canals				Pipeline	Resaca
	Lined	Unlined	Unknown	Total		
Mains	329	466	0	**795**	192	76
Laterals	370	246	57	**673**	1755	
Totals	**699**	**712**	**57**	**1467**	**1947**	**76**

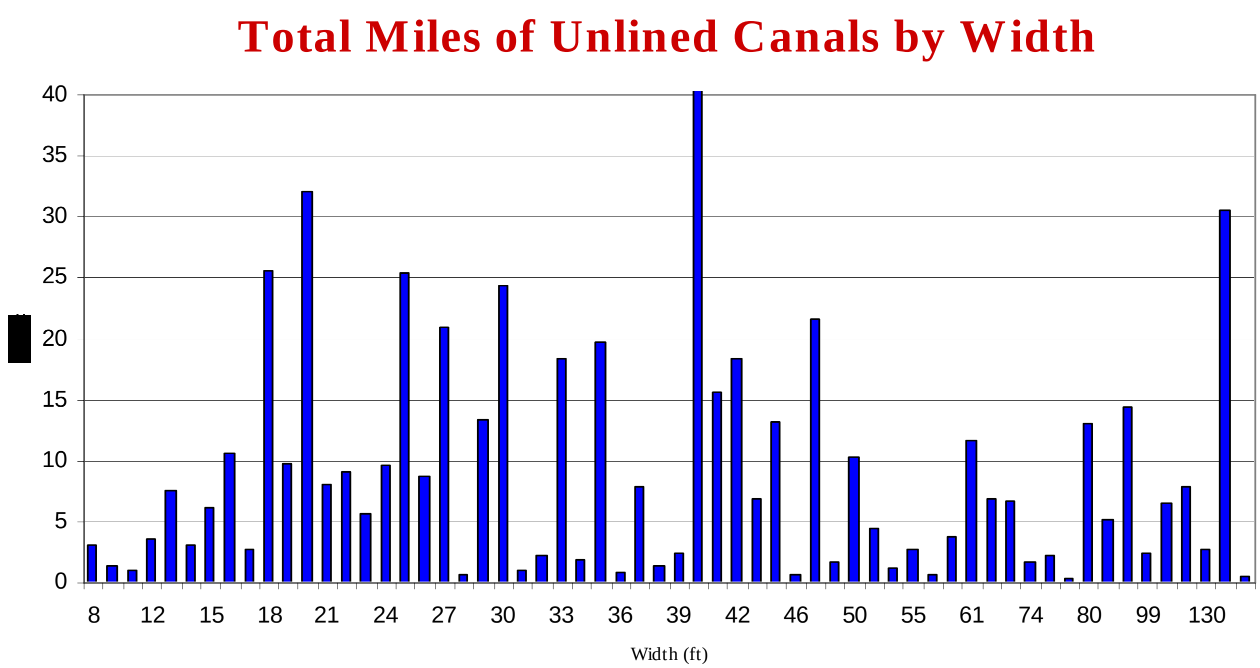
The total extent of the distribution networks is shown on the left. We have obtained information on the lining status of all but 57 miles of canals (Table 4).

"Laterals" refers to the secondary and tertiary networks of districts, which carry water from the mains to the field turnouts.

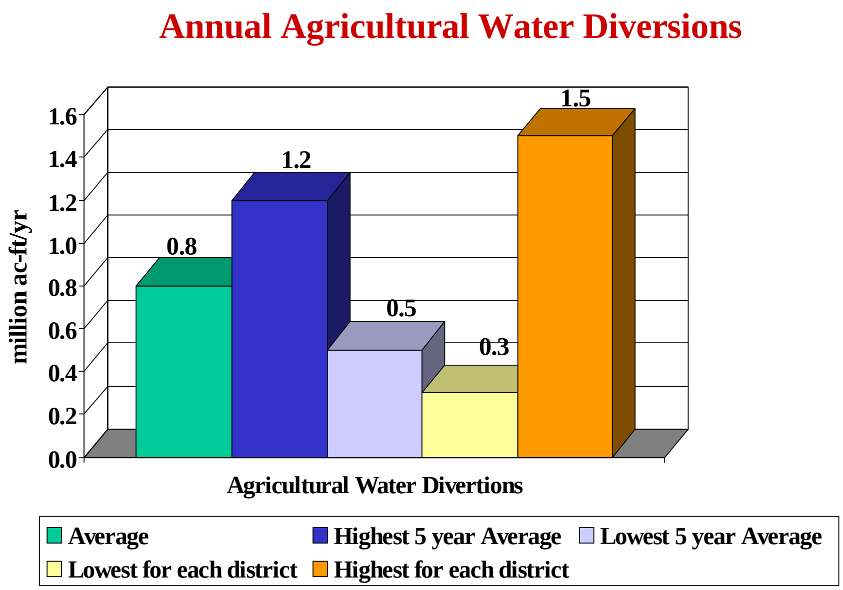
"Resaca" refers to ox bow lakes common in the LRGV. These are used by districts as water storage and transportation channels.

The lengths of lined and unlined canals by top width are shown in the two charts below. See Table 6 for information on the storage reservoirs and capacity. Additional details on the water distribution networks are provided in Tables 3 and 4. County breakdowns of canal lengths by known widths and lining status are given in Table 5.



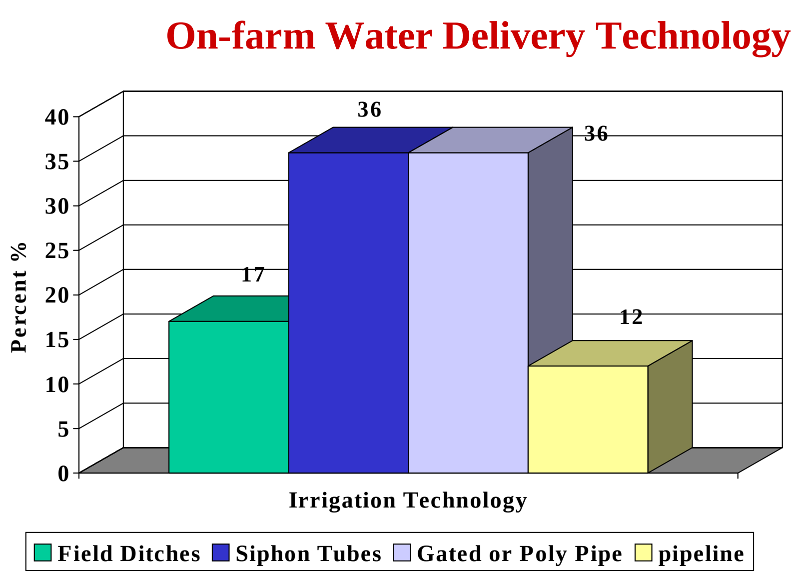


Diversions



As shown above, agricultural water diversions vary greatly from year to year depending on water supply, weather, and crop economics. Diversions for the period 1986-2004 as obtained from the Rio Grande Watermaster Office are given in Tables 8 and 9.

ON-FARM WATER DELIVERY TECHNOLOGY



This chart shows the current use of on-farm water supply methods.

Poly pipe generally has the least water loss and can promote good surface irrigation efficiency.

Cutting of field ditches and siphon tubes generally provide insufficient control over water flow for good surface irrigation efficiency.

WATER MEASUREMENT PROGRAMS

We estimate that about 57% of on-farm water deliveries are directly measured or metered by districts. The most effective programs are those that provide incentives through water pricing or credit programs, and in which district personnel provide technical assistance to growers on improved irrigation water management. For example, Brownsville uses a combination of incentives, tailwater fines and technical assistance. The district moved valves to the center of fields at no cost to the grower to facilitate the use of poly pipe and surge flow valves. Similarly, Bayview provided poly pipe to growers at low cost when first implementing a water metering program.

District Databases

However, water measurement programs require additional manpower for collecting and recording the data. Districts without modern databases and water accounting systems have had difficulty in managing the large amounts of information being collected.

Most districts have custom (i.e., non-commercial) databases which district personnel do not know how to modify. Thus, the database programmer must be contracted to make changes which are needed for water accounting and for integration with GIS-based management systems. Uniform database formats and software among districts would help promote district accounting system modernization.

CONVEYANCE EFFICIENCY

We estimate the current average conveyance efficiency of districts as 69.7. 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 (6 inches for most districts that do not meter or measure).

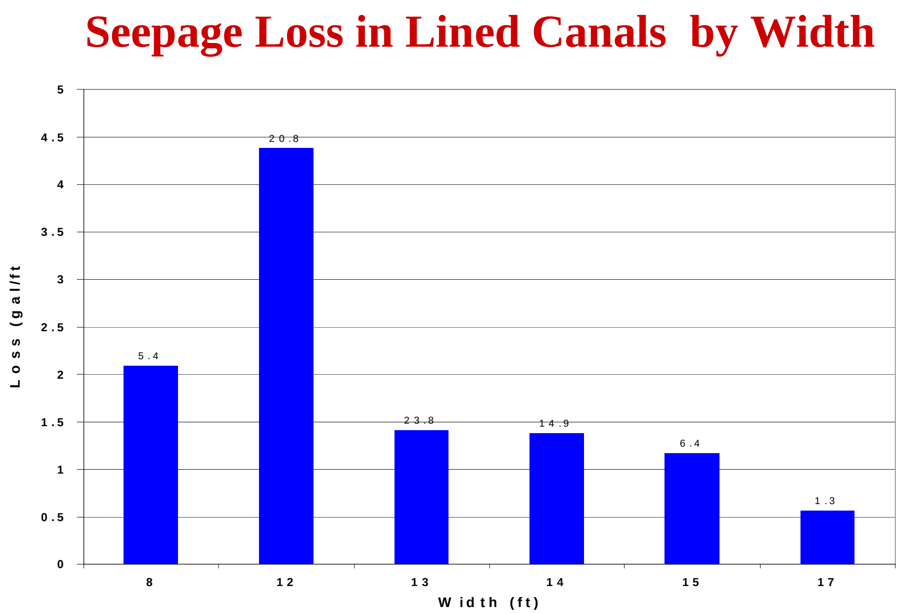
Districts express conveyance efficiency in terms of efficiency, the percent of water lost, or amount of water pumped (in feet). For example, District A must pump 8 inches from the river in order to deliver 6 inches to the field. District A's losses can be expressed as a:

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

Conveyance loss includes other factors in addition to seepage and evaporation. Table 10 shows the various components of conveyance efficiency under the three major categories of Transportation, Accounting, and Operational losses. County estimates of district conveyance efficiencies are given in Table 15.

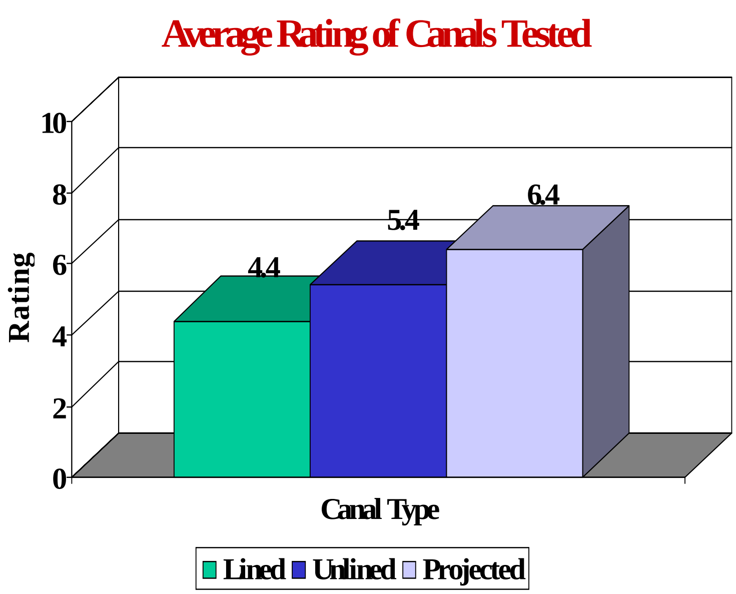
Lined Canals

The term "lined canals" refers to canals lined with concrete of similar material. Since 1997, we have conducted seepage and total loss tests in 34 lined canals using the ponding test method. The results are shown below and in Table 11. Note that total loss tests include canal seepage and evaporation, as well as water that may have leaked undetected through gates and valves.



The chart on the left shows the measured seepage loss rates in concrete canals for representative widths.

The highest loss rates occurred in canals less than 12 feet in width.



We rates most of the canals tested on a scale from 1 (poor) to 10 (excellent).

The results are shown on the left. Overall, lined and unlined canals which were tested are in poor condition with an average condition rating of 4.4 and 5.4, respectively.

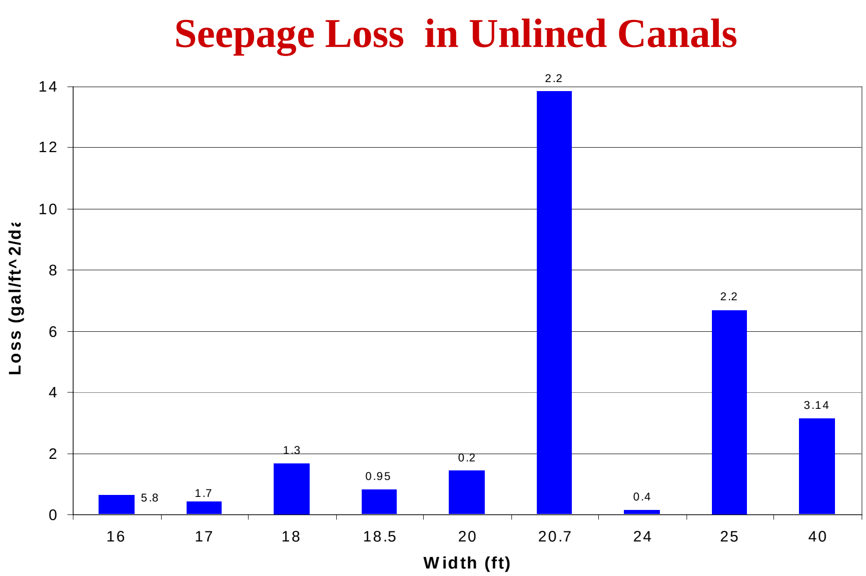
We estimate that the average rating of all lined canals in Region M is 6.4.

The poor condition of the lined canals indicate problems with materials and construction methods. Most canals are lined with unreinforced concrete, which are susceptible to cracking due to shrinking and swelling soils. For larger canals, consideration should be given to composite construction with reinforced concrete and membranes.

Lining and pipeline replacement of canals to reduce seepage is not the only consideration. Leaking gates and valves can also be a major source of water loss and should be considered as part of any rehabilitation program.

Unlined Canals

We have conducted 9 seepage loss tests in 9 and 11 total loss tests in unlined canals (Table 11b). These loss rates were similar to those reported in the scientific literature based on soil type (Table 1).



For the LRGV (not including Maverick Irrigation District), the extent of unlined canals that are located in loamy to sandy soils is given below, along with the total canal surface area for lining. This information was not completed for Maverick ID since a GIS-based soil series map for the county was not available.

Unlined Canals in Sandy and Loamy Soils*

Width (ft)	Extent (miles)	Area (million ft^2)
0-39	48	9.4
40-69	39	13.5
>70	31	17.9

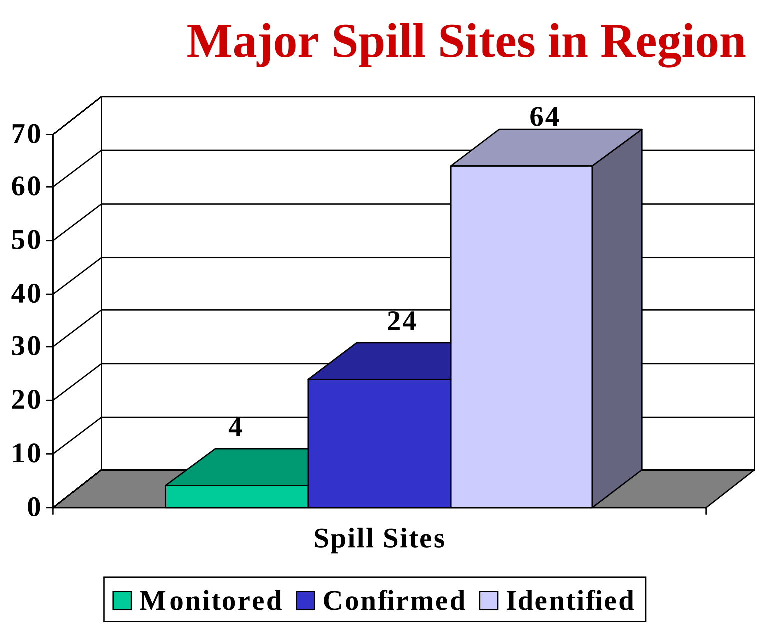
* includes all mains and 64 % of laterals for LRGV.

In a rehabilitation program, unlined canals in lighter, more permeable soils should be investigated for possible lining or replacement with pipelines, particularly canals that are less than 40 feet in width.

Spills

Four (4) spill loss and recovery sites were documented previously. Two of the sites allowed excess canal water to flow into pipes. The third was a drop inlet in a reservoir to control water levels, and the fourth is a pump-back system to return water from a reservoir to a canal.

The spill loss rates for the first 3 sites ranged from 28 to 1118 ac-ft/yr for the period 1999-2000 (Table 12). The one spill recovery site monitored saved 4684 ac-ft/yr that otherwise would have been lost without this facility. We conclude that spills are a major source of water losses in the region. We have independently verified 24 major spill sites in the region out of a total of 64 identified in surveys.



Spill loss reduction involves rehabilitation of distribution networks such as increasing the capacity of segments and the construction of storage, interception and recycling facilities.

It also involves better management of the system through automatic gate control and training of canal riders and other district personnel on distribution system management.

POTENTIAL WATER SAVINGS

Table 14 summarize the procedures and assumptions used in calculating the on-farm potential water savings shown below. Individual county estimates of water saving potential are provided in Tables 16 and 17. For these estimates, drought conditions are based on the year 2010 water supply scenario of 0.8 million ac-ft developed by R.J. Brandes for this project. Normal conditions are based on the average diversions for the highest 5 years during the period 1986 - 2004 (Table 9).

WATER SAVING POTENTIAL IN IRRIGATION DISTRICTS AND ON-FARM (acre-feet per year)

Water Supply Condition	District Conveyance Efficiency Improvement	On-farm Practices and Methods	
		With district improvements	Without district improvements
drought	159,631	174, 537	105,029
normal	210,944	226,178	142,852

The water savings listed under *District Conveyance Efficiency Improvement* (above) are based on increasing current efficiencies to 90%. Individual county estimates of current efficiencies and water saving potential are provided in Table 16 for Cameron, Willacy, Hidalgo and Maverick, the four counties containing irrigation districts.

The water savings listed under *On-farm Practices and Methods* (above) would result from the expansion over current levels of practices and technology related to:

- implementation of water measurement or metering programs
- replacement of field ditches and siphon tubes with poly pipe or gated pipe
- adoption of improved water management practices and technologies

Achievable on-farm water savings are listed for each county in Tables 16 and 17. No significant on-farm water savings are expected in Web, Zapata and Jim Hogg Counties.

Water savings are given for two cases: with and without improvements in district conveyance efficiency. Conveyance efficiency determines how much water reaches the field turnout. Its improvement will also help eliminate the “head” problems experienced in the region and enable the use of improved water management practices and technologies.

Uncertainties in Estimate

There is uncertainty about the accuracy of the basic information that districts use to estimate conveyance efficiency, particularly:

- the amount of water pumped or diverted into the system, and
- 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 pumping rate, pumping plant capacity, or engine/motor and pump performance. Due to the physical layout of the pumping plants, it is difficult to independently verify these rates. Historically, little water measurement was done at the field turn-out, and the amount delivered is also an estimate in many districts. Some districts have antiquated database and accounting systems, making it difficult to extract water use records for analysis.

ABBREVIATIONS

ID	Irrigation District
ITC	Irrigation Technology Center (for more information, see http://itc.tamu.edu)
GIS	Geographical Information System
LRGV	Lower Rio Grande Valley of Texas, includes the counties of Cameron, Hidalgo, Willacy and Starr
Phase II	Integrated Water Resources Planning - Phase II Project, involving Cameron, Hidalgo, and Willacy Counties.
Region M	Rio Grande Planning Region, defined by the Texas Water Development Board as: Cameron, Hidalgo, Willacy, Starr, Maverick, Web, Zapata, and Jim Hogg Counties
REPORT 1	The report: *Potential Water Savings in Irrigated Agriculture for the Rio Grande Planning Region (Region M),* December 22, 2000 by Guy Fipps (see http://idea.tamu.edu for a downloadable copy)

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