Irrigation District Engineering and Assistance

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Task 1 and 3 Extension Engineering
Task 1: Irrigation District Studies

- Provide technical assistance, applied research and educational programs to improve water management and promote water conservation and modernization.

Task 3: Institutional Incentives

- Evaluate irrigation district infrastructure needs and develop strategies to efficiently deliver water for agricultural use, and to facilitate the adoption of efficient irrigation technologies.
Highlights 2008 - 2009

- Map Series
  - Texas Legislation
  - Expansion of Urban Area
- Canal Lining Evaluation Conclusions
- Ponding Test Manual
- Automation/Telemetry Demonstrations
Map Series of the Rio Grande River Basin

- Texas Legislative Districts
- Expansion of Urban Area
Texas Legislative Districts

- Texas House (2003 – 2012)
- Texas Senate (2003 – 2012)
110th U.S. Congressional Districts (2007-2009) and Irrigation Districts of the Lower Rio Grande Basin

Irrigation Technology Center
http://ftc.tamu.edu
July 2008
Texas Senate Districts (2003-2012) and Irrigation Districts of the Upper Rio Grande Basin

Irrigation Technology Center
http://itc.tamu.edu
July 2008
### Table 3. Legislative Districts Listed by Irrigation Districts

<table>
<thead>
<tr>
<th>District</th>
<th>TX House</th>
<th>TX Senate</th>
<th>U.S. House</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Rio Grande Basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adams Garden Irrigation District No.19</td>
<td>38, 43</td>
<td>27</td>
<td>15, 27</td>
</tr>
<tr>
<td>Bayview Irrigation District No.11</td>
<td>37</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Brownsville Irrigation District</td>
<td>37, 38</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Cameron County Water Improvement District No.16</td>
<td>38</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Cameron County Irrigation District No.2</td>
<td>38, 43</td>
<td>27</td>
<td>15, 27</td>
</tr>
<tr>
<td>Cameron County Irrigation District No.6</td>
<td>37, 38, 43</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Cameron County Water Improvement District No.10</td>
<td>37</td>
<td>27</td>
<td>27</td>
</tr>
</tbody>
</table>

### Table 4. Legislative Districts Listed by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Legislative District</th>
</tr>
</thead>
<tbody>
<tr>
<td>US House of Representatives</td>
<td></td>
</tr>
<tr>
<td>Lower Rio Grande Basin</td>
<td>15, 27, 28</td>
</tr>
<tr>
<td>Middle Rio Grande Basin</td>
<td>23</td>
</tr>
<tr>
<td>Upper Rio Grande Basin</td>
<td>16, 23</td>
</tr>
<tr>
<td>Texas House of Representatives</td>
<td></td>
</tr>
<tr>
<td>Lower Rio Grande Basin</td>
<td>36, 37, 38, 39, 40, 41, 43</td>
</tr>
<tr>
<td>Middle Rio Grande Basin</td>
<td>74, 80</td>
</tr>
<tr>
<td>Upper Rio Grande Basin</td>
<td>74, 75, 76, 77, 78, 79</td>
</tr>
<tr>
<td>Texas Senate</td>
<td></td>
</tr>
<tr>
<td>Lower Rio Grande Basin</td>
<td>20, 27</td>
</tr>
<tr>
<td>Middle Rio Grande Basin</td>
<td>19</td>
</tr>
<tr>
<td>Upper Rio Grande Basin</td>
<td>19, 29</td>
</tr>
</tbody>
</table>
Expansion of Urban Area

  - El Paso
  - Maverick
  - Cameron
  - Hidalgo
  - Willacy
Expansion of Urban Area

Urban area defined as...

- continuous developed and/or developing area that is no longer in agricultural use
- included all residential communities and subdivisions (with or without homes)
- properties with more than one dwelling
- single dwellings on large properties outside the city
Irrigation District refers to all:

- irrigation,
- water control,
- water improvement,
- conservation,
- reclamation, and municipal utility districts that deliver agricultural irrigation water and hold Class A Agricultural Water Rights or a similar allocation.
## Expansion of Urban Area

### Texas Counties

<table>
<thead>
<tr>
<th>Counties</th>
<th>Total Acreage</th>
<th>Urban Area 1996</th>
<th>Urban Area 2006</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acreage</td>
<td>Acreage</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Cameron</td>
<td>613,036</td>
<td>66,189</td>
<td>81,635</td>
<td>23</td>
</tr>
<tr>
<td>El Paso</td>
<td>656,492</td>
<td>208,180</td>
<td>234,155</td>
<td>12</td>
</tr>
<tr>
<td>Hidalgo</td>
<td>1,012,982</td>
<td>118,466</td>
<td>160,095</td>
<td>35</td>
</tr>
<tr>
<td>Maverick</td>
<td>826,915</td>
<td>9,816</td>
<td>12,019</td>
<td>22</td>
</tr>
<tr>
<td>Willacy</td>
<td>393,819</td>
<td>3,084</td>
<td>3,509</td>
<td>14</td>
</tr>
</tbody>
</table>
## Expansion of Urban Area

### Districts’ Service Areas

<table>
<thead>
<tr>
<th>District</th>
<th>Approx. District Area</th>
<th>Percentage of District Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acreage</td>
<td>Urban Area 1996</td>
</tr>
<tr>
<td>Adams Garden</td>
<td>9,600</td>
<td>5.5 %</td>
</tr>
<tr>
<td>Bayview</td>
<td>10,700</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Brownsville</td>
<td>22,000</td>
<td>40.0 %</td>
</tr>
<tr>
<td>CCWID16</td>
<td>2,200</td>
<td>12.0 %</td>
</tr>
<tr>
<td>CCID2</td>
<td>79,000</td>
<td>10.6 %</td>
</tr>
<tr>
<td>CCID6</td>
<td>33,000</td>
<td>13.3 %</td>
</tr>
<tr>
<td>CCWID10</td>
<td>4,700</td>
<td>3.0 %</td>
</tr>
<tr>
<td>Delta Lake</td>
<td>85,600</td>
<td>1.3 %</td>
</tr>
<tr>
<td>Donna</td>
<td>47,000</td>
<td>9.3 %</td>
</tr>
<tr>
<td>El Paso</td>
<td>92,800</td>
<td>35.5 %</td>
</tr>
<tr>
<td>Engelman</td>
<td>11,200</td>
<td>1.3 %</td>
</tr>
<tr>
<td>Harlingen</td>
<td>56,500</td>
<td>26.0 %</td>
</tr>
</tbody>
</table>
## Expansion of Urban Area

### Urban Area Increase

**Table 5. Urban Acreage within Irrigation Districts in 1996 and 2006.**

<table>
<thead>
<tr>
<th>District</th>
<th>Urban Area 1996</th>
<th>Urban Expansion through 2006</th>
<th>Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams Garden</td>
<td>532</td>
<td>1,380</td>
<td>160 %</td>
</tr>
<tr>
<td>Bayview</td>
<td>24</td>
<td>120</td>
<td>392 %</td>
</tr>
<tr>
<td>Brownsville</td>
<td>8,724</td>
<td>9,915</td>
<td>14 %</td>
</tr>
<tr>
<td>CCWID16</td>
<td>260</td>
<td>415</td>
<td>60 %</td>
</tr>
<tr>
<td>CCID2</td>
<td>8,384</td>
<td>10,925</td>
<td>30 %</td>
</tr>
<tr>
<td>CCID6</td>
<td>4,439</td>
<td>7,948</td>
<td>79 %</td>
</tr>
<tr>
<td>CCWID10</td>
<td>135</td>
<td>224</td>
<td>66 %</td>
</tr>
<tr>
<td>Delta Lake</td>
<td>1,127</td>
<td>1,841</td>
<td>63 %</td>
</tr>
<tr>
<td>Donna</td>
<td>4,357</td>
<td>7,310</td>
<td>68 %</td>
</tr>
<tr>
<td>El Paso</td>
<td>32,967</td>
<td>35,443</td>
<td>8 %</td>
</tr>
<tr>
<td>Engelman</td>
<td>144</td>
<td>331</td>
<td>130 %</td>
</tr>
<tr>
<td>Harlingen</td>
<td>14,662</td>
<td>16,955</td>
<td>16 %</td>
</tr>
<tr>
<td>HCCID9</td>
<td>16,721</td>
<td>22,716</td>
<td>36 %</td>
</tr>
<tr>
<td>HCID1</td>
<td>22,633</td>
<td>25,327</td>
<td>12 %</td>
</tr>
<tr>
<td>HCID12</td>
<td>417</td>
<td>469</td>
<td>322 %</td>
</tr>
</tbody>
</table>
Analysis

- Used our estimate of the size of the service areas of the water districts.
- Urban area estimates have about a 10% margin of error.
- No legal descriptions of properties or survey data were used in the development of this map series.
Expansion of Urban Area
Hidalgo County 1996-2006

Irrigation Technology Center
http://itc.tamu.edu
March 2009
Expansion of Urban Area

Individual District Maps

- Sent to Districts along with map series report
- Posted Online at:

http://idea.tamu.edu/gis.php
Expansion of Urban Area

Summary

- HCMUD1 - most urbanized 89.5%
- Valley Acres & Bayview – least urbanized
- HCID2 - largest number of urban acres
- HCID16 & HCID19 – largest increase in urban acres
Canal Lining Evaluation

Yearly evaluations and ratings to determine durability and long-term viability of new canal linings.
Purpose of Lining Evaluations

- Ensure continued water savings
- Help districts select durable canal lining material
- Develop guidelines for maintaining performance
  - vandalism
  - material installation
  - maintenance/repair
Activities

- Identified 28 lining segments, totaling 20 miles in 7 irrigation districts with 6 different lining materials

- Inspected each project segment at least once a year for 3 years

- Where possible, performed pre- and post-seepage loss tests to document actual water savings from lining existing canals
Canal Lining Projects by Lining Material Type

Irrigation Technology Center
http://itc.tamu.edu
January 2009

Legend
Material Type
- Polyester with Shotcrete
- PVC with Shotcrete
- EPDM Rubber
- PVC Alloy
- Polypropylene
- Polyurethane

# Project Number
- Zoomed in Area
    (see next page)
Example of Water Savings

- Performed pre- and post- re-lining seepage loss tests on Lateral A canal of Hidalgo County Irrigation District No.2
- 7 mile long section of concrete canal in poor condition was re-lined with Polyester/shotcrete
- Water losses were reduced after lining by 94%

**before**
- 1.98 gal/ft²/day
- 11.20 ac-ft/mi/yr

**after**
- 1.17 gal/ft²/day
- 227.14 ac-ft/mi/yr
# Lining Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester with protective barrier</td>
<td>A geocomposite consisting of two layers (top and bottom) of 8 oz/yd(^2) nonwoven polyester bonded to an olefinic copolymer geomembrane, 20 mil thick. The protective barrier consists of 2-3 inches of shotcrete.</td>
</tr>
<tr>
<td>PVC with protective barrier</td>
<td>Non-reinforced Poly Vinyl Chloride (PVC). The protective barrier consists of a wire mesh with 2.5 inches of shotcrete.</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>A reinforced polyester scrim 16 oz/yd(^2) between polypropylene layers, 24 mil thick.</td>
</tr>
<tr>
<td>PVC Alloy</td>
<td>A polyvinylchloride blend, reinforced with a polyester scrim, 40 mil thick.</td>
</tr>
<tr>
<td>EPDM Rubber</td>
<td>A non-reinforced EPDM (ethylene propylene diene monomer), 45 mil thick.</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>Two layers of 3-oz/yd(^2), heat-bonded, non-woven geotextile saturated with liquid polyurethane, 40 mil thick.</td>
</tr>
</tbody>
</table>
# Performance Ratings

<table>
<thead>
<tr>
<th>Rating</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>0%: no damage and no maintenance required</td>
</tr>
<tr>
<td>Good</td>
<td>0 – 5%: mild damage to top anchor and canal interior 1 to 2 significant repairs needed per year</td>
</tr>
<tr>
<td>Fair</td>
<td>5 – 20%: mild damage to top anchor and canal interior 3 to 5 significant repairs needed per year</td>
</tr>
<tr>
<td>Poor</td>
<td>20 – 50%: mild damage to top anchor and canal interior 6 to 10 significant repairs needed per year</td>
</tr>
<tr>
<td>Serious Problems</td>
<td>50 – 100%: mild damage to top anchor and canal interior 10+ significant repairs needed per year</td>
</tr>
</tbody>
</table>

*Note: Percentages are based on the linear length of the lining project.*
Results

Excellent performance is with a geo-membrane overlaid with a protective barrier (shotcrete, concrete, etc.)

- Polyester with shotcrete
- PVC with shotcrete
Results (no cover)

Polypropylene

- Good performance (Rating of Excellent to Good)
- Some installation problems observed
Results (no cover)

PVC alloy:
- Excellent to Good performance
- Not very susceptible to vandalize, difficult to cut
Results (no cover)

EPDM rubber

- Poor performance (Rating of Excellent to Serious Problems)
- Problems observed: vandalism, mowing damage, rotting, inadvertent damage, vegetation under the material
Results (no cover)

Polyurethane

- Worst performance (Rating of Excellent to Serious Problems)
- Problems observed: vandalism, mowing damage, rotting, inadvertent damage, installation problems)
# Results

<table>
<thead>
<tr>
<th>Material</th>
<th>No. of Projects</th>
<th>Total Miles</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>with a protective barrier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyester with shotcrete</td>
<td>4</td>
<td>14.47</td>
<td>Excellent</td>
</tr>
<tr>
<td>PVC with shotcrete</td>
<td>1</td>
<td>2.61</td>
<td>Excellent</td>
</tr>
<tr>
<td>without a protective barrier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polypropylene</td>
<td>2</td>
<td>0.36</td>
<td>Excellent to Good</td>
</tr>
<tr>
<td>PVC Alloy</td>
<td>3</td>
<td>0.05</td>
<td>Excellent to Good</td>
</tr>
<tr>
<td>EPDM Rubber</td>
<td>8</td>
<td>2.04</td>
<td>Excellent to Serious Problems</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>9</td>
<td>1.42</td>
<td>Excellent to Serious Problems</td>
</tr>
</tbody>
</table>
Conclusions

- Regular maintenance is required for all non-covered materials.
- Inspections should be carried out at least once a year during the non-irrigation season (December-January).
- The materials without a shotcrete layer are exposed to vandalism and other damage, and may be inadvertently damaged by animals/people.
- Poor installation of any of the materials makes the product more susceptible to vandalism by leaving folds and loose areas that are easy to cut.
Conclusions

• Most damage has occurred on the exposed areas of the liner and top side walls of the canal from cuts made with a sharp object (probably intentional vandalism) unintentional vandalism.

• In areas where kids are playing, swimming in the canals, or being mischievous, intentional and unintentional vandalism will occur.

• Vultures have been reported to pick at the seams on the EPDM Rubber; animal hoofs can cut some liners.
Consideration when Planning New Lining Projects

Lining Installation

- the methods used to overlap and mend/seam the layers of lining material together

- the methods used for attaching the material to the canal walls, around structures, and to the top of the levee (top anchor)

- the total width of the liner and extension on top of the levee in relation to the normal and maximum operating depth of the canals
Use of a Protective Barrier

- Increases cost, but these costs may be offset by the reduction in costs of maintenance and repairs over the life of the project.

- An important consideration is the ability shotcrete to adhere to the liner.
  - The polyester material has small fibers (similar to the harden side of Velcro) to which the shotcrete will stick when sprayed on to the liner (Fig.20)
  - The PVC liner has a smooth texture to which the shotcrete will not stick, and a wire mesh needs to be used on the top of the liner to provide grip and added reinforcement.
Maintenance

- A regular inspection and maintenance program is important so that repairs can be completed on a time basis.

- Districts should consider having their personnel trained to perform the repair and maintenance which sometimes requires specialized equipment, and similar glues and adhesives used during the installation process.

- Removing sediment from lined canals may be more difficult due to the limitations of using heavy machinery, and may require increased manual labor (Figure 23).
Ponding Test Manual

- The ponding test method is considered to be the most accurate way to measure seepage losses from irrigation canals.

- Texas AgriLife Extension Bookstore
  http://agrilifebookstore.org/
Ponding Test Manual

- Provides complete details for using this method. Including sections:
  - on preparing for the test
  - constructing the dam
  - selecting and installing equipment
  - measuring canal shapes
  - calculating seepage losses from data collected
Automation, Telemetry, and Flow Measurement
Objectives of Demonstrations

- Create in-house capacity in canal operation and control concepts, and automation applications
- Demonstrate cost-effective and alternative technologies for SCADA
- Assist districts in designing/implementing projects which have a water conservation/management purpose
- Evaluate and advise districts on equipment/software options and other technical issues
Automation/Telemetry Demonstrations

- United Irrigation District
- HCID6 (Mission #6)
- CCID6 (Los Fresnos)
SCADA Systems

Components

- Master Station
- RTU
Terminology

**SCADA** - Supervisory Control and Data Acquisition System

A term that includes remote control and automation systems (such as controlling gates in a canal system)

Usually including remote monitoring and collection of data (such as water levels) upon which decisions are made
Terminology

**RTU (Remote Terminal Unit)**
Deployed in the field and typically includes PLC, radio, power supply, and other electronic devices.

**PLC (Programmable Logical Controller)**
Monitors the automation site, and based on sensor data and operational rules, decides if adjustments are required, and makes adjustments as needed.
Typical RTU
Cameron County Irrigation District No.6 – Main Weir

- Telemetry system to allow monitoring of flow into main canal at the District office (~20 miles away)
Results

- Real-time flow data access in the district office
- Uses simple, inexpensive equipment/software and telephone communications.
- Web-based flow monitoring system where water use can be accessed through internet
Past Day: Monday, August 03, 2009

Avg. Water Level: 1.08 ft  Avg. Flow Rate (CFS): 131.20  Total Acre Feet: 260.30

Activity in the Past 24 Hours (CFS)

Activity in the Past 10 Days

Total Dissolved Solids: 769 ppm (24hr average) (in the testing phase)
United Irrigation District

Initial Work

- Replacement of old, manually operated gates on a main canal with a radial gate
- Lean how to operate system based on FLOW
United Irrigation District

- Set up new gate for remote control from District office

- District will move to total automation (or “full SCADA”)  
  - once new gate is calibrated for flow
  - as operational rules are defined
Flow Monitoring

- In June 2008, we installed a flow meter downstream of the gate.
- District personnel can now can see flow data and gate openings at the same time in district office.
Calibration of Gate

Matching flow with the gate opening (a 4-20mA analog output signal from the actuator) as a percentage of opening
Calibration of Gate

Investigating the use of much cheaper water level sensors instead of a flow meter for gate control and calibration.
Hidalgo County
Irrigation District No.6

- Full automation with remote control options of main gates and reservoir system

- Purpose:
  - Prevent flooding of area neighborhoods during rain events
  - Improve system management
Results

- Automated two additional gates on reservoir system and a flow monitoring station after second lift pump
- Implemented *Clear SCADA* (Human-Machine Interface software) in district office for the gate control, real time data display, store and analysis
Activities for this Year

- Expansion and Development of Automation
- Website Hosting
- GIS Online
- Canal Riders Training Development
- GIS Classes
Irrigation District Database Integration into Geographic Information System (GIS) and the Web
INTRODUCTION

Much data is stored at the district level, but it is often difficult for district personnel and others to use. Integration of the district’s database into a Online GIS will help in the use of this data.

PURPOSE OF WORK

- Setup daily mapping of water accounts (e.g. orders and distributed volumes) to help in daily operations and management
- Provide online modeling results that predicted crop water needs and irrigation scheduling
Irrigation District Database Integration into GIS and the Web

ACTIVITIES

- Adapt Brownsville I.D.’s water account database for automatic daily GIS integration
  - Analyze & provide recommendations for Brownsville Irrigation District’s database
  - Setup automatic link between water account database and GIS maps
- Create interactive on-line maps at http://watergis.tamu.edu/
- Setup password protection to enable district personnel and farmers to access account and operational data
- Evaluate mathematical models that predict soil moisture and compare results with observed field data
Irrigation District Database Integration into GIS and the Web

Example of Brownsville I.D. database analysis and link to GIS

One water account but 2 legal parcels and 2 fields (cultivated area less than total)

Two water accounts because 2 owners

One water account but 4 fields managed differently (many water orders, sometimes simultaneous, planting date unknown)
Irrigation District Database Integration into GIS and the Web

Example of Brownsville I.D. database analysis and link to GIS
**Irrigation District Database Integration into GIS and the Web**

**Example: Comparison of soil moisture observed and predicted**

**Input data:**
- Local rainfall and temperature
- Soil texture and observed moisture
- Farm operations: crop, tillage, irrigation (dates, volumes, and method), drainage

Testing of the field component of the CRITERIA model is on progress at 3 sites. Field data have been collected by the AgriLife Research personnel at Weslaco.
RESULTS - http://watergis.tamu.edu/

Irrigation District Database Integration into GIS and the Web
RESULTS - Interactive on-line maps

- Tools (identify, queries, reports, etc.):

http://watergis.tamu.edu
Web GIS Application Help

Click on the desired Web GIS Application link. The following will be displayed:
- a console with a list of information on the left
- a map in the centre displaying the information checked in the list,
- a tool bar on top to help find and interact with data.
Note that the first time the web application is opened it takes long because all data is downloads to the local computer.

Example of a Web Application map (Lower Rio Grande Valley 2005)

In the console choose the information to be displayed. Note that some might be grouped different levels. To see the description of symbols all levels must be explored.

Explore the map in the central part of the screen, which displays the information checked in the console list. A tool in the left high corner helps to quickly zoom in, zoom out, and pan the map and a ruler in the bottom right corner that show the scale selected.

Operate queries and interact with the map using the tool bars. It is possible to:
1. find information in the map using preselected queries and print a report
2. zoom in and out
3. pan
4. get to the full map extent
5. go to back and forward extent
6. magnify up to 10x
7. map identify
8. measure point coordinates, and line or polygon extent
9. show an overview of the map

Note that the identify tool allows you to see information associate with time, if these are stored in the map (e.g. irrigation dates and volumes for the same water account field), as described in the example below.

A default “Web Mapping Application Help” describe additional features of the Web GIS Applications.
Irrigation District Database Integration into GIS and the Web

RESULTS - Interactive on-line maps

- Compressed maps to improve performances:
  - Not compressed
  - Compressed (faster, same information, no check boxes)
Irrigation District Database Integration into GIS and the Web

RESULTS - Interactive on-line maps

- Mix compressed and not compressed:
RESULTS - Interactive on-line maps

- Public maps:
Irrigation District Database Integration into GIS and the Web

RESULTS - Interactive on-line maps

- Image services:

2001

2006
RESULTS - Interactive on-line maps

- Real time products for Districts:
Map & Publications

- 5 County Maps showing expansion of urban area
- 3 Maps showing 110th US Congress (2007-2009)
- 3 Maps showing Texas Senate (2003-2012)
- 3 Maps showing Texas House (2003-2012)
- 30 Individual Irrigation District Maps showing the expansion of urban area
Map & Publications


Irrigation District Engineering and Assistance

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