

Gate Rehabilitation Project in LCRA's Gulf Coast Irrigation Division



**Final Report for Texas Water Development Board Grant
Contract 1713582135**

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Executive Summary

The Lower Colorado River Authority owns and operates three irrigation divisions in the lower Colorado River basin. When water is available for all three irrigation divisions, these systems account for about two-thirds of total LCRA water use in a dry year. In 2010, LCRA began work on a major infrastructure project to remotely control 11 main canal gate structure sites in the Gulf Coast Irrigation Division. The project included developing a Supervisory Control and Data Acquisition (SCADA) communications system and remote monitoring of existing overflow locations. This project is the fifth and final phase of the 2010 gate rehabilitation project to complete automation and remote control of 57 main canal gate structure sites in the eastern canal system. This project installed 16 gates at 12 sites and integrated them into the existing SCADA system.

The project is estimated to save about 600 acre-feet of water per year. Water management has improved on the rest of the eastern Gulf Coast canal system as a result of LCRA controlling the last 20-mile section of the Wadsworth canal line. This project implements irrigation district conveyance improvements recommended as a water management strategy in the 2016 and 2021 Region K Water Plans. Reducing water use and improving water management in the Gulf Coast Irrigation Division helps LCRA operate the canal system optimally in conjunction with the nearly complete Arbuckle Reservoir.

Gate automation and control in the Gulf Coast canal system is the first and most cost-effective conservation measure to improve system water use efficiency. Information generated through data gathered from full automation of the Gulf Coast canal system will benefit other planned water supply and conservation measures, such as prioritization of areas for a pilot canal lining project and planned gate rehabilitation projects in LCRA's other irrigation divisions. LCRA will continue to assess the effectiveness of the project through delivery efficiency, including measured reduction in overflows and on-farm water demand performance metrics. LCRA will report the information to the Texas Water Development Board (TWDB) each year for five years and as requested, beyond that time frame if water is not available to provide savings estimates for five years of data.

The project was completed on time and on budget.

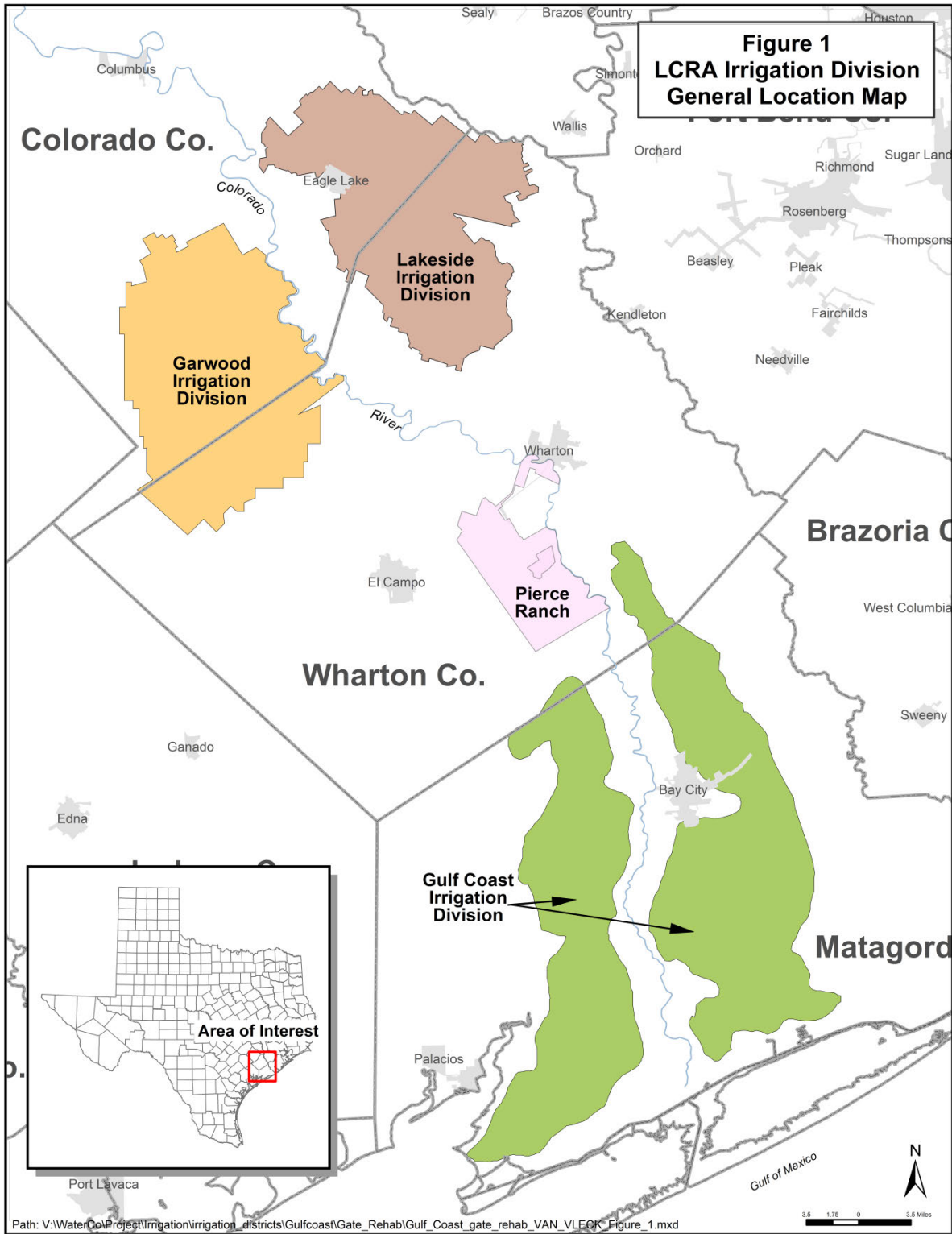
1 Introduction

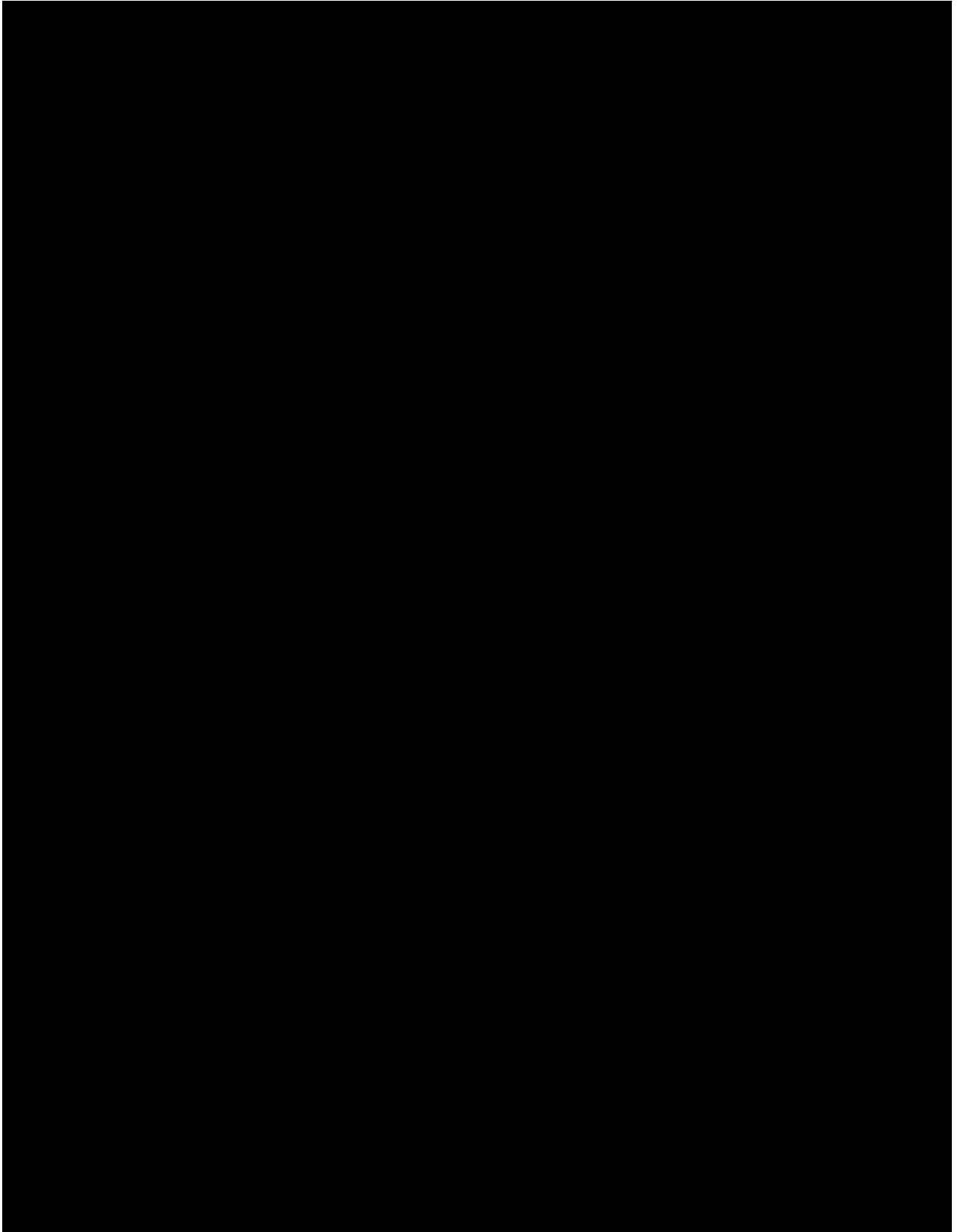
The Gulf Coast Irrigation Division operates under the Texas Commission on Environmental Quality's Water Right Number 14-5476 for the diversion of water from the Colorado River for agricultural use, and the use of stored water from the Highland Lakes under water rights 14-5478 and 14-5482. It has a serviceable area of 490 square miles, 350 miles of managed canals and approximately 2,400 structures. Figure 1 is a general location map of LCRA's irrigation divisions and Figure 2 is an overview of the entire Gulf Coast Irrigation Division canal system.

The control or "check" structures in the Gulf Coast canal system include bulkheads, water boxes, slide gates, flash board risers, pipes, valves, pipe headers, crossings, siphons, under-drains, bridges and foot bridges. The original check structures date back to the 1920s and 30s. Gate rehabilitation in Gulf Coast began in 2011 with the initial project automating 11 check structures with aluminum slide gates at the beginning of the eastern canal system. In 2014, LCRA completed Phase 2, which automated the entire Van Vleck line (11 sites) on the eastern canal system, and three sites serving an industrial customer at the beginning of the Wadsworth line of the eastern canal system. Automation of gates in the western canal system began in 2014. Phase 3 of the project completed the Markham/Buckeye line at the beginning of the western canal system in 2015, and Phase 4 completed the Oyster Lake line at the end of the western canal system in 2017 (see Figure 2). The original 2011-2012 automation project also included development of a SCADA system and a radio-based data communication system, which has since been upgraded.

Rice is the major crop grown (about 85% in most years) in the Gulf Coast, with the remainder being turf grass and row crops. In 2018, about 11,700 acres of rice were planted, with 7,550 acres of that watered for a second crop. In addition, about 3,450 acres were watered for turf, row crops or to create ponds for attracting wildlife. In recent years, rice acreage in this area is significantly lower than historical averages of about 20,000 acres. Total diversions for the Gulf Coast Irrigation Division have ranged from approximately 70,000 acre-feet per year to 200,000 acre-feet per year in the last 10 years.

LCRA's run-of-river water right for Gulf Coast is for the diversion of up to 262,500 acre-feet per year. Currently, agricultural and industrial customers are served from the canal system.



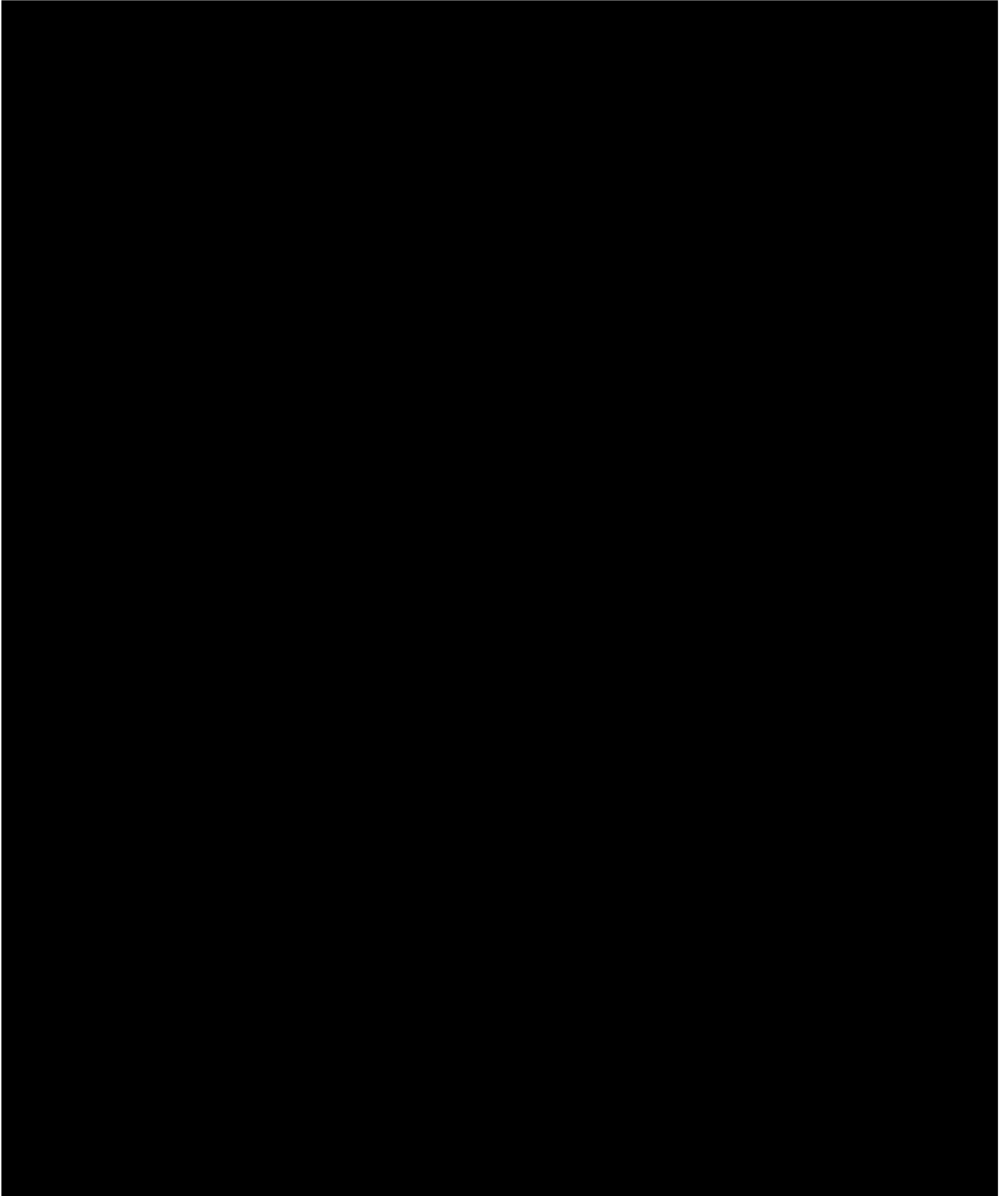


1.1 Project Objectives

The project's objective was to expand the gate automation project started in 2010 by retrofitting and automating 12 additional check gate structures at the end of the Wadsworth line on the eastern canal system in LCRA's Gulf Coast Irrigation Division (see Figure 3 for detailed project location). Each check gate structure consists of one or two aluminum slide gates with actuators and instrumentation for automatic control. This project utilizes a radio-based data communication system (DCS), a SCADA system, and an upgrade of the overflow monitoring site for this canal section that was developed for the initial gate automation project. The SCADA component provides LCRA operations the ability to better control water levels and flow rates within the canal and field delivery systems. This additional control improves operating efficiency, reduces energy consumption and conserves water throughout the canal system.

The project goals included:

- Conserving water by reducing the number of spills through spill measurement and monitoring;
- Conserving water by remotely monitoring water levels, which makes the system more efficient. The flow will be estimated by measuring the cubic feet per second through the gates using Bernoulli's Equation;
- Conserving water by controlling water levels to better utilize the storage capacity of the canal system:
- Reducing pumping hours and motor run time by maintaining full canals and reducing the frequency and number of canal recharges; and
- Reducing energy consumption by limiting the driving miles required to manually operate check gates.



2 Scope of Work

2.1 Project Methods

2.1.1 Engineering Design, Procurement and Construction

Engineering Design and Procurement

The Texas Historical Commission and LCRA's environmental compliance team approved the construction, concurring that no significant historical sites exist at any of the rehabilitated structures. LCRA engineering staff completed and sealed the engineering design plans. LCRA's engineering services and purchasing staffs procured the equipment and materials for the gates and radio system. All of the major equipment identified for the project was acquired under existing LCRA contracts.

Gate Fabrication

The LCRA Rail Fleet Maintenance Facility in Smithville manufactured the gates.

The gates are a front bolt-on mount design. This allows the gate to open above the highest water level in the canal so it could function manually in the event of a malfunction. The following gate specifications were used for the new gates:

- Gate frame: 5 feet wide by 11-14 feet tall, depending on site.
- Gate leaf: 5 feet wide by 5-7 feet tall, depending on site.
- Aluminum plate: Grade 6061-T651, 0.378-inch thickness.
- Bolts and fasteners: Stainless steel.
- Slide strips: UHMW-Black 3M CVT Lam-N-Hard Pressure Sensitive
- Gate actuator: Venture Actuators MA-8A4358653-64M

Gate Installation and Field Construction

LCRA Irrigation Operations employees completed the field construction. Work included preparing the site for installation of the fabricated gates, actuators, electrical supply, control cabinets and radio telemetry.

The Gulf Coast Irrigation Division led the gate installation effort with support and inspection by LCRA Engineering Services. The majority of the work associated with this task was completed outside the irrigation season, but wet weather during the winter delayed the installation of some gates until April 2019.

2.1.2 Radio and SCADA Systems Programming and Integration

Radio Data Communication System

LCRA Engineering Services staff and LCRA Telecom staff developed radio systems for each new site and integrated them into the existing radio communication system to reliably communicate data from the field sites (gates) to the control room at the division office. GE Harris SG5300 radios were installed for the 12 check structures. These radios communicate over LCRA's OpenSky network to the ClearSCADA Server at

LCRA's Gulf Coast Irrigation Division office. This office and main radio tower building have around-the-clock physical security and alarm-system monitoring. The SCADA-managed switch inside the radio building is password protected. OpenSky is a wireless communication system that supports voice over IP and data transport over a long ranges using a 900MHz frequency. Telecom staff conducted a signal survey using software, and staff performed field checks at a few sites. Signal levels were recorded after each radio is installed.

General specifications of the radio system are:

- Location of tower: Existing LCRA tower at the Gulf Coast office.
- Federal Communication Commission (FCC) and radio frequency band: Licensed 900 MHz ISM.
- Number of data radios at check structures: 12
- Antennas (for both types): CSI-AY/806-960/11 or PCTEL WMLPV800.
- Minimum antenna height: 6 feet.
- Radio types at check structure: Harris SG5300.
- Power supply and battery backup: 12 VDC 3A minimum – 300AH battery capacity.
- Surge and lightning protection: Polyphaser IS-B50HN-C2.

Data from each site is polled and received at an existing master radio located at the Gulf Coast office, and radio data is fed into the irrigation SCADA network. The antenna is located on an existing LCRA tower. There is an existing monitored overflow structure at the end of this canal section at Wooden which is was tied to the SCADA network during the first phase of the gate rehabilitation project in 2012.

SCADA Programming

There are two programming components to this project. The first is the SCADAPack Remote Terminal Unit (RTU) controller programmed using Telepace software and data reporting necessary to operate and monitor the gate installations via the radio data communication system. Communication is done over Transmission Control Protocol (TCP)/Distributed Network Protocol (DNP3). The SCADAPack RTU requires a login (username/password) to connect to any port.

The second SCADA component is ClearSCADA advanced human machine interface (HMI). This integrated the new gates into the SCADA system built during the original gate rehabilitation. The SCADA system is used to monitor and control canal gates remotely from the Gulf Coast office control room. There is a firewall between the switch in the control room and the ClearSCADA server. An LCRA user/password login is required to access the ClearSCADA application over the control



network and another user/password login is required to make any control or application changes. The SCADA system also includes alarm functions sent to operations staff through “short message service” (SMS) and email. All data from the gates is stored on a computer server technically referred to as a “local historian,” which can be used to detect trends and generate reports. An LCRA irrigation operator can set the gates in auto upstream level control or “Set to Order” (STO). The 12 new gates were added into the existing SCADA system with minimal programming modification because it was created with a template-based design for each check structure site. LCRA Irrigation Operations staff with some support from LCRA Engineering Services completed all HMI/SCADA programming work to integrate the 12 new gates into the system. Figure 4 shows a screen shot of the user interface for the software.

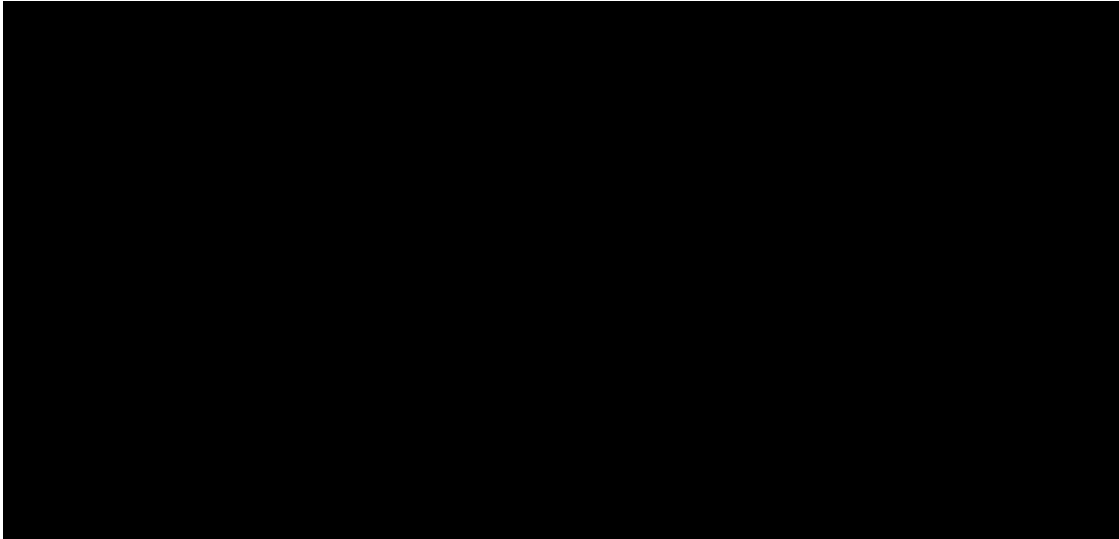


Figure 4: User interface for gate control software

Startup and Acceptance Testing

Testing included integrating all of the various subsystems, check structures, SCADA and radio DCS into a functional check structure monitoring and control system. LCRA Irrigation Operations staff did the performance and reliability testing and acceptance.

2.1.3 Regulatory and Conservation Reporting

Staff received approval to proceed with construction from the Texas Historical Commission, completed an internal environmental checklist and received clearance from TWDB engineering. An LCRA project manager and project analyst oversaw the execution, procurement, control and closeout of the proposed project. This included organizing and directing the project team, processing payment requests, updating the project schedule and preparing progress reports. LCRA water conservation staff completed the final report.

Water savings reported for the five years following the completion of construction will be measured by comparing the volume of overflows at monitored locations at the end of the east canal system after installation of the gates to overflow measurements taken in 2005-2006. Delivery efficiency (on-farm water delivered/total water diverted at the river)

and on-farm water demand (water delivered/acres watered) also will be compared to previous years.

3 Project Results

3.1 Engineering Design and Construction

The Wadsworth line segment of the gate rehabilitation project was completed in April 2019. In June 2018, gate design plans were finalized and materials were ordered for gate fabrication. Gates were fabricated between July and August 2018. Panel and electrical drawings were approved by July 2018. Solar control panels were fabricated by the end of September. Materials for



gate installation were ordered between August and December 2018. Site preparation work began in November 2018 and was completed by March 2019. This included civil work (supporting structures needed for radio systems and minor concrete work for gate installation), setting control panels and solar panels, and gate installation. Staff tracked each site's progress, including civil work and work on the control panel, conduits, level transmitter, wiring, battery and solar panels, gauges, system grounding, antenna and radios, gate 1, RTU, and SCADA, and generally completed one site before moving on to the next.

3.2 Radio and SCADA Systems Programming and Integration

LCRA Engineering and Telecom staff began SCADA programming to integrate each new gate into the OpenSky radio network in early 2019 and completed the work in April 2019. The radios were installed in the spring 2019 and fully tested by May 2019.

3.3 Reporting and Water Savings

3.3.1 Budget Reporting

This project was successfully completed on time and on budget. Table 1 shows the timelines associated with each task. Table 2 shows the final budget and schedule performance. The final budget was 92% of the estimated budget. Contingency funds were overestimated for Tasks 1 and 2, and LCRA’s Smithville Rail Fleet Maintenance Facility was able to find an efficiency when fabricating the gates that reduced the amount of waste, so less aluminum was needed to fabricate the gates.

Table 1: Schedule Timeline By Task

Task	2018												2019											
	Irrigation Season												Irrigation Season											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	16	17	18	19	20	21	22	23	24	25	26	27	16	17	18	19	20	21	22	23	24	25	26	27
contract signed August 29, 2017						▼																		
Task 1: Engineering Design, Equipment Procurement and Gate Fabrication																								
Task 2: Gate Installation, Radio / SCADA Systems Programming and Integration																								
Task 3: Regulatory and Conservation Reporting																								

Table 2: Budget and Schedule Performance

Description	Budget	Expenditures To Date
Task 1	\$248,271	\$222,409
Task 2	\$112,180	\$106,778
Task 3	\$7,003	\$8,994
Total	\$367,453	\$338,181

3.3.2 Water Savings

In the original project proposal, staff estimated the amount of water conserved through this project would be approximately 900 acre-feet per year, or 75 acre-feet per year per structure. The estimate assumed an average water use from 1999 to 2011. Because the savings is based on a percentage of total flow, the savings could decrease based on recent decreases in acreage served per year. Average savings results from 2019 to 2022 based on a savings analysis comparing predicted water use to actual water used in the Gulf Coast Irrigation Division for first and second crops, and taking weather and acreage variability into account using a regression analysis indicate approximately 567 acre-feet of savings may be attributed to the project. The savings estimates are conservative, since they are based on the minimum of the confidence interval range for each model prediction. Savings numbers are based on water use reductions that exceed normal variations due to climate and statistical uncertainty.

Staff expects the original savings estimate to increase if real-time relay of downstream water demand information to upstream gates can be implemented successfully.

3.3.3 Outreach

In September 2017, LCRA staff held an agricultural advisory committee meeting at the Arbuckle Reservoir construction site that included a trip to the Gulf Coast Irrigation Division Bay City Office to see the nearby Office Lock, which is a representative automated gate structure similar to the gate structures automated along the Wadsworth canal line as part of this project.

In February 2023, LCRA staff held an agricultural water conservation field day in Garwood featuring a keynote speaker from United States Department of Agriculture's Agricultural Research Service (USDA-ARS) division in Arkansas and five LCRA customers who farm in the LCRA irrigation divisions. Brandon Mathis and Randy Epps with LCRA moderated a question and answer session on LCRA's gate rehabilitation projects but unfortunately the field tour was cancelled due to inclement weather. 25 LCRA customers attended the event.

4 Conclusions

The Gulf Coast Gate Rehabilitation Project on the Wadsworth line has been a successful and timely project. The construction was completed on time and under budget.

Based on data from 2019-2022, the regression model indicates about 3,400 acre-feet was saved per year throughout the entire canal system. Between 2012 and 2019, five separate gate rehabilitation projects have been completed, totaling 57 sites in the eastern and western canal systems. Besides maintaining more consistent canal water levels, this real-time SCADA system also has allowed LCRA's Irrigation Operations staff to identify more quickly structure blockages caused by debris.

5 Acknowledgments

The successful completion of this project would not have been possible without the hard work of LCRA staff. Particular recognition goes to the entire staff at the Gulf Coast Irrigation Division under the leadership of Randy Epps, manager of Irrigation Operations, Stephen Crow, Irrigation Operations superintendent for Gulf Coast, and Mark Fisher, supervisor of general craft, who planned the project. Carina Hinojosa was the project manager, and Annette Keaveny as the project analyst handled the overall project accounting and financial reporting to TWDB.

LCRA staff from the following departments also assisted with this project:

- Irrigation Operations (construction): Brian Garcia, Gary Garza, Randy Jurek, Dawn Kaul and Cody Thompson.
- Telecom: Brett Janecka.
- Smithville Rail Fleet Maintenance Facility: Matt Hancock.
- Engineering: Sam Brown.

6 Glossary

DSC: radio-based data communication system

HMI: human machine interface

RTU: Remote Terminal Unit

SCADA: Supervisory Control and Data Acquisition