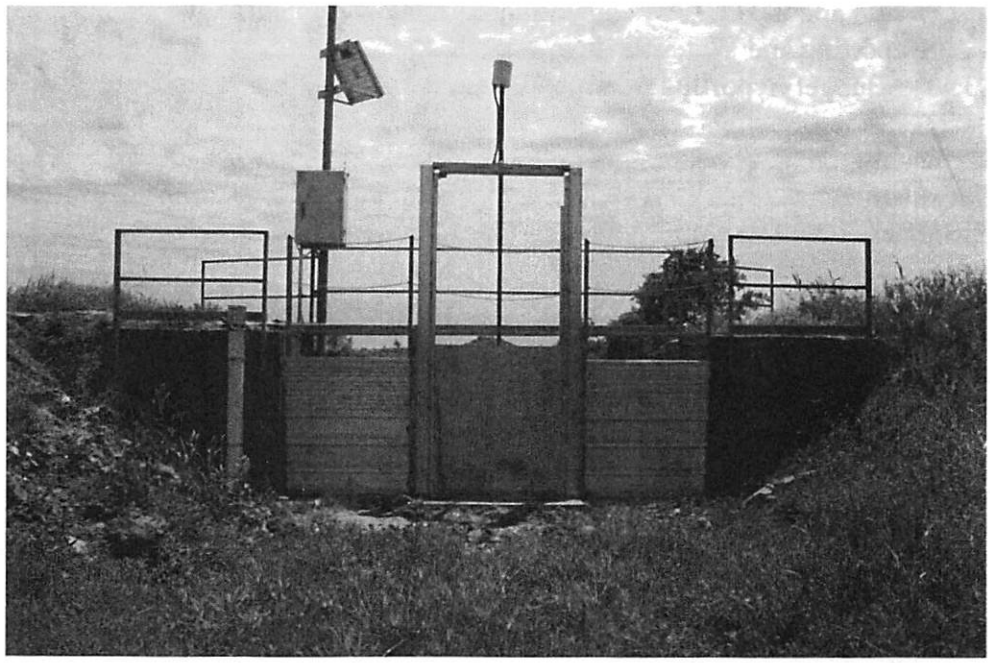
Gate Rehabilitation Project in LCRA's Gulf Coast Irrigation Division



Final Report for Texas Water Development Board Grant Contract 1313581610

March 2015

Stacy Pandey, Senior Water Conservation Coordinator
Lower Colorado River Authority

Gate Rehabilitation Project in LCRA's Gulf Coast Irrigation Division

Final Report for Texas Water Development Board Grant Contract 1313581610

March 2015

Stacy Pandey, Senior Water Conservation Coordinator
Lower Colorado River Authority

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Executive Summary

The Lower Colorado River Authority (LCRA) 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 expanded the 2010 gate rehabilitation project to extend the automated gates to the end of one canal line in the eastern canal system. This project installed 10 gates at nine sites and integrated them into the existing SCADA system.

In 2014, due to the ongoing severe drought, the Gulf Coast Irrigation Division was completely cut off from Highland Lakes stored water for a third irrigation season, so it is not possible to verify savings estimates at this time. The water savings estimates from this project are about 400 acre-feet per year, based on an average year without curtailment, at a cost of $42 per acre-foot saved. By controlling all the main gates within the canal line, the project will improve water management on the entire eastern Gulf Coast canal system, eliminating 50 to 70 percent of estimated overflows lost from the end of the system. Reducing water use and improving water management in the Gulf Coast Division will help LCRA operate the canal system optimally, in conjunction with the planned off-channel reservoir at the head of this system, and have the flexibility to deliver water efficiently even during partial curtailment.

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 this project will benefit other planned water supply and conservation measures, such as the new Lane City off-channel reservoir and prioritization of areas for a pilot canal lining project. Previously, there was no way to accurately monitor water flow constantly throughout the canal system. Once water is no longer curtailed, LCRA will assess the effectiveness of the proposed 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 water rights number 14-5476, for the diversion of water from the Colorado River for agricultural use, and water rights numbers 14-5478 and 14-5482, for the use of stored water from the Highland Lakes. It has a serviceable area of 490 square miles, and includes 350 miles of managed canals and approximately 2,400 structures. Figure 1 presents a general location map of LCRA's irrigation divisions, and Figure 2 presents an overview of the Gulf Coast canal system and the various gate rehabilitation projects conducted since 2012.

The control or "check" structures include bulkheads, water boxes, slide gates, flash board risers, pipes and valves, pipe headers, crossings, siphons, under-drains, bridges and foot bridges. Most of the existing check structures are original and date back to the 1920s and 1930s. Eleven check structures were automated in 2011-2012 with aluminum slide gates. This automation project also included a SCADA system and a radio-based data communications system. The picture above shows the original typical structure.

The water in the canal system supports several crops. Rice is about 85 percent of the crop in years when irrigation water is not restricted, with turf grass and row crops making up the rest. Due to the ongoing severe drought, 2011 was the last year that rice crops in this division were irrigated with surface water. In 2011, about 18,300 acres of rice were planted, and 15,100 acres were irrigated for a second crop. About 12,400 acres were irrigated for turf, row crops or to create ponds for attracting wildlife. LCRA's billing system generated these acreage figures, which only represent acreage irrigated by surface water supplied through the canal system. LCRA does not have information about land irrigated by groundwater. The Gulf Coast Division signed 52 water delivery contracts for rice in 2011 and delivered supplemental water for about 80 additional contracts. In a normal year, the number of supplemental contracts would be closer to 150, but water for wildlife ponds was curtailed in 2011. Total diversions for the Gulf Coast Irrigation Division have ranged from approximately 80,000 acre-feet per year to 195,000 acre-feet per year over the 10 years previous to 2011. Detailed information about water use and irrigated acreage from 2009-2013 is available in LCRA's 2014 Water Conservation Plan (http://www.lcra.org/water/save-water/Documents/2014-Water-Conservation-Plan.pdf).

The Gulf Coast Irrigation Division has a run-of-river water right of 262,500 acre-feet per year. This water right was acquired by LCRA in 1960 and has a priority date of Dec. 1, 1900, for 228,570 acre-feet, and Nov. 1, 1987, for the remaining 33,930 acre-feet. This water right was historically used solely for agricultural purposes, but LCRA amended the water right in 2011 to include industrial use and the canal serves both types of customers.

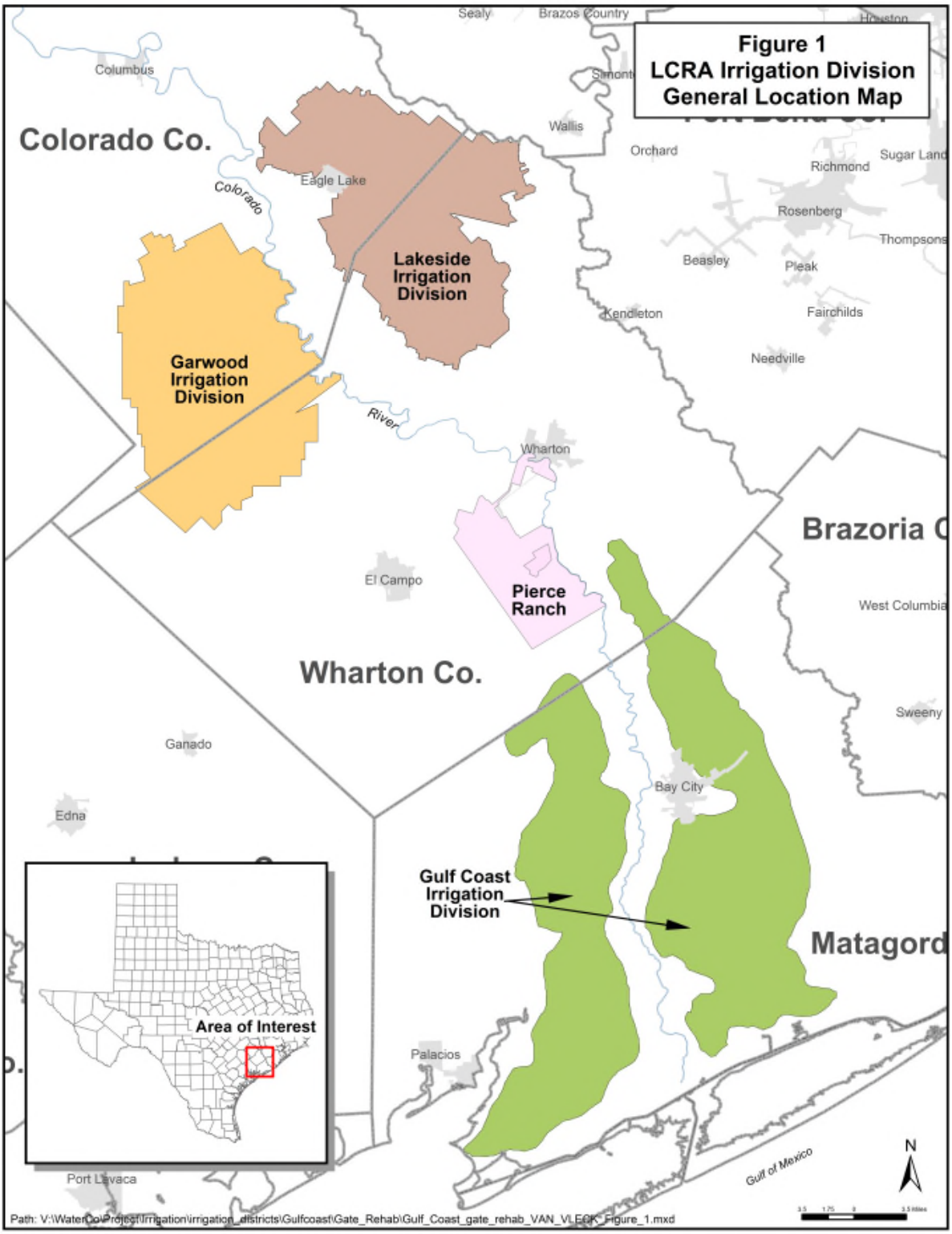


Figure 1
LCRA Irrigation Division
General Location Map
Colorado Co.
Wharton Co.
Brazoria C
Matagord
Lakeside Irrigation Division
Garwood Irrigation Division
Pierce Ranch
Gulf Coast Irrigation Division
Area of Interest
Sealy
Brazos Country
Columbus
Simonton
Wallis
Orchard
Richmond
Sugar Land
Eagle Lake
Colorado
Rosenberg
Thompsons
Beasley
Pleak
Kendleton
Fairchilds
Needville
River
Wharton
El Campo
West Columbia
Sweeny
Ganado
Bay City
Edna
Palacios
Port Lavaca
Gulf of Mexico
N
Path: V:\WaterCo\Projects\Irrigation\irrigation_districts\Gulfcoast\Gate_Rehab\Gulf_Coast_gate_rehab_VAN_VLEGK_Figure_1.mxd

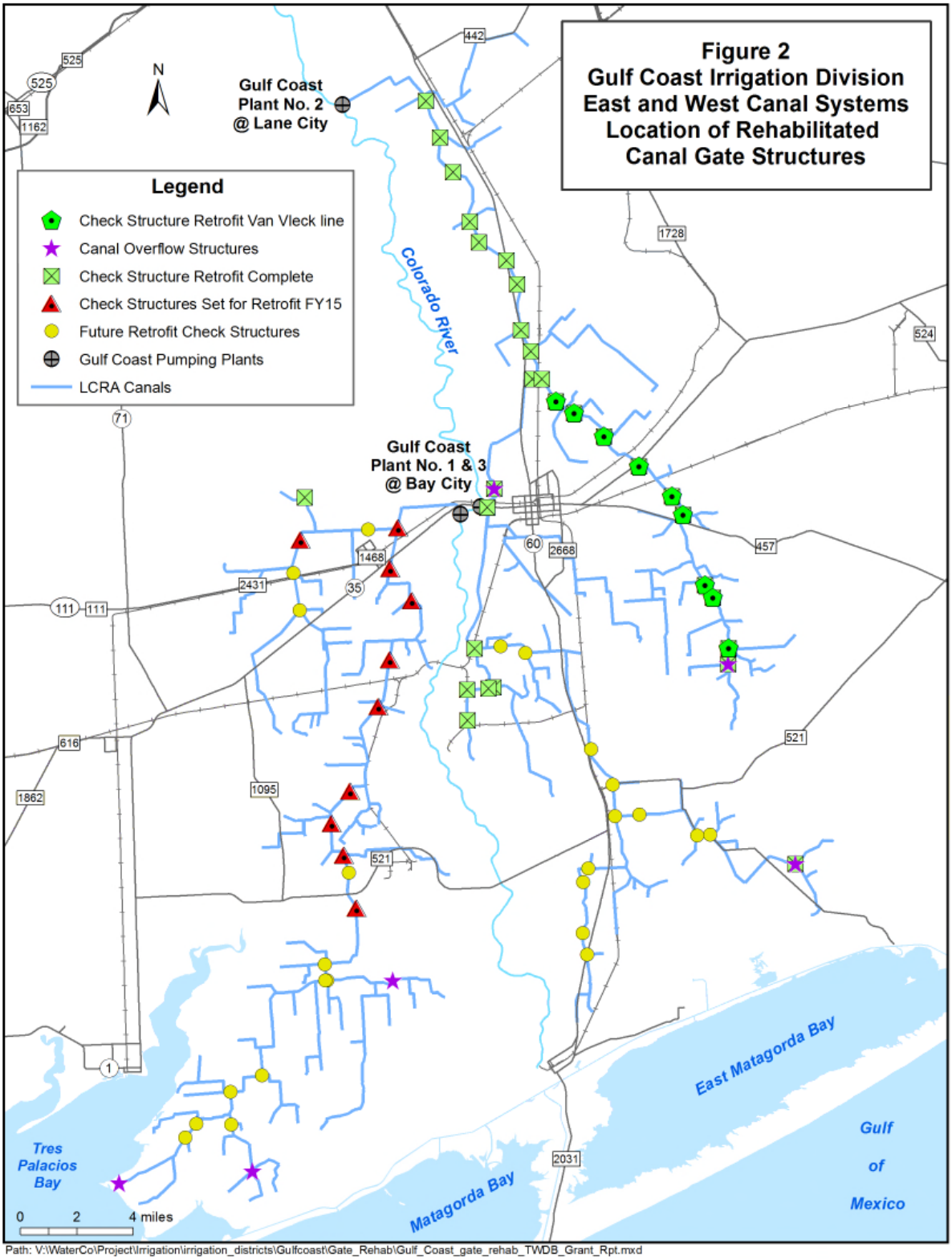


Figure 2
Gulf Coast Irrigation Division
East and West Canal Systems
Location of Rehabilitated
Canal Gate Structures
N
Gulf Coast
Plant No. 2
@ Lane City
Gulf Coast
Plant No. 1 & 3
@ Bay City
Legend
Check Structure Retrofit Van Vleck line
Canal Overflow Structures
Check Structure Retrofit Complete
Check Structures Set for Retrofit FY15
Future Retrofit Check Structures
Gulf Coast Pumping Plants
LCRA Canals
Colorado River
East Matagorda Bay
Gulf
of
Mexico
Matagorda Bay
Tres
Palacios
Bay
0
2
4 miles
525
653
1162
442
1728
524
71
60
2668
457
1468
2431
35
111
616
1862
1095
521
2031
1
Path: V:\WaterCo\Project\Irrigation\irrigation_districts\Gulfcoast\Gate_Rehab\Gulf_Coast_gate_rehab_TWDB_Grant_Rpt.mxd

1.1 Project Objectives

The project's objective was to expand the gate automation project started in 2010 by retrofitting and automating nine additional check gate structures downstream of the previous project 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 a overflow monitoring site for this canal section that were 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, reduce energy consumption and conserve 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.

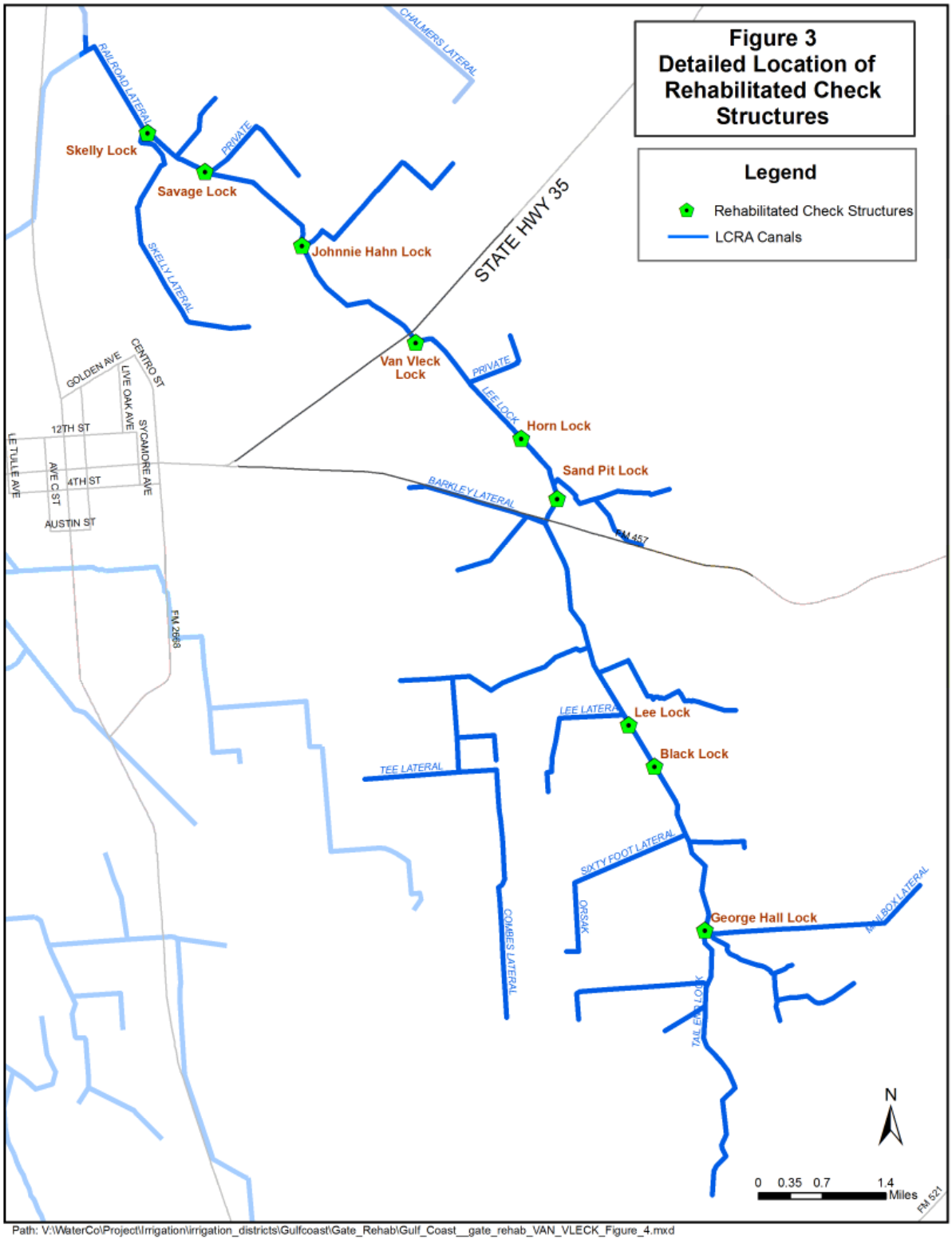


Figure 3
Detailed Location of Rehabilitated Check Structures
Legend
Rehabilitated Check Structures
LCRA Canals
Skelly Lock
Savage Lock
Johnnie Hahn Lock
Van Vleck Lock
Horn Lock
Sand Pit Lock
Lee Lock
Black Lock
George Hall Lock
RAILROAD LATERAL
CHALMERS LATERAL
PRIVATE
SKELLY LATERAL
STATE HWY 35
LEE LOCK
BARKLEY LATERAL
FM 457
LEE LATERAL
TEE LATERAL
SIXTY FOOT LATERAL
ORSAK
COMBES LATERAL
TAILBOX LATERAL
TAIL END LOCK
FM 2668
FM 521
GOLDEN AVE
LIVE OAK AVE
CENTRO ST
SYCAMORE AVE
LE TULLE AVE
AVE C ST
12TH ST
4TH ST
AUSTIN ST
N
0 0.35 0.7 1.4
Miles
Path: V:\WaterCo\Project\Irrigation\irrigation_districts\Gulfcoast\Gate_Rehab\Gulf_Coast__gate_rehab_VAN_VLECK_Figure_4.mxd

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: 68 inches wide by 10 feet to 14 feet tall
- Gate leaf: 56 inches wide by 5 feet tall
- Aluminum plate: Grade 6061-T651, 0.378-inch thickness.
- Bolts and fasteners: all 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 the necessary site preparation for installation of the fabricated gates, actuators, electrical supply, control cabinets, and radio telemetry.

The LCRA's Gulf Coast Irrigation Division led the gate installation effort with support and inspection by LCRA Engineering Services. Normally, the majority of the work associated with this task would be completed outside the irrigation season, but the curtailment of irrigation water in 2013 allowed the work to be completed faster.

2.1.2 Radio and SCADA Systems Programming and Integration

Radio Data Communication System

LCRA Engineering Services staff and the LCRA Telecommunications staff (Telecom) 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 Gulf Coast Irrigation Division office. GE Harris SG5300 radios were installed for the nine check structures. These radios communicate over LCRA's OpenSky network to the ClearSCADA

Server at LCRA's Bay City office. The Bay City 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 range using a 900MHz frequency. Telecom staff conducted a signal survey using software and staff performed field checks at a few sites. Signal levels are recorded after each radio is installed.

General specifications of the radio system are:

- Location of tower: existing LCRA tower at the Bay City office.
- Federal Communication Commission (FCC) and radio frequency band: licensed 900 MHZ ISM.
- Number of data radios at check structures: nine.
- Antennas (for both types): MAXRAD 12db Onmi.
- Minimum antenna height: 8 feet.
- Radio types at check structure: Harris SG5300.
- Power supply and battery backup: 12 VDC 3A minimum – 100AH battery capacity.
- Surge and lightning protection: Pole and control panel grounded 2 feet underground and 5 feet away from the pole. Surge protection added to the radio coaxial cable and control panel power feed.

Data from each site is polled and received at an existing master radio located at the Bay City office, and radio data is fed into the irrigation SCADA network. The radio system's security system requires a login for each radio unit. The master radio sets up a hopping frequency between the master and the remote radios. The control boxes at each site are locked. The antenna is located on an existing LCRA tower. The water level monitoring site that was originally planned downstream of the last gate was not needed as there is one at an existing location downstream of these sites.

Also, the radio towers presented in the original grant proposal were not needed due to successful migration to the OpenSky network, saving the expense of the towers and installation labor.

SCADA Programming

There are two programming components to this project. The first is the SCADAPack Remote Terminal Unit (RTU) controller. Telepace software was used to program the RTUs in a ladder/C programming logic. All 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 Bay City 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 controls 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 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 10 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 Engineering Services completed all HMI/SCADA programming work to integrate the 10 new gates into the system. Figure 4 shows a screen shot of the user interface for the software.

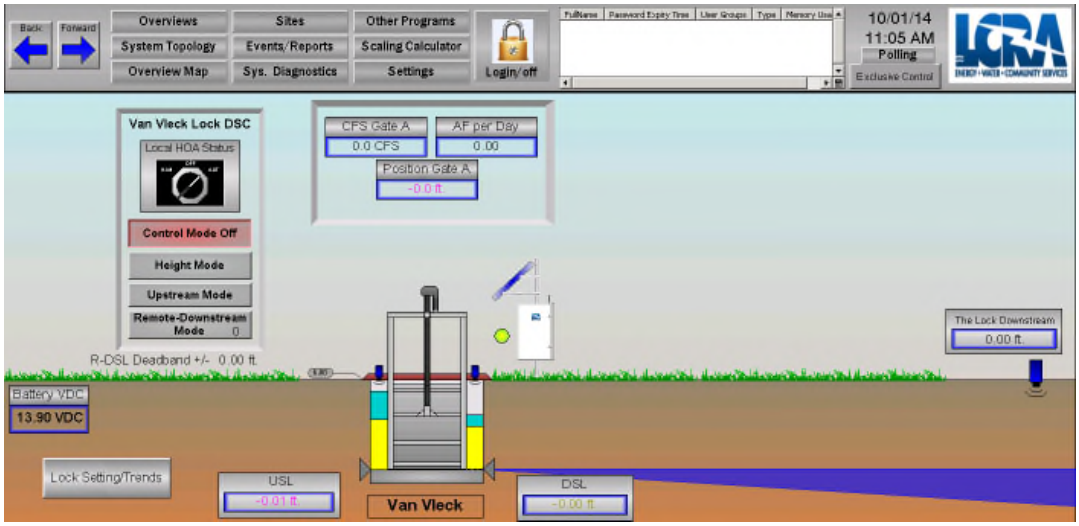


Figure 4: User interface for gate control software

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 Engineering Services did the performance and reliability testing and acceptance, to the extent possible given that a complete curtailment of stored water from the Highland Lakes was in effect for the Gulf Coast Irrigation Division in 2014.

2.1.3 Regulatory and Conservation Reporting

Staff received approval to proceed with construction from the Texas Historical Commission and completed an internal environmental checklist. An LCRA project manager 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 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) will also be compared to previous years.

3 Project Results

3.1 Engineering Design and Construction

The Van Vleck line segment of the gate rehabilitation project was completed between July 2013 and July 2014. By August 2013, all site material and equipment was ordered and gate design plans were finalized. In fall 2013, solar control panels and gates were fabricated. Site preparation work began in early fall and was completed by February 2014. 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 through a spreadsheet that included: civil work, control panel set, conduit run, level transmitter set, wire pulled and terminated, battery and solar panel set, staff gauges, system grounded, antenna and radio set, radio tested, gate 1 set, RTU tested, and SCADA tested.

3.2 Radio and SCADA Systems Programming and Integration

LCRA Engineering and Telecom staff spent several weeks working on network design for the OpenSky radios, beginning in the summer of 2013 and visiting the site once. This is LCRA's first gate rehabilitation project that used the OpenSky radio network. Staff began SCADA programming to integrate each new gate in fall 2013 and completed the work in May 2014. The radios were installed in the spring of 2014 and fully tested by May 2014. There was concern about the new radios having enough bandwidth since the radio network is on a voice/data network, but all of the sites tested were within required parameters. LCRA Telecom has added more channels to the OpenSky radio network to prevent any issue in the future. This eliminated the material and installation cost for individual radio towers at each of the nine sites.

3.3 Reporting and Water Savings

3.3.1 Budget Reporting

The 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 95 percent of the estimated budget.

Table 1: Schedule timeline by task

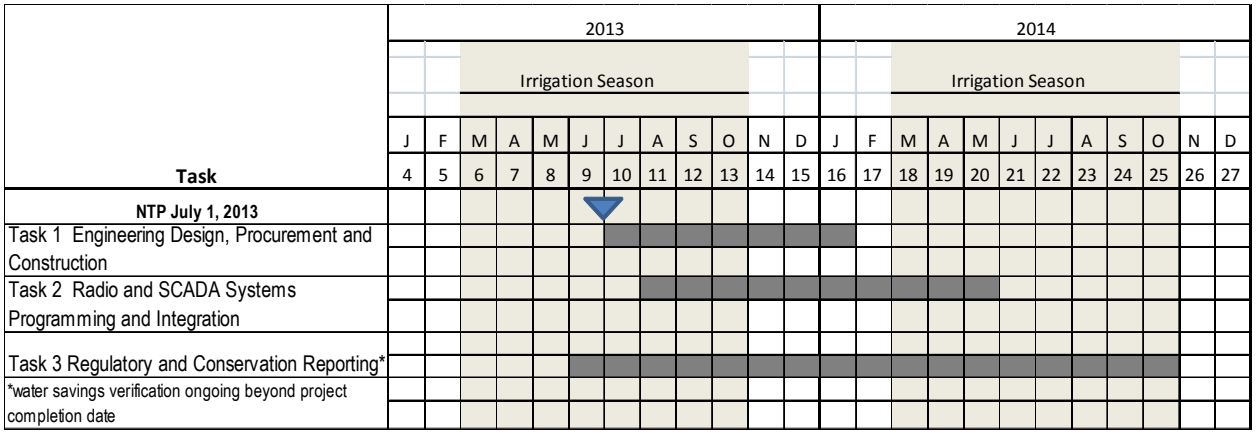


Table 2: Budget and Schedule Performance

Description	Budget	Expenditures To Date
Task 1	$198,244	$197,419.94
Task 2	$64,803	$62,479.87
Task 3	$15,386	$5,456.97
Total	$278,433	$265,356.78

3.3.2 Water Savings

In the original project proposal, staff estimated that the amount of water conserved through this project would be approximately 400 acre-feet per year. This estimate was based on projected savings spread over 33 gates that must be automated to remotely control all main gates in the eastern canal system using upstream control. 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 in a partial curtailment situation. However, reductions from eliminating 70 percent of spills indicated a similar savings. It is possible the full savings estimate will be realized during a partial curtailment situation if spills are eliminated.

Unfortunately, water savings cannot be estimated for 2014 due to curtailment of stored Highland Lakes water to the Gulf Coast Irrigation Division. Staff has not been able to complete final operational testing on the Van Vleck line gates due to this curtailment. However, staff has successfully tested downstream control with a few gates installed at the same time as this project

to serve an industrial customer. Staff plans to implement this methodology on the Van Vleck line when water is available for agricultural use in Gulf Coast Irrigation Division. Staff expects the original savings estimate to increase if real-time relay of downstream water demand information to upstream gates can be implemented successfully on the Van Vleck line.

4 Conclusions

The Gulf Coast Gate Rehabilitation Project on the Van Vleck line has been a successful and timely project even though there has been no opportunity to verify water savings. The construction was completed on time and under budget in the middle of a historic drought.

It will take several years in which the irrigation divisions are operating, to realize the benefits of the gate rehabilitation projects that have been implemented in the Gulf Coast Irrigation Division. Between 2012 and 2014, three separate gate rehabilitation projects have been completed, totaling 28 sites, in the eastern canal system, and a fourth project was initiated in 2014 on the western canal system to retrofit ten additional sites. LCRA's Irrigation Operation staff members have already seen a benefit of using a real-time SCADA system to move a measured amount of water through the eastern canal system. This system has already saved water by not over estimating pumping demands for water deliveries to an industrial customer receiving water throughout the drought.

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, Kelly Webber, Irrigation Operations superintendent for Gulf Coast, who planned the project, Keith Shufflebarger, who coordinated field construction activities and Brad Funk with Engineering Services, who completed the SCADA programming and prepared the budget for the original project. Gary Pavalock was the project manager and Shanna Gillum handled the overall project accounting and financial reporting to the TWDB.

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

- Irrigation Operations (construction): Henry Schelp, Mark Fisher, Randy Jurek, Brian Garcia, Jason Gibson, Brandon McDonald, Wyatt Schultz, John Krobot and John Salinas.
- Telecom (radio communication system): Manuel Alanis, Eddie Krekel and Tavion Williams.
- Smithville Rail Fleet Maintenance Facility (gate fabrication): Matt Hancock and Joe Caridi.
- Engineering: Robert Caffee.

6 Appendices- Gate Design Engineering Plans

6.1 Skelly Lock Gate Design Documents

6.2 Savage Lock Gate Design Documents

6.3 Johnnie Hahn Lock Gate Design Documents

6.4 Van Vleck Lock Gate Design Documents

6.5 Horn Lock Gate Design Documents

6.6 Sand Pit Lock Gate Design Documents

6.7 Lee Lock Gate Design Documents

6.8 Black Lock Gate Design Documents

6.9 George Hall Lock Gate Design Documents