DEMONSTRATION OF GATE CONTROL WITH SCADA SYSTEM IN LOWER RIO GRANDE VALLEY IN TEXAS

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ABSTRACT

The management of canal operations with centralized control provides a powerful way to monitor the existing conditions at the site, regulate water demands and supplies, while minimizing delays and losses. Three control structures on lateral E3-A of Delta Lake Irrigation District (DLID) in the Lower Rio Grande Valley (LRGV) in Texas will be automated and integrated with the Supervisory Control and Data Acquisition (SCADA) system in two Phases. Control of two gate structures, Check 1 and Check 2, at the most upstream of the lateral will be integrated with SCADA system first in Phase 1. The third gate structure, Check 3, at the downstream of Check 2 will be automated in Phase 2 to conduct research on delivering unknown irrigation demands. This system will be utilized as a long-term management and decision support tool for the district. This study focuses on the methodology of integrating the canal automation with the optimal management strategies of turnout structures to meet on-farm delivery demands. The discussion reviews the identification and selection of the SCADA system components for DLID.

INTRODUCTION

Irrigation in the Lower Rio Grande Valley

The Lower Rio Grande Valley (LRGV) (Figure 1) area in Texas experienced two severe droughts in 1996 and 1998. The farmers could not get enough water and were looking for support to optimally manage irrigation. Engineers at Texas Cooperative Extension have been undertaking water conservation projects in LRGV to produce water savings in the region and to improve conveyance efficiency in order to achieve optimal irrigation that will also help in drought conditions.

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There are 28 water districts in Hidalgo, Cameron and Willacy Counties in LGRV. These districts (Figure 1) hold combined agricultural water rights totaling 1,468,314 ac-ft. The water right at the smallest district is 625 ac-ft and 174,776 ac-ft at the largest district. The largest eight districts account for 69% of the total and Delta Lake Irrigation District (DLID) holds 174 776 ac-ft. The main distribution networks consist of 790 miles of canals, 124 miles of pipeline, and 76 miles of Resacas. The secondary and tertiary networks ("laterals") consist of about 670 miles of canals and 1690 miles of pipelines. There are 552 miles of lined canals, 614 miles of unlined canals, and about 294 miles of canals with unknown lining status. (Fipps, 2005).

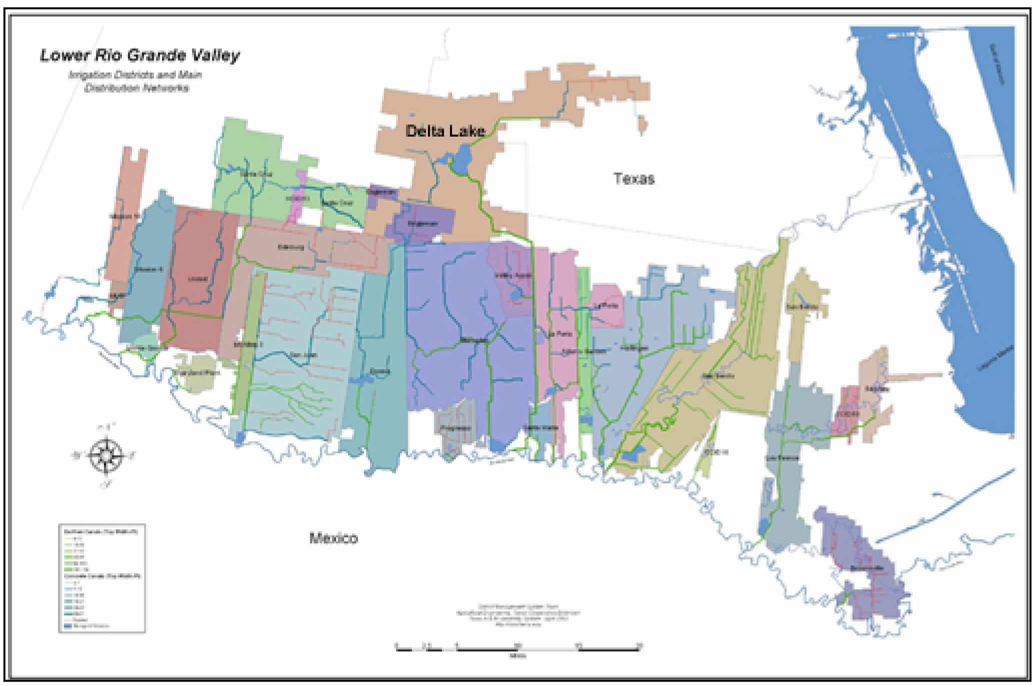

Figure 1. GIS map of distribution network in LRGV.

Project Plan

The canal control combined with SCADA system improves the management of canals and accordingly increases the conveyance efficiency. In addition, these systems can reduce the delays while delivering irrigation demands and maximize the yields while saving water in the area of LRGV. Canal control structures can be controlled by a unit located at the site (local automatic control) or at a monitoring station away from the site (supervisory control). Both the local and supervisory systems can include the SCADA and telemetry systems.

Control of gates from the main office has never been implemented in DLID. A pilot project will start in the near future to control three gate structures on E3-A lateral (Figure 2) of this district's distribution network from office by utilizing SCADA system. The project will be achieved in two phases. In Phase 1, two gate structures, Check 1 (Figure 2 and 3) and Check 2 (Figure 2, 3 and 4), at the point where lateral separates to north and south, will be automated. Phase 2 will be performed soon after Phase 1 is implemented. In Phase 2, Check 3 (Figure 2) which is the first check structure at the downstream of Check 2 will be automated to conduct research on control algorithms and management of flow in case of delivering unknown demands.

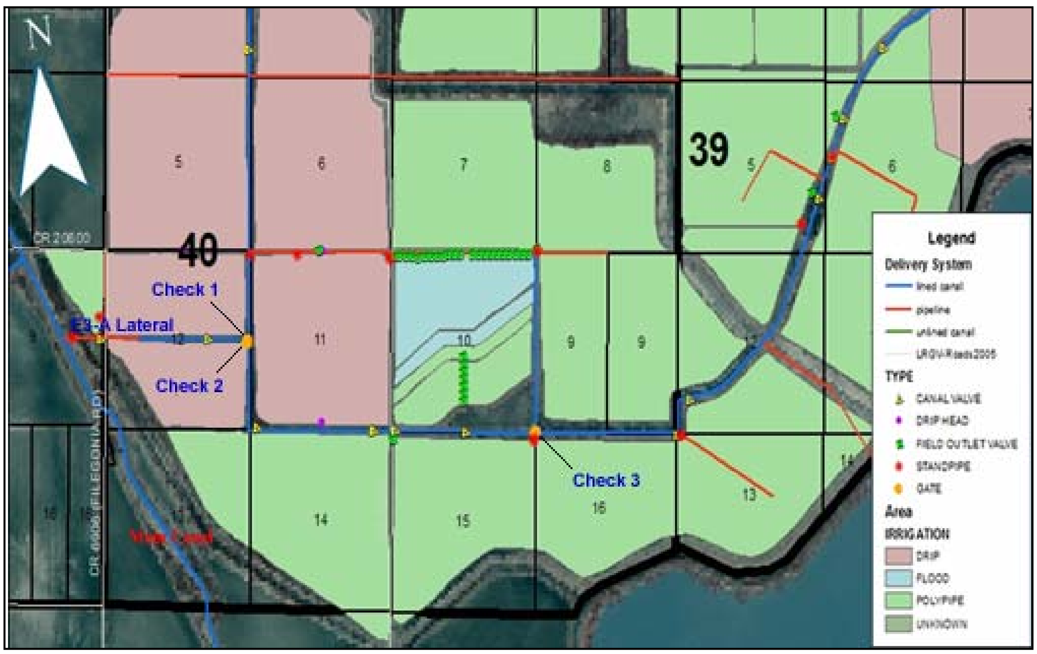

Figure 2. GIS Map of distribution network and irrigated fields of E3-A lateral.

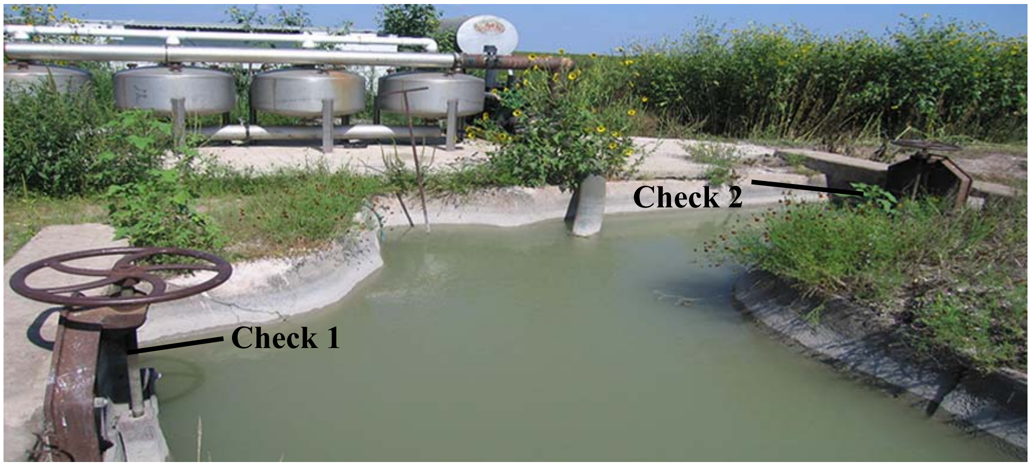

Figure 3. View of Check 1 and Check 2 structures.

Figure 4. View of Check 2 (heading south).

Irrigation Technology Center (ITC) team at Texas A&M University is working on E3-A lateral (Figure 2) to recommend the optimal management methods of turnout structures and on-farm irrigation practices and to increase on-farm efficiency for the fields served by this lateral. The purpose of installing the SCADA system fits to the tasks of this project, so SCADA system will be tied with this project.

Irrigation Flow Delivery In LRGV

Local manual control of gate structures is predominant in LGRV. This creates management problems due to the lack of experience and technical knowledge required to route the flow in complex canal systems (Buyalski et al, 1991). Flow is delivered by rotation, schedule or on demand by operators in canal systems. In scheduled delivery method, the operator knows the flow rate, duration and time of the irrigation for any turnout in advance and they route the flow to the turnout by changing the settings of the upstream gates. In most of the irrigation districts in LRGV, flow is delivered with scheduled delivery. Under local manual control, this kind of delivery causes head problems at the turnouts and the fields cannot get the required amount of water. In addition to these, there is always delay in the delivery of the ordered flow. However, scheduled flows can be delivered on time with SCADA systems.

INTEGRATION OF ON-FARM MANAGEMENT WITH SCADA SYSTEMS

The check structures can be controlled in a way to satisfy the optimal on-farm management objectives. This will help water users optimally manage the demand, and deliver only the recommended amount of water to each field exactly on scheduled time. ITC team developed on-farm management tool (Figure 5) to find the irrigation requirements at each turnout and irrigation interval for each field composing of furrows. The data coming from weather stations will also be tied to this tool in order to predict the evapotranspiration and crop water requirements that will be used for the determination of irrigation schedules. Within the scope of the project, the developed tool will be utilized as a component of the SCADA system and the check gates will be controlled according to the demand schedule obtained from this tool.

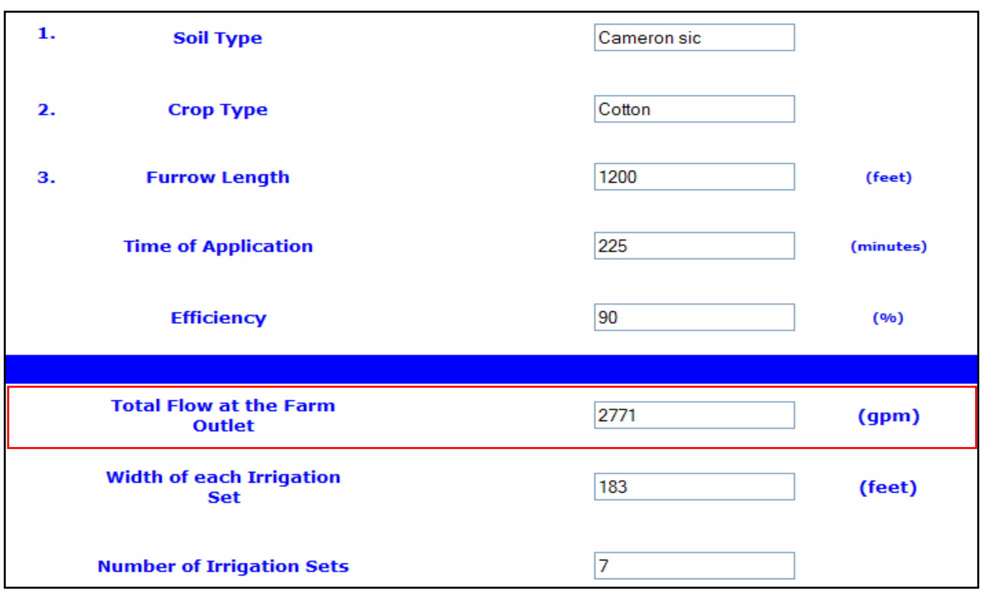

Figure 5. On-Farm Irrigation Tool.

SCADA SYSTEM COMPONENTS IN DLID PROJECT

Automatic canal control with SCADA systems requires the availability of communications, office and field equipment (Figure 6). The SCADA system composes of office software, Programmable Logic Controllers (PLC), sensors, gate actuators and the communication system. Combining the software and remote units located at the office SCADA system offers the easiness of monitoring and managing the structures from the office. Most of the companies do not supply all of the SCADA components. Therefore, the users should combine different companies' products and form different sets of components according to their needs.

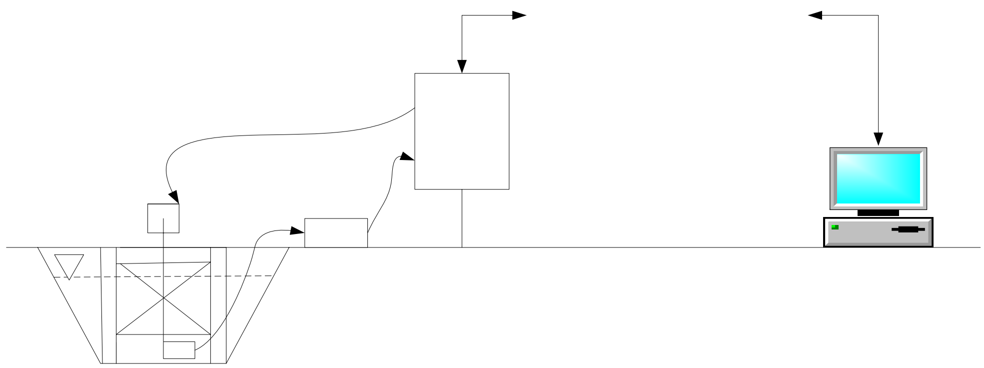

Figure 6. SCADA System Structure.

In Phase 1, these two gates will be controlled manually from the office in order to route the required flow to downstream and maintain constant water level at the upstream according to the known demand schedules. This system will assure monitoring of the water depth and the flow in the canal from the office. So, the operator will not need to go to the site to change the opening of the gate. However, the main task is to change the setting of the gates correct, have reliable flow delivery to the turnouts, collect data, and store it in the database.

To perform this study, the available equipment in the market is investigated. The products of two companies, which have so many applications that fit the tasks of this study, are selected for further investigation. The equipment of these companies with their costs is provided. This information is given in Table 1. The total cost of the set up will be shared between ITC and DLID (Table 2).

THE COST AND METHODOLOGY OF THE SCADA SYSTEM SET UP IN DLID

The Control Microsystems's controller is selected to be used in this study. In the beginning of the study, the gates will be calibrated to derive the H-Q curves and the C coefficient for each structure. These curves will be utilized while estimating the flow passing through the structures by using the data coming from upstream, downstream water level sensors and gate sensors. The PLC and the software components of the system will control the gates remotely (Xianshu et al, 2001). There will be one water level sensor (pressure transducer) at the upstream and two water level sensors (pressure transducer), each of which will be at the downstream of the each gate. Each gate will be equipped with gate sensors to measure the opening and gate actuator to change the amount of the opening. Water level and gate sensors and gate actuators will be connected to the PLC as analog inputs. The communication will be used to transmit the data collected at the PLC at the field to the central office and send the commands from the computer in the office to the PLC at the field. So, operators at the office will monitor the data transferred and take the necessary actions to establish the constant water level at the upstream and deliver scheduled water to downstream. These actions will be sent to the field PLC as commands. The commands will be transmitted to the gate actuators to change the setting. The operator will also have the capability to check the level when away from the office. Telepace Logic Program (Telepace LLP) software will be used to debug the Ladder Logic control programs for the SCADAPack controllers (Xianshu et al, 2001). The users can also write their own control processes as C code to program the controller.

Table 1. The equipment and cost provided from two companies.

	Company 1	**Company 2**
Office Equipment	$6,130.00	$13,940.00
*SCADA Software		
**Controller Software		
Radio System		
***Office Computer System		
Antenna		
Site Equipment	$5,946.00	$3,520.00
Field Station		
Controller		
Radio Connection		
***Transmission and Cables		
Operator Interface		
Power Supply		
***Miscellaneous Hardware		
Antenna		
Cable, installation, burying		
***Vandalism Enclosure		
Sensors and actuators	$7,000.00	$5,500.00
Water level sensors (3)		
Gate Sensors (2)		
Gate Actuators and Motors (2)		
Total	**$19,076.00**	**$22,960.00**

***** **:** The SCADA software for Company 2 is provided from another company
****** **:** The software for Company 2 is used in order to achieve downstream control.
***** :** The equipment is provided from another company.
Note: Cable, installation and burying costs are not included.

Table 2. Total cost share between district and ITC.

	Company 1	**Company 2**
Two Gates		
Gate 2 communicates with Gate 1 with radio		
Our Cost	$11,576.00	$16,960.00
District's Cost	$7,500.00	$6,000.00
Total Cost	**$19,076.00**	**$22,960.00**
One Gate		
Our Cost	$9,102.00	$15,450.00
District's Cost	$3,750.00	$3,050.00
Total Cost	**$12,852.00**	**$18,500.00**

Check 3 will be automated in Phase 2 in order to maintain constant water level at the upstream pool and also to work on the controllers to deliver unknown demands. When a disturbance occurs in the pool between Check 2 and Check 3 (Figure 2), the system should handle this automatically by changing the gate settings and bring the system back to the steady state and deliver the ordered flow. According to the water level, the gate opening will be changed automatically. The discussion of current and applied algorithms (Malaterra et al, 1998; Rogers et al, 1998; Buyalski et al , 1991; Goussard, 1993; Rogers et al, 1995) studied in order to come up with the necessary controller formulation for the E3-A lateral. One of the unsteady hydraulic simulation models available in the market such as MIKE 11 (DHI, 2004), SOBEK (DH, 2004), SIC (Cemegraf, 2004) will be used in order to simulate the flow and estimate the necessary water level and flow set points for the system to deliver the irrigation demand. The feed forward control will be used to route the known demands. The feedback commands will be utilized in order to minimize the differences from the set points and minimize the delays created by the disturbance (Clemmens et al., 2005). The SCADA and communication system along with the proper numerical model and control algorithms must be compatible and set accordingly to the existing canal conditions and operation practices. The canal controller that is selected should be suitable with the irrigation practices in the lateral and the canal geometry (Strelkoff et. al., 1998; Buyalski et al, 1991).

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