REMOTE MONITORING AND OPERATION AT THE COLORADO RIVER IRRIGATION DISTRICT

Victor Ruiz[1]
Julio Navarro[2]
Mario Paredes[2]
Bernardo Andrade[2]
José Anguiano[2]
Francisco Delgado[2]
Ofelia Begovich[3]
Javier Ramirez[1]

ABSTRACT

The Colorado River Irrigation District is the last irrigation district and water user on the Colorado River. It obtains 80% of the allocated volume to the district from the Colorado River. The inflow to the district presents fluctuations. The first 27 km of the mail canal are used as buffer reservoir. Between 2002 and 2004 to improve water management, the National Water Commission, Mexican federal agency responsible of water reclamation, installed a remote monitoring system for the head control structures. The system was integrated around MODBUS as communication protocol, Lookout from National Instruments as man machine interface, SCADAPack from Control Microsystems as remote terminal units, "The Probe" from Milltronics as level sensors, Transpak potentiometer transmitters for gate opening and MDS 4710 and 4910 radios from Microwave Data Systems for communication. The remote monitoring system installed was complemented with the remote operation of one control structures. The system starts operation on February of 2005. The remote monitoring system reduces the time required to know, to quantify and to correct the flow and level fluctuations present on the head control structures.

INTRODUCTION

In many regions of Mexico as in Mexicali, water is the main limiting factor for development. The marked competition between the municipality, industry and agriculture is pushing toward more efficient use of this limited natural resource. Agriculture, the largest water consumer, is looking for new technologies to improve water and soil conservation. Remote monitoring and control systems are one of these technological alternatives under analysis in Mexico.

To improve water use and management, the management of the irrigation districts was transferred to user associations and modernization programs were done.

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[1] Instituto Mexicano de Tecnología del Agua. Paseo Cuauhnahuac 8532, Jiutepec, Morelos 62550, Mexico,{vmruiz, jramirez}@tlaloc.imta.mx
[2] Distrito de Riego 014, Río Colorado, Comisión Nacional del Agua. Reforma y Calle "L", Colonia Nueva, Mexicali B. C. Mexico jnavarro@grpbc.cna.gob.mx
[3] CINVESTAV-Gdl., López Mateos Sur 590, 45232, Guadalajara, Jalisco, México, obegovi@gdl.cinvestav.mx

While the first action was successful in the more profitable districts, the second presented innumerable problems. New infrastructure and remote monitoring-control systems were installed without realistic operational plans and experience making the modernization projects obtained limited results.

Previous Experiences

Between 1988 an 1992 the National Water Commission ("Comisión Nacional del Agua", CNA), federal agency in charge of water reclamation in Mexico, made two remote monitoring projects "El Canal Alto" in the Yaqui River Irrigation District and "Bachimba" in the Delicias Irrigation District. Both projects fell short of expectations as a result of the limited experience of the CNA and the companies making the system integration. The bad selection of the gate opening sensors, remote terminal units and communication system contributed to the limited results. The remote monitoring systems installed had never been used and they are partially dismantled.

Since 1994 the Mexican Institute of Water Technology and CINVESTAV had been working on the remote monitoring and operation of irrigation canals. Today, the first canal operation experiences done in simulation had been transformed into real time experiences on laboratory and field. The laboratory evaluations and the exchange of experiences with National and International agencies helped IMTA and CINVESTAV to obtain the necessary experience to fulfill the supervision and integrations of the remote monitoring systems the CNA requires. Two laboratory canal models were instrumented to evaluate sensor, actuators and remote terminal units. Some multi-input multi-output and single input single output algorithms had been tested on both canals.

In this paper we describe the experiences on the integration of the remote monitoring for the Colorado River Irrigation District (CRID). In the first section of the paper we describe the irrigation district and the remote monitoring project as part of a modernization project for the district. On a second section we describe the system integration process and the experience obtained.

COLORADO RIVER IRRIGATION DISTRICT

The CRID is on of the largest irrigation district in northwestern Mexico. It is located on the northeast of the State of Baja California close to the border with the USA with an average altitude of 25 m. The irrigation district supplies water to 210,000 ha. property belonging to 16,500 farmers. The CRID has been divided into 22 User associations and one User Association Federation. The district was created in 1955, however some land had been irrigated since 1935. The maximum temperature in the summer is 55 ^{o}C and minimum in the winter is - 5.0 ^{o}C. The water sources are the Colorado River with and annual allocation of 1.85 billion m^3 and 550 wells that supply annually 500 million m^3. The Morelos Diversion Dam

channels the Colorado River water onto the Reform Canal. The Reform canal and its two main secondary canal, “Independence” and “Revolution” conveys and distributes the water (Fig. 1). Lining has been placed in approximately 70 % of the main canals and 60 % of the distribution network. The control structures along the canals are radial and slide gates.

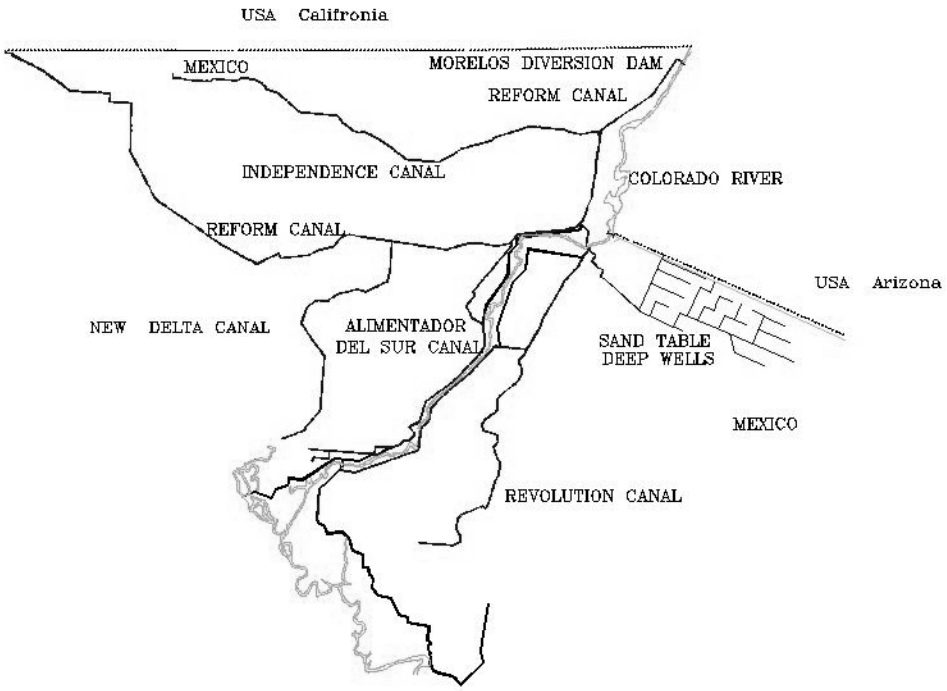

Figure 1. Colorado River Irrigation District canal network.

The turnouts to secondary canals and farm outlets have a capacity of 0.1 m^3/s to 35 m^3/s. The main turnouts are located at the downstream end of the reaches however many small turnout are located along the reaches. The turnout structures are radial and slide gates for the secondary canal and Miller gates for the farm outlets. Parshall flumes are located at the head of some secondary canals for flow measurement. Constant downstream water-depth is used as pool operation method [Ref 1]. Manual upstream regulation is applied as control method [Ref 1].

The CRID is divided into three irrigation units. The name of the unit is given by the canal that distributes the water in the unit, Independence, Reform and Revolution.

The main crops in the CRID are wheat (70%) during the winter, Cottom (60%) in the summer and alfalfa (30 %). The main on-farm irrigation method is furrow (80%); other methods are drip and sprinklers for some vegetables and for the first irrigation for many crops. The users have allocated an average of 14000 m^3 for each hectare registered in the irrigation year.

The Colorado River water is scheduled according an international agreement between Mexico and USA signed in 1944. On October and November the district and the Users Associations prepare the delivery program for the next year determining the volume required each month. On December the Mexican and USA international water commission approves the volume requirements for the next year. The International agreement establishes a minimum flow and the possibility to change the volume allocated for any month no more than 20% with notice of at least a month in advance. The weekly delivery program is requested with 7 days in advance in agreement with the volume authorized for the month.

Modernization project

In 1997 the Colorado River irrigation district made a modernization project to improve canal operation. One of the components considers the use of the first 27 km of the Reform Canal as a buffer reservoir and concentrates the operation problems on the Revolution canal where 66 deep wells from the "Sand Table" (Fig. 1) will compensate flow variations. To supervise the first 27 km of the Reform Canal and the turnouts for the "Independence" and "Revolution" Canals, a remote monitoring system was considered.

REMOTE MONITORING PROJECT

On 1999 CNA made a contract to design a remote monitoring system to supervise the Morelos Diversion Dam, the first 27 Km of the Reform canal and its two main turnouts the Independence and Revolution Canals. The remote monitoring project was solved using a master slave communication system with Modbus as protocol. The system was designed around the Smart Wire Remote terminal Units from Control Microsystems, potentiometer Float (Celesco) sensor for level, Transpak transducer potentiometer- current loop for gate position and Modpac Plus spread spectrum radios from Curry Control. The master station will be at the CNA operation office located at the control structure of the Km 27+000 on the Reform Canal.

To integrate the remote monitoring system according the design already done, the CAN made a contract with a local company to acquire and install the system components, in 2002. Simple mistake product of design errors and the no experience of the company on canal data measurement made that the remote monitoring system attained very low performance and its installation took more time than expected (Fig. 2). The light weight floats connected to the Celesco sensors were not able to follow the canal level variations. The gate opening sensors presented calibration difficulties, it is not possible to adjust the zero in some gates, the gates calibration were made without considering the span and zero of the Transpak transducer making the calibration of each gate a unique case. Finally, the Spread Spectrum Curry Control radios do not attain the performance

wished, during some days no communications between the master station and the remote unit were observed. These facts in addition to the lack of well defined training program and the hermetical job made by the integration company on the installation forced the irrigation district to request IMTA to help the district to receive the remote monitoring system and to repair the system to obtain the desired performance.

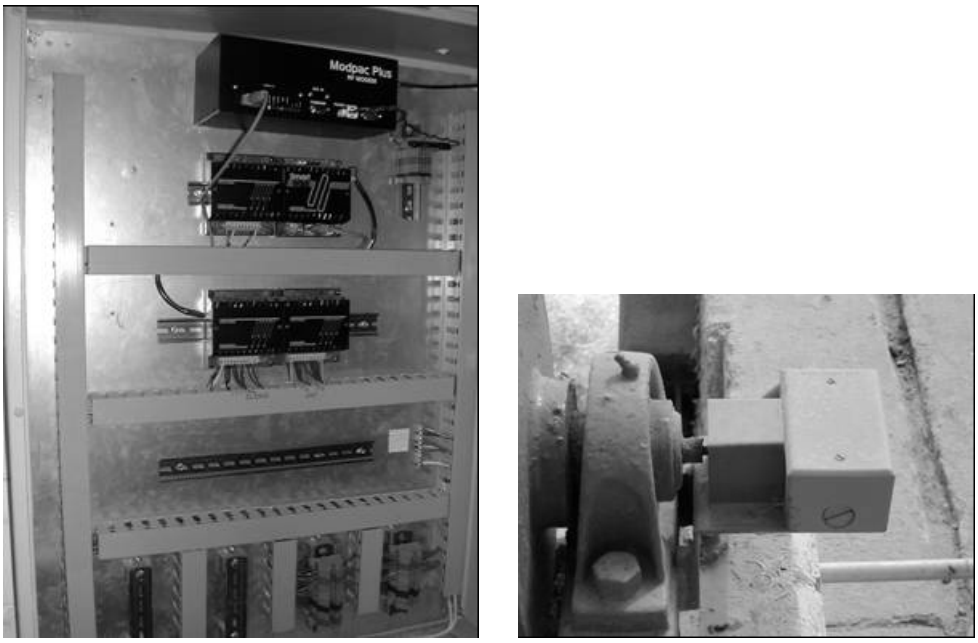

Figure 2. Remote Monitoring System Installed on 2002.

Since the second half of 2003 IMTA have been working with the Irrigation District. IMTA detect the performance problem on the sensors and radio and the impossibility to have a local screen on each remote site to display the local information with the RTU selected on the design. IMTA recommended: the radio must have a minimum performance of 95 % of valid response frames, a local display at the control structures must show de data and gate position to ditchriders, the level and gate position errors must be smaller to +/- 1 cm (minimum resolution of the scales present on the canal). To complete the remote monitoring system CNA requested IMTA to review the 1999 design and update it to install level sensors upstream and downstream the Morelos Diversion Dam, to measure level on the Matamoros control Structure and Sanchez Mejorada Canal (Fig. 3) and consider a remote monitoring and control system for the control structure of Km 4+100 on the Revolution Canal (Fig. 4). With the field experience on the Carrizo District and the help provide by the staff of Imperial Irrigation District the design for the new points considered the next equipment: MDS 4710 B and 4910 B radios for the new communications system, The Probe form Milltronics Siemens as level sensor, Vantage 2210 from Eastech Badger for level transducer and data logger, Transpak for potentiometer – current loop

transducer for gate opening sensor, SCADAPack and Vision from Control Microsystems as RTU and man-machine interface. The selection of the radios was validated with a field test, MDS 4710B radios where used to communicate all the remote monitoring units on operation and design. With the participation Sage Designs Inc. a Free Wave radios used with the SCADAPack were tested to relay the master station with the remote site integrated on 2002. The percentage of valid response frames with the tested radios during a 1 hour test was 100%. The Free Wave radio is a spread spectrum radio as the Curry Control. This confirms that the communications problem was product of the radio selected. The Curry Control radios request 2 repeaters to ensure de communication between the master station and the remote site separated 15 Km (repeater every 5 Km). With the spread spectrum radios from Free Wave no repeater is required, the same conditions for the MDS radios. With the MDS radios, the connections between the master station and the Diversion Dam, the farther remote site to the master station did not require any repeaters. It is only necessary to consider the right size for the antenna´s tower obtained from a line sight study.

As a consequence of the performance evaluation carried out by IMTA on the remote monitoring system CNA requested the integrator to recalibrate the sensor and fix the radio performance. Since the contract signed in 2002 for the integration of the remote monitoring systems did not consider any defect associate to the design, the performance established by IMTA was impossible to attain. By the end of 2003, CNA and IMTA agree to buy the necessary equipment, radios, man-machine interface, RTU, ultrasonic level sensor to obtain the desired performance and simplify the future maintenance of the system under integration. Finally in September 2004 the integrator gave the systems finished to CNA. The remote monitoring system installed presented a very limited performance.

On the second half of 2004, with the equipment acquired by CNA on 2003, IMTA started the installation of the level sensor and data loggers (Vantage 2210) on the diversion dam, Matamoros Control structures and Sanchez Mejorada Canal.

When the integration company gave the remote monitoring systems to CNA, the communication system and RTU was changed. The Spread Spectrum Radio, Curry Control radios was changed by MDS 4710B radios working on 450 – 470 MHz. The Smart Wire RTU was changed by a SCADAPack which made possible the installation of a man machine interface (“Vision”) to present the local measurements.

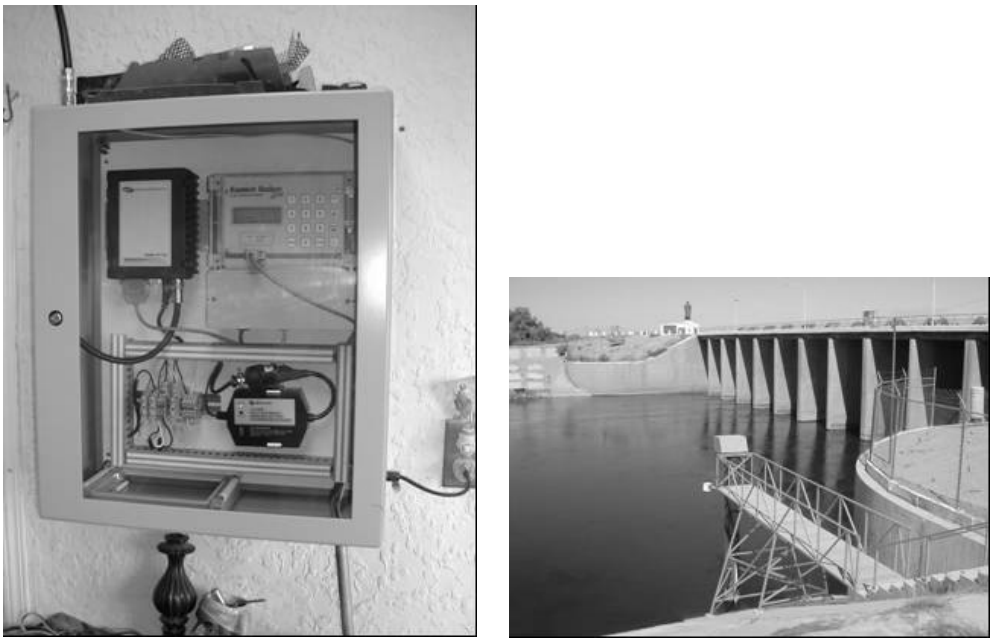

Figure 3. Remote Monitoring using the Vantage 2210.

By the end of 2004 the instrumentation of the Km 4+100 Revolution Canal Control structure started. This control structure has 3 radial gates and its discharge is free. The upstream level was measures with the ultrasonic level sensor "The Probe". For the gate position sensor the opening was determined measuring the turns of a gear on the gear box of the gate opening mechanism. A third order equation was used to relate the turns of the gear with the gate opening. A 10 turn, 10 K potentiometer is used to measure the turns. A Transpak transducer transforms the resistance of the potentiometer on a 4-20 mA loop. Since the number of turns on the gear to measure the gate opening travel was not equal to the turns of the potentiometer a small gear box is used to adjust this difference. This gear box is located between the potentiometer and gear box as group of Roger Hansen from the USBR Provo used on the remote monitoring systems integrated by them. For the operation of the 3 phases motor of the gate actuator the electric circuit of the electromagnetic motor relays was modified to advice the RTU with a digital signal the operation mode of the gate (manual of PLC) and to allow the digital outputs of the RTU turn on the motor on the desired directions. The manual operation of the control structure was not modified.

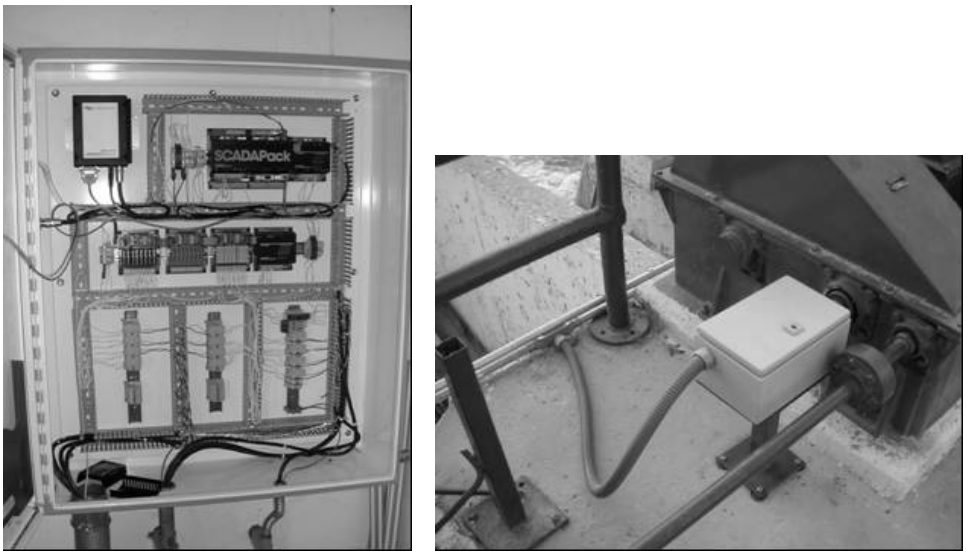

Figure 4. Remote monitoring systems at the KM 4+100 Control Structure.

The installation of all the equipment made by IMTA the last year was done with the participation of the electromechanical maintenance staff of the CNA´s irrigation district. The participation of IMTA was completed with a training program to allow the district made the daily operation and basic maintenance of the system.

For this year, the irrigation district will complete the remote monitoring and operation of the control structures and main turnouts on the first 27 KM of the Reform canal, install a Acoustic Doppler Current Profiler at the head of the Reform Canal where the lined canal start and consolidate the training on operation and maintenance on the installed SCADA system for the staff of the irrigation district and company selected by the district for the maintenance of the system. The district is looking for a local company that trained by IMTA will be responsible for the maintenance of the SCADA system installed.

CONCLUSIONS

The Colorado River Irrigation District has started to use remote monitoring and operation systems. Today it is possible to follow the canal performance and reduce the effect on any flow variations on the control point where CNA gives water by volume to the User Association Federation in charge of the main canal operation. The good result obtained with the first site motivated the district to complete the instrumentation of all the head control structures of the district and supervise the distribution made by the Water Users Association Federation at some critical points.

Canal remote monitoring is a simple task if the right equipment is used. If it is not the case, it can become a nightmare that never ends.

REFERENCES

1. Buyalsky C. P., Ehler D. G, Falvey H. T, *Canal Systems Automation Manual*, A water Resources Technical Publication. Bureau of Reclamation. Denver, Colorado, 1991.