MODERNIZATION OF THE WALKER RIVER IRRIGATION DISTRICT WATER GAUGES

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ABSTRACT

The Irrigation Training and Research Center (ITRC) and Walker River Irrigation District (WRID) collaborated on WRID's Water Gauge Improvement Project with support from the Bureau of Reclamation, U.S. Department of Interior in Carson City, Nevada. This paper presents a summary of the proposed plan and implementation for improving water gauges in WRID with strategic engineering recommendations for new hardware and control equipment; water management strategies; flow measurement devices; and integration of a new district-wide SCADA system. Field investigations and engineering analyses were carried out by the ITRC in 2009 to inspect existing WRID infrastructure, to review current operational procedures, and to interview district staff. This information was analyzed and compiled to summarize the scope of work for system improvements. The ITRC prioritized the order of engineering implementation and automation recommendations, provided planning-level cost estimates, and has assisted WRID in organizing implementation over the past five years.

INTRODUCTION

The recommendations in this paper are guided by successful experiences of many other irrigation districts with the transformation of old, manually-operated canal systems into modern projects operated with high levels of water delivery service and a clear accounting of water diversions. A successful irrigation modernization program must maintain an appropriate balance of technical upgrades and management sustainability. In the case of WRID, the motivation for irrigation modernization is the need for robust and cost-effective measurement and control of flows diverted from the Walker River. These flows are monitored by a Supervisory Control and Data Acquisition (SCADA) system, and can now be managed remotely through SCADA. Figure 1 shows a location map of irrigation facilities and USGS hydrologic monitoring stations in the Walker River Basin.

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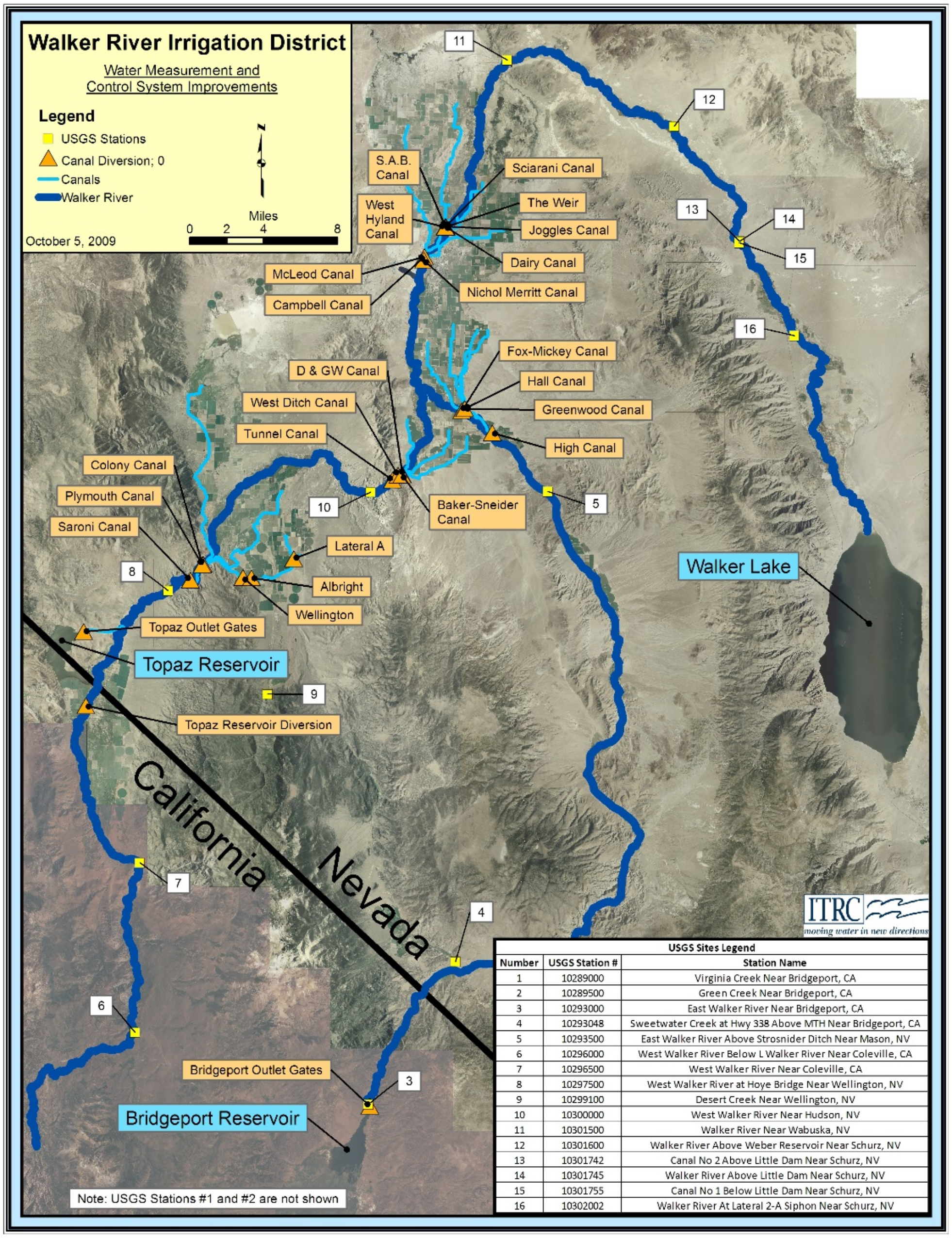

Number	USGS Station #	Station Name
1	10289000	Virginia Creek Near Bridgeport, CA
2	10289500	Green Creek Near Bridgeport, CA
3	10293000	East Walker River Near Bridgeport, CA
4	10293048	Sweetwater Creek at Hwy 338 Above MTH Near Bridgeport, CA
5	10293500	East Walker River Above Strosnider Ditch Near Mason, NV
6	10296000	West Walker River Below L Walker River Near Coleville, CA
7	10296500	West Walker River Near Coleville, CA
8	10297500	West Walker River at Hoye Bridge Near Wellington, NV
9	10299100	Desert Creek Near Wellington, NV
10	10300000	West Walker River Near Hudson, NV
11	10301500	Walker River Near Wabuska, NV
12	10301600	Walker River Above Weber Reservoir Near Schurz, NV
13	10301742	Canal No 2 Above Little Dam Near Schurz, NV
14	10301745	Walker River Above Little Dam Near Schurz, NV
15	10301755	Canal No 1 Below Little Dam Near Schurz, NV
16	10302002	Walker River At Lateral 2-A Siphon Near Schurz, NV

Figure 1. Irrigation facilities and USGS hydrologic monitoring stations in the Walker River Basin

Project Objectives

This project was designed to implement automated flow control to produce better flow rate and volume measurement of water deliveries as well as provide remote monitoring and control of the water deliveries.

In addition, the district-wide SCADA system established in the project will form the backbone for future automation to be installed at other canal headworks. The project also included the upgrading of check structures in the Saroni Canal. The improved water level control structures keep turnout deliveries constant.

Review of Original (pre-Modernization) Water Operations

WRID operates five divisions covering approximately 80,000 acres in Nevada and California. There are approximately 50 sub-systems using irrigation water supplied in part by WRID including community ditch systems.

WRID pre-modernization system operations were characterized as follows:

- The headworks of a typical canal usually consists of one or two wooden slide gates with manually-operated steel lifting mechanisms (with hand wheels). One or two separate sets of slide gates were installed in some sites – with the downstream one (if it existed) operating as flow control. The canals had various types of spill structures; if located upstream of a Parshall flume, the structures maintained a desired flow rate in the canal through manual adjustments to the spill settings.
- Push-up diversion dams were built across the Walker River with large native rocks and streambed materials at the diversion points. This maintained a minimum hydraulic head across the canal headworks when river levels were low.
- The diversion channels at a canal headworks typically had a continuous return flow structure (of various designs) that served somewhat to keep water levels constant at the flow control gates by returning a portion of the diverted flow.
- The main conveyance canals had flashboard check structures of varying designs for maintaining canal water levels for turnouts.

Water orders are filled as follows:

- Ditchtenders take water orders from customers. Some water orders come straight to the WRID office.
- Ditchtenders turn in water cards every day at 1:00 p.m. The summary reports of daily allocations (same as the delivered volume) are based on the compiled information from all the water cards.
- A daily water schedule is allocated to all canal systems and direct turnouts according to the determined natural base flow by the water master. A scheduling meeting is held every afternoon (at 1:00 p.m.) with the water master and ditchtenders to analyze the next day's customers' water requests that are made to ditchtenders compared to the determined natural flow.

PROJECT SUMMARY

Project Components

A total of 17 sites were included in the plan for WRID. Implementation of the recommendations were intended to provide benefits for WRID and its customers by improving the accuracy of measured diversions from Walker River and enhancing the real-time control capabilities of water managers. The system improvements also provide a foundation for future modernization programs and improved transparency of water management in the District. Completion of final designs required some additional information such as local survey data and the preparation of drawings, in addition to an evaluation and field testing of communications options.

Cost Summary

The initial Water Gauge Improvement Project cost estimate was $3.5 million (refer to Table 1). Annual additional O&M costs were estimated to be about $131,000. This cost was primarily for maintenance of the SCADA system. It was expected that the district would enter into a service agreement with an appropriate integration firm for periodic, semi-annual and annual check-ups of the SCADA system.

Table 1. WRID system improvements cost estimate summary overview

Component	Sub-Total Cost†	Annualized Capital Costs	Annual O&M Costs
Project Design, Engineering and Administration	$568,000	$49,000	-
Site Preparation, Surveying, and Civil Works	$313,000	$22,000	-
Canal Measurement and Control Upgrades (17 SCADA Sites and Base Station)	$2,475,000	$233,000	$129,000
Canal Water Level Control Upgrades with Long-Crested Weirs (3 New Structures)	$96,000	$6,000	$2,000
Total	**$3,452,000**	**$310,000**	**$131,000**

† Includes Mobilization (5%) and Engineering & Project Management (15%), plus Contingency (25%)

TECHNICAL SCOPE OF WORK

The following section specifies the major "package" components that were part of the upgrades for each canal headworks. These major components included:

1. A self-contained motorized slide gate(s) in a district-standard configuration
2. A broad-crested weir (built from concrete) to replace the existing Parshall flume(s)
3. A SCADA Remote Terminal Unit (RTU) for automatic control of the slide gate(s) and communication with the office base station in Yerington
4. Various modifications to the existing spill structures (depending on site conditions)

Overview of Water Management Strategies

Implementation of the water gauge improvement projects created new management capabilities for water managers in WRID. The key strategies include the following:

1. Control of diversions based on maintaining a constant target flow rate from canal headworks along the Walker River to match ordered demand for each canal system. Each canal headworks is equipped with new automated flow control gates and control systems for this purpose.
2. One person in the office can observe flows at key points throughout the service area; eventually, information from storage reservoirs will also be available. This central water manager makes decisions on a more frequent basis as part of a real-time and coordinated approach to water distribution throughout WRID's points This involves the new automated hardware at the canal headworks, but also more significantly, active, real-time management of the system.
3. Existing flashboard check structures were evaluated and prioritized for upgrading with long-crested weirs. The improved canal water level control at turnouts means that large changes in canal flow no longer affect the system's capability to provide steady and measureable water deliveries. Operators have the ability to run lower or

higher canal flows in order to meet irrigation demands while keeping more constant turnout flow rates.

4. The start of each canal is equipped with an upgraded water measurement device to be used in the new automated control system. Accurate measurement of canal diversions is important for proper management of scarce water resources. Knowing the actual amount of water delivered to the canals allows for a more complete understanding of the water demands in the system, and makes water records for individual accounts more precise. The flow rates and volumes of water delivered to the different canal systems is also critical information for water users in assessing and upgrading their own on-farm water management.
5. New SCADA capabilities facilitate real-time remote monitoring of conditions throughout the Walker River Basin. Changes to canal flows can be made at specified times with accurate measurement of the current and historical *CFS*, as well as the delivered volume in *Acre-Feet*. The water operations and record-keeping practices have been simplified.

Automated Flow Control Gate Package. A major element in planned upgrades is the introduction of automated flow control gates at the headings of the selected canal systems. As part of this process, the existing slide gates were removed and replaced with a new headgate automation package that includes:

1. Fabricated aluminum slide gate(s) containing:
    a. Gate frame with guide rails, seals, and cross bars (self-contained)
    b. Reinforced rectangular gate leaf
    c. Stainless steel threaded shaft
2. Electric motor gate actuator (several standard sizes based on site conditions) with:
    a. Local control switches/pushbuttons
    b. Top mounting (on top of gate frame)
    c. Hand wheel for manual operation
    d. Internal gate position sensor
    e. Internal end-of-stroke limit switches
    f. Solar power
3. SCADA controller and communications

The objective was to have a **district-standard** slide gate and actuator package in WRID at all district canal headings.

The slide gate(s) require the following specifications:

- Series 8200 Fabricated Slide Gate (by Fresno Valves and Casting Inc., Selma, California) or approved equivalent
- Gate material (frame, slide and reinforcing): aluminum
- Stem material: stainless steel
- Flat back mount (secured to either a concrete headwall or angle iron)
- 3-sided J-seals (sides and top)
- Flush bottom seal

The electric motor actuator requires the following specifications:

- Rotork IQ Series or approved equivalent
- Series IQD10, multi-turn [Direct current, 24 VDC]
- Local controls (local/stop/remote)
- Internal position sensor with 4-20 mA AO or Modbus Interface Card (2-wire RS485)
- Torque switch protection and over-temperature protection
- Side-mounted hand wheel

The SCADA integrator is responsible for all the connections from the actuator to the control system and for the design and installation of the solar power system.

In order to fabricate the gates, the manufacturer requires information such as the opening width and frame height. The self-contained frame design can be mounted in place of the existing tandem wooden headgates using either anchor bolts into the existing concrete walls or anchoring to new pieces of angle iron that are mounted to the concrete walls.

Flow Measurement Upgrades with Broad-Crested Weirs

Properly designed, constructed and maintained water measurement devices are a key component of the proposed irrigation modernization improvements in WRID. In addition, accurate flow measurement structures were required for integration with the new automated flow control gates. These structures were installed at the headworks of each canal system identified in the plan.

Several issues with the existing Parshall flumes at the canal headworks were observed during the initial site investigations of the WRID system including:

- Maintenance. The Parshall flumes were mostly constructed of mild steel and did not have anodes for corrosion protection. The condition of some flumes was poor enough that they had to be rebuilt instead of just primed and painted. For long-term use any re-painted steel flumes had to be equipped with anodes, at additional cost. Pitting and uneven surfaces of old steel flume walls/floors can decrease accuracy.
- Moss problems. Medium-to-heavy levels of moss growth were observed at every Parshall flume visited. **Figure 2** shows an example of moss growing at the entrance to the Parshall flume in the S.A.B. Canal. This growth affects the hydraulics of the structure enough to lower its accuracy.

Figure 2. Moss growth on the entrance to the Parshall flume in the S.A.B. Canal

- Over-designed capacity. The original Parshall flumes (or pairs of flumes in some cases) were over-designed relative to the maximum canal flow rate they were intended to measure. For example, a 6-ft Parshall flume has a free flow discharge capacity of 103 CFS at a measuring head of 2.5 ft; however, most of the existing 6-ft Parshall flumes were only handling flows of about 25-30 CFS. It is more difficult to accurately measure lower flow rates with higher capacity Parshall flumes.
- Non-standard conditions. Most of the examined Parshall flumes were generally within the design tolerance of the key dimensions. Parshall flumes are designated by the width of the throat section (*W*), and generally this dimension was within a few hundredths of a foot of the requirement. However, most of the entrance conditions to the existing Parshall flumes did not have the recommended wing walls or rounded corners that help to reduce turbulence. This is particularly important in the case of flumes where the readings are taken manually with a staff gauge. It was observed that many of the existing Parshall flumes were difficult to accurately read within ±0.01 ft on the staff gauges. In addition, the canal banks upstream of many flumes were encroaching on the entrance section so that aquatic weeds or tree branches were partially obstructing the flow.
- Lack of stilling wells. All the flow measurement structures utilized at the upgraded canal headworks required stilling wells for the protection of electronic sensors.

It was doubtful that using the existing Parshall flumes provided any long-term benefits to WRID as part of the water measurement and automated control upgrades. Parshall flumes are generally no longer recommended and have not been built in modern irrigation projects for a number of years due to the superior advantages of the broad-crested weir. Additionally, many of the canal headworks do not have sufficient hydraulic head (drop in water surface) for acceptable controllability of automated flow control gates. At places where the existing head available is less than 1 or 2 feet, there was a drop on the downstream side of the Parshall flume. For example, at the Colony Canal there was only about 1 foot of drop across the slide gate headworks at high flows, but on the downstream side of the flume there was a drop of 0.75 ft.

It was recommended to replace the Parshall flumes at these locations with properly-designed broad-crested weirs, so this additional head could be utilized for control of the automated flow control gates (i.e., the water downstream of the flow control gates would be lowered).

Before a final design decision could be made about the suitability of broad-crested weirs at each of the identified locations, however, topographic survey data needed to be collected and analyzed to determine if there was enough hydraulic head available. The broad-crested weir was determined to be the best device for applications in WRID (for open channel flow measurement) based on the following characteristics:

- Accurate over the entire range of flows
- Simple, easy-to-understand readings that are easily verifiable in the field
- No required manual adjustments, on-going calibration checks, or excessive maintenance
- Vandalism resistant
- SCADA compatible

Figures 3 and 4 show examples of the recommended type of measurement structure.

Figure 3. Concrete broad-crested weir built in a rectangular cross-section (Truckee Carson ID)

Figure 4. Concrete Replogle flume in the Hollow Tree Drain (Grassland Water District)

The broad-crested weir (e.g., Replogle flume, ramp flume or long-throated flume) is a flow measurement device with a proven track record and thousands of successful installations in irrigation districts.

An advantage of installing new broad-crested weirs in the WRID canals is that they will require minimal maintenance except for periodically checking the site to clean moss off the concrete ramp. It would also be easy to integrate these new flumes into the proposed SCADA system.

The Replogle flume will provide an accurate measurement of flow rate. As with the Parshall flumes, the Replogle flume allows for rapid stabilization of flows when the gates are changed and rapid feedback to the RTU controlling the radial gates. The operator is able to monitor the flow rate from the district office and change the target flow rate, in addition to having the option of overriding the automatic function and manually controlling the gates.

ITRC Flap Gates for Automatic Spills. Spill structures were updated at a number of canal headworks sites. In many of these sites there were several feet of drop in the water surface between the canal and the river where the spill was returned. In these places, the recommendation was to install an ITRC Flap Gate to provide a constant water level (within ±0.05 ft) while serving as an automatic continuous spill.

The justification for upgrading the existing flashboard spill structures was that at the same size (i.e., the same width), the ITRC Flap Gate can pass significantly more water while maintaining better water level control. For example, a 4-ft wide flashboard spill would pass about 10 CFS with a depth of about 1 ft (head) on the weir, and the same weir could pass about 30 CFS, but the water depth would have to increase to 2 ft. A 4-ft wide ITRC Flap Gate can pass from 0 CFS to about 50 CFS with only minimal changes in the upstream water level.

There are important operational justifications for having continuous spills upstream of the automated flow control gates. The automated flow gates do not have to move as frequently if operators can always divert more water than is required for irrigation demands. Due to the short distance, It has no effect on the overall amount of water diverted from the river because the ‘excess’ water is immediately returned to the same reach of river. In addition, the continuous spills provide an inherent safety feature in the event there are any problems with the gate automation.

A spreadsheet design program allows users to customize the gate size and weight for the desired location. The updated design spreadsheets are available at http://www.itrc.org/reports/flapgate.htm.[4]

[4] The design spreadsheet provides no analysis of the structural soundness or integrity of a gate or of the supporting structure.

WRID SCADA SYSTEM

SCADA is a valuable tool for enhancing water management. The SCADA component of this project involved the design, deployment, calibration, documentation, and verification of industrially-hardened hardware and software for new canal control and measurement. This system can be remotely accessed in real-time from a base station computer and mobile laptops running specialized human-machine interface (HMI) software.

The new WRID SCADA system has improved the reliability and flexibility of water deliveries throughout the service area. Other benefits of SCADA include real-time water accounting, upgraded record-keeping capabilities for historical analysis and forecasting, and faster response times to user inputs and alarms. Future web-based reporting for water use or water quality datasets will also be facilitated by this well-designed SCADA system.

The implementation of the WRID SCADA system involved a series of steps:
1. Radio testing and evaluation of practical, cost-effective communication options
2. Presentation to district staff and board members of the Water Gauge Improvement Project and decisions about the scope, schedule, and budget for implementation
3. Meetings and field visits to selected sites to finalize details of the hardware requirements, along with any structural modifications involved
4. Preparation of the final RFP
5. Hardware installation, implementation, calibration, testing, etc.
6. Field verification
7. Training and on-site service support

The use of robust equipment and software conforming to standardized specifications, along with following some basic rules and practical techniques, ensure the implementation of a properly engineered SCADA. This type of system is reliable and can be expanded into the future. The following requirements were used to design of the new WRID SCADA system:
- Open system architecture
- A robust high-speed data radio network
- Industry-standard hardware components with Windows-based software
- System scalability
- High system reliability with redundancy of critical systems

Example Site at River Simpson 1 Canal

The location of the River Simpson 1 Headworks SCADA project at the diversion from the West Fork of Walker River is shown in Figure 5. This diversion is downstream from the Plymouth Canal Diversion. The design capacity of the canal headworks is approximately 60 CFS, with an average capacity of 34 CFS.

The layout of the old existing water control and measurement infrastructure at the headworks of the River Simpson Canal is also shown in Figure 5. The configuration and function of the old existing structures consisted of:
1. Two (2) 5-ft wooden slide gates (manually operated)
2. A 6-ft Parshall flume
3. No spill structure on the spill channel back to the Walker River

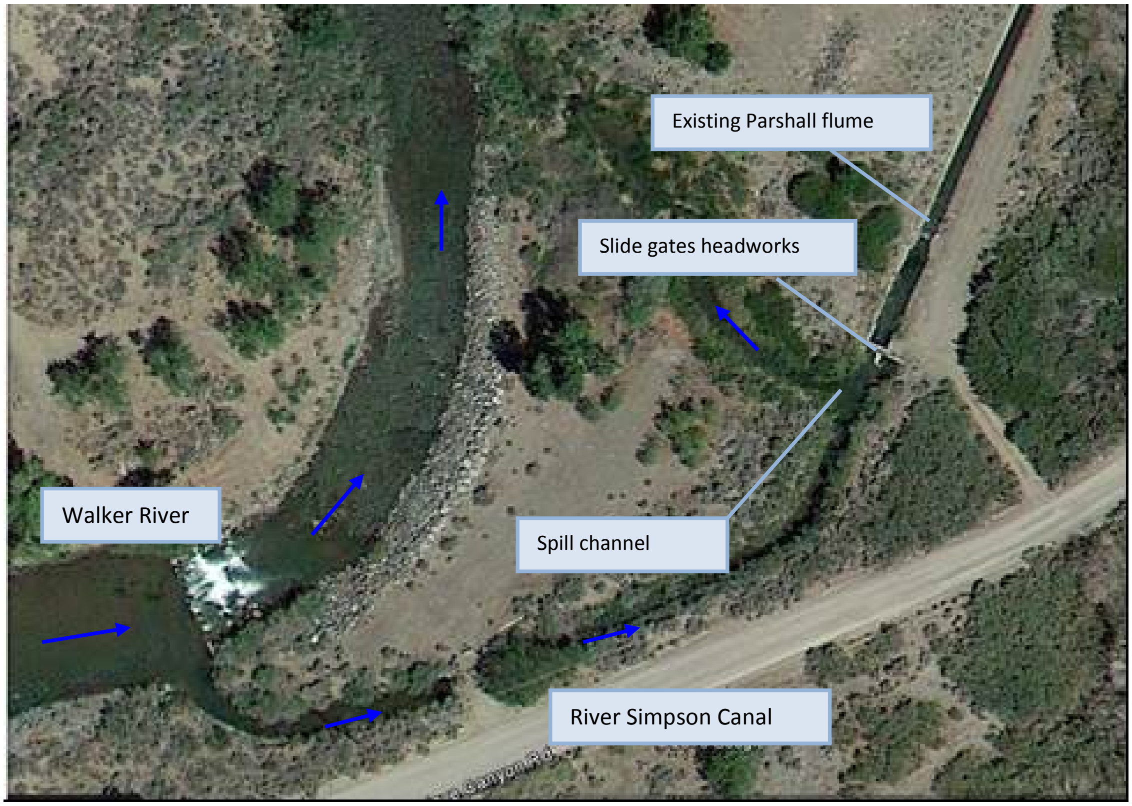

Figure 5. Location map of the River Simpson 1 Headworks on the Walker River

The WRID SCADA project at the River Simpson 1 Headworks involved the following features:

- Communication tower
- Two new automated flow control gates (48” by 60” Series 8200 fabricated slide gates by Fresno Valves and Casting) installed in a new reinforced concrete headwall structure
- Resettable flow rate target accessible via the ClearSCADA HMI workstation at the headquarters office and from SCADA-equipped laptops
- Solar-power (12/24 VDC) to power the system
- Implementation by a team including:
    - WRID: installation of gate hardware, vandalism enclosure, and stilling wells
    - Fresno Valves and Casting: gate hardware and electric motor drive system
    - Integrator: SCADA integration, RTU, redundant gate and water level sensors, HMI programming, radio communications
- Uses district-standard hardware/software
- Flow rate (CFS) and water level data (Feet) transmitted to the base station at the WRID headquarters office every 1 minute via radio
- On-site display of flow rate (CFS) and upstream water level (Feet), and other control parameters, in addition to local data logging and storage

Modernization Improvements. The upgrades at the River Simpson 1 Headworks consisted of:

- Adding a controller and establishing communications with the antenna tower across the river for remote communications to the district's headquarters office in Yerington, Nevada
- Installing a new ITRC Flap Gate (see Figure 6) in the existing open spill channel for maintaining fairly constant water levels on the new automated slide gate. The flap gate was designed with a capacity for continuous spill up to approximately 25 CFS (approx. 4-ft wide and 2-ft deep).
- Replacing the existing Parshall flume with a new Replogle flume that is linked to the SCADA system for automatic control of the slide gate. The new flow measurement structure was installed in roughly the same location as the existing Parshall flume.

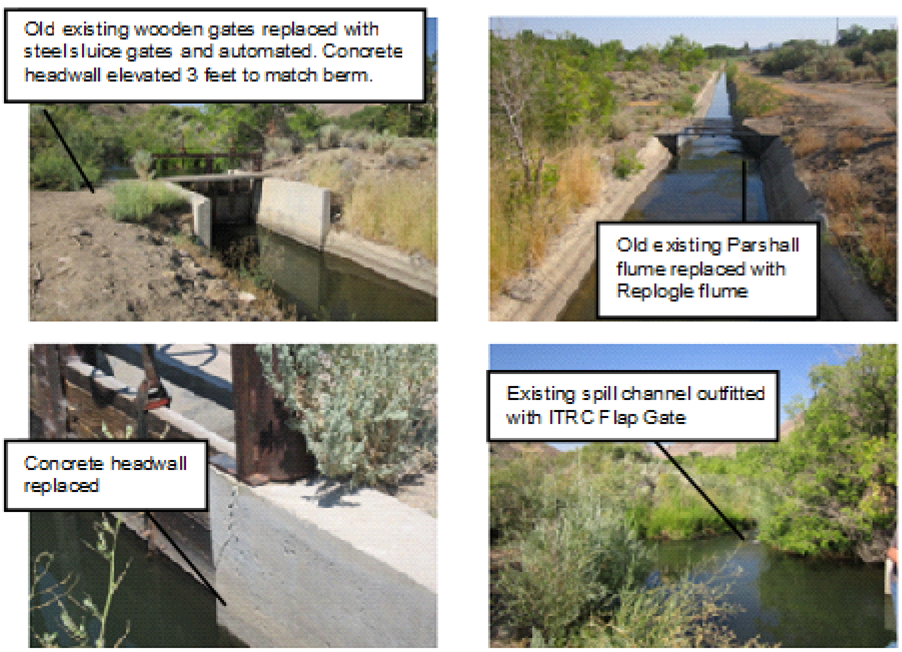

Figure 6. River Simpson 1 Headworks upgrades

SCADA System Operations. An overview of the new SCADA system components at the River Simpson 1 Headworks is shown in **Figure 7**.

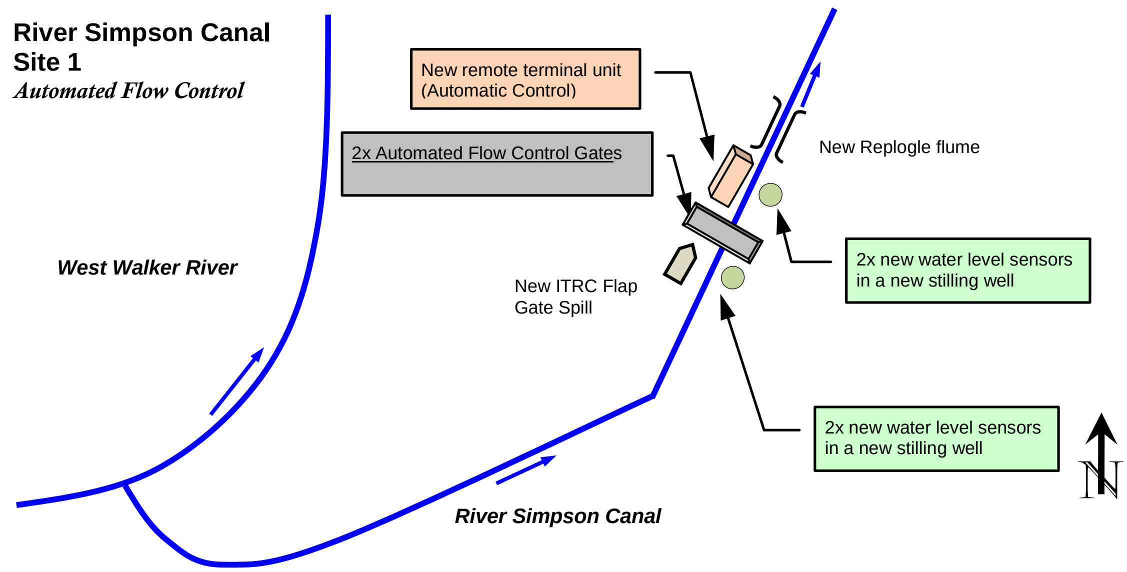

Figure 7. Schematic overview of the SCADA system at the River Simpson 1 Headworks

The main Remote Terminal Unit (RTU) was pre-assembled, bench-tested, and made ready for operation by the Integrator prior to delivery to WRID. Alteration, logic functions, metering, alarm, and all other control components used in the monitoring system are performed by the SCADA system. The "district standard" RTU consists of a stand-alone distributed control center with self-contained electronics and sensor systems including a graphical operator interface terminal. The control system consists of a SCADAPack 32/350 PLC or approved equivalent to control the timing of operation, gate alteration, control, and alarm functions, in addition to other specified equipment. A single PLC was used to control the gate.

Other components of the system include water level sensors; gate position sensors; an autodialer for emergency notification of alarm conditions (via the office HMI software); a battery backup system; and hand/off/auto selector switches and misc. electrical wiring. The water levels sensors upstream and downstream of the check structure (a total of four sensors) were provided and installed by the Integrator.

The SCADA system for the River Simpson 1 Headworks automated gates performs the following functions:

1. User-defined automated flow rate control
2. Remote manual control of the fabricated slide gates to target gate openings
3. Remote monitoring of RTU status (intrusion alarm, battery voltage, etc.)
4. Remote monitoring of the flow rate (CFS) through each gate
5. Remote monitoring of the upstream water level in the river intake channel
6. Remote monitoring of the downstream water level in the Replogle flume
7. Remotely select which of the two redundant sensors (for every measurement) should be considered the "primary" sensor for control purposes
8. Remotely (but via a secure mode) change key controller setpoints
9. Remotely change the operation mode from automatic to manual (if necessary)

All construction and implementation has been completed at the River Simpson 1 Canal site with all components operating accurately and efficiently.

MODERNIZATION SITE-SPECIFIC DETAILS

The following sections show some of the details on the implementation of modernization. Figures 8 through 13 demonstrate the extensive scope of the work to date and thereby show the utility of the plan.

Saroni Canal

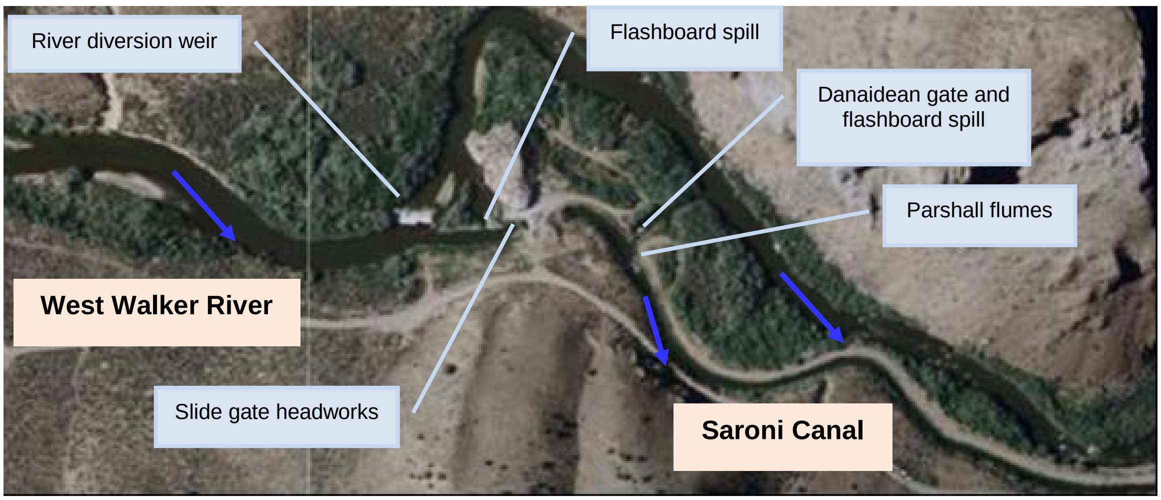

Figure 8. Layout of the existing Saroni Canal diversion from the West Walker River

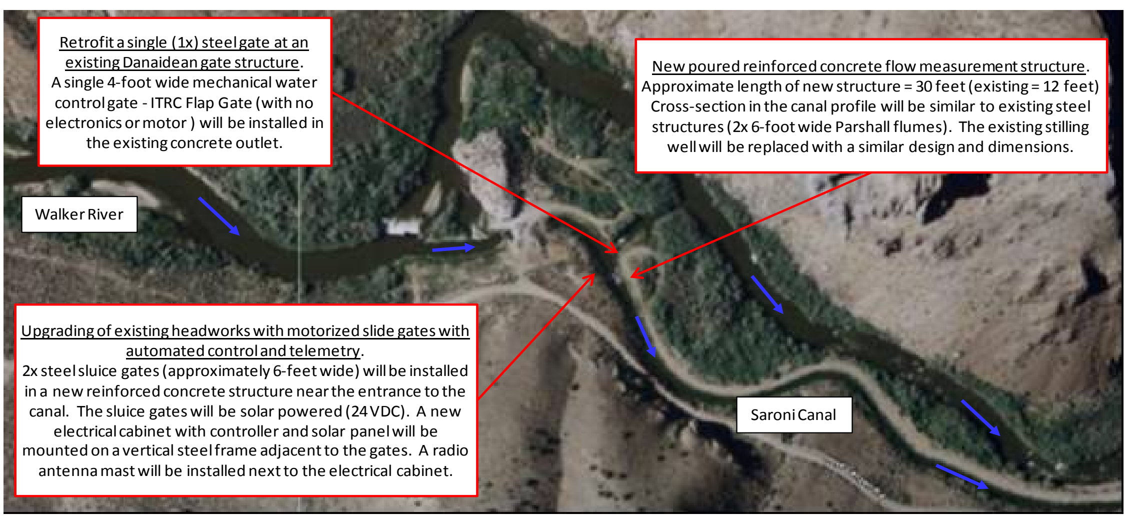

Figure 9. Layout of the modernized Saroni Canal Headworks on the Walker River

The existing Saroni Canal diversion consisted of a 75-ft rock weir for diverting irrigation water, a 4-ft flashboard structure for continuous spill back into the river, two wooden slide gates used for rough flow control purposes, a combination water level control structure with 4-ft Danaidean gate and 6-ft flashboard bay, and two 6-ft Parshall flumes. One of the modernizations consists of two new automatic flow control gates to replace the two slide gates at the start of the canal.

An ITRC Flap Gate replaced the existing spill structure located upstream of the existing slide gates. These slides gates continuously spill approximately 30-35 CFS to maintain fairly constant water levels. A 30-ft long-crested weir was incorporated into the structure for emergency spill purposes to automatically spill excessive amounts of water that could occur in high river conditions. The existing concrete flashboard structure was in poor condition and was removed when the spill structure was installed.

At the tunnel inlet upstream at the canal headworks, it was more economical to install new automated flow control gates instead of building a new structure downstream of the Danaidean gate and create it to function as a continuous spill.

The Parshall flumes were replaced with a single broad-crested weir that is connected to the SCADA system for automatic control of the new slide gates. Buried electrical conduit connects the two water level sensors installed in a stilling well and the new broad-crested weir to the new RTU that was installed adjacent to the new flow control gates at the canal headworks.

Upgrading the structures has had many positive outcomes, some of which include:

1. Better water delivery service to turnouts. The hydraulic head on the turnouts does not vary nearly as much with time.
2. Less rodent damage to canal banks. If the water levels are more stable, the rodents do not have as much opportunity to dig into wet, but unsaturated, soil.[5]
3. Fewer accidental spills; low-risk inherent safety for operations.
4. Better worker safety conditions; safer access to control structures.
5. Less-frequent adjustments and more efficient use of labor resources.
6. Ability to operate at higher flow rates. If the water can be maintained at more stable levels, with a high degree of confidence, then the canals can be operated with less freeboard – allowing higher flow rates.

[5] This is a common situation but it is not known at this time how much of a problem rodents cause in WRID.

Plymouth Canal

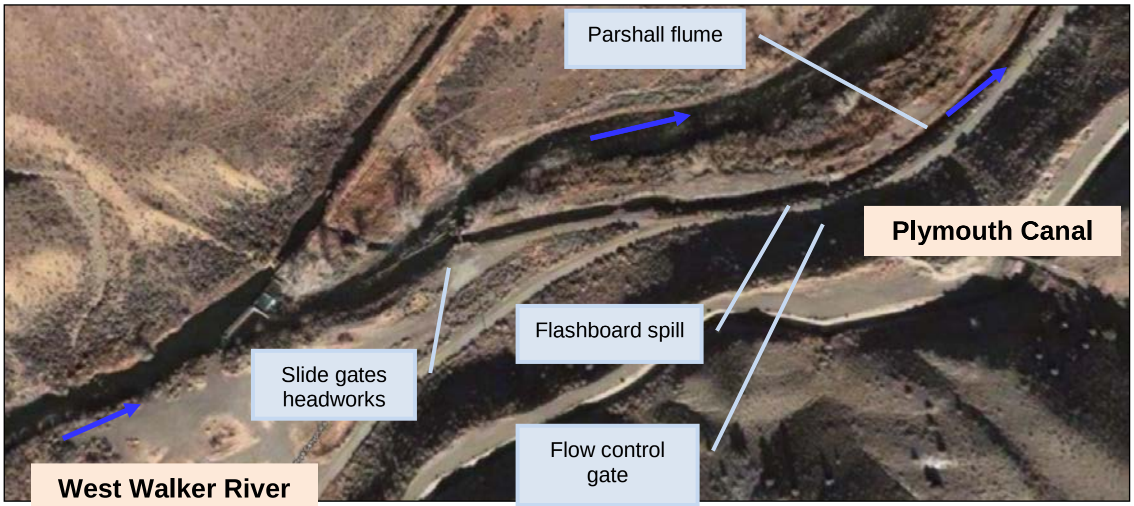

Figure 10. Layout of the existing Plymouth Canal diversion from the West Walker River

Figure 11. Layout of the modernized Plymouth Canal Headworks on the Walker River

The existing water control and measurement infrastructure at the headworks of the Plymouth Canal consisted of two 6.25-ft wooden slide gates (manually operated), a 4-ft flashboard spill structure for continuous spill back to the river, a 5-ft aluminum slide gate with non-functional on-site automated control system (manually operated), and a 6-ft Parshall flume. Modernizations made did not include the two slide gates at the start of the canal. They were left as-is and are normally operated almost wide open.

One modernization that was incorporated was overhauling the existing flashboard spill structure with a new ITRC Flap Gate. The existing headgate was upgraded and includes a controller and data radio modem and antenna tower for remote communications to the district's headquarters office in Yerington, Nevada. The existing control panels were removed and replaced with a new RTU by the Integrator.

Another modernization was the installation of a new water gauge (broad-crested weir) which incorporated water level sensors for use with the new automated control code. The existing Parshall flume was replaced with a broad-crested weir that is connected to the SCADA system for automatic control of the slide gate.

Fox-Mickey Canal

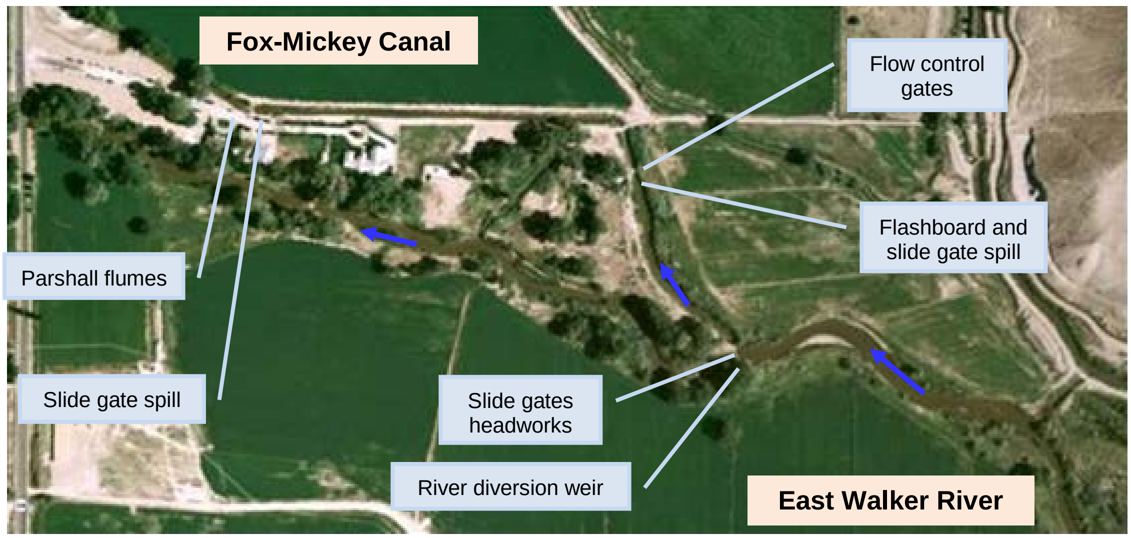

Figure 12. Layout of the existing Fox-Mickey Canal diversion from the East Walker River

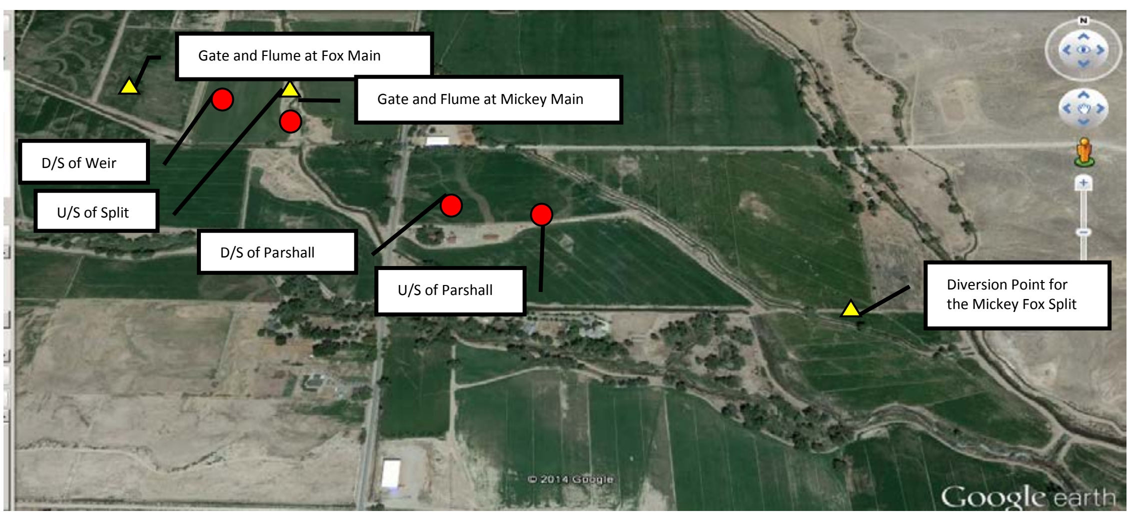

Figure 13. Layout of the modernized Fox-Mickey Canal split

The existing water control and measurement infrastructure at the headworks of the Fox-Mickey Canal consisted of a 40-ft diversion weir, two 8-ft wooden slide gates (manually operated), a spill structure with a 4-ft flashboard bay and a 48-inch slide gate, two 7.5-ft slide gates (manually operated), a spill structure with an 18-inch slide gate, and two 6-ft Parshall flumes. Modernizations made did not include two slide gates at the start of the canal, which were left as-is and are normally operated almost wide open.

One modernization that was incorporated was the overhauling of the existing slide gates with the new design that consists of an ITRC Flap Gate, which maintains fairly constant water levels on the new automated slide gates by continuously spilling approximately 50-60 CFS. The two slide gates downstream of the spill structure were removed and replaced with two new automatic flow control gates. In addition, the Parshall flumes were replaced with a single broad-crested weir that is connected to the SCADA system for automatic control of the new slide gates. The flow measurement structure was installed at a location further upstream in order to reduce the length of buried conduit required. Buried electrical conduit connects the two water level sensors installed in a stilling well at the new broad-crested weir to the new RTU that is installed adjacent to the flow control gates at the canal headworks.

CONCLUSION

The ITRC has input a system of remote monitoring and control that has improved water delivery for WRID. The ITRC has implemented numerous new flow measurement devices, new hardware and control equipment, as well as discussed water management strategies with WRID. There has been no compromise on quality of the engineering design, electronics, and SCADA systems, because in the long run using high-quality, off-the-shelf technology is more economical based on the published experience of the ITRC. The ITRC has approached the modernization strategy by using the simplest device when possible, such as long-crested weirs. Costs on some items can vary widely depending upon challenges with communications, decisions about who does the construction and gate installation work, un-anticipated structural problems, prevailing wages, etc.