10 YEARS OF SUPERVISORY CONTROL AND DATA ACQUISITION MODERNIZATION IN NORTHERN CALIFORNIA (1996 – 2006)

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ABSTRACT

The Bureau of Reclamation, Mid-Pacific Region, Water Conservation Field Services Program (WCFSP), and the Irrigation Training and Research Center (ITRC) at Cal Poly State University, San Luis Obispo, have been working with Reclamation irrigation water contractors and others on district delivery system modernization and Supervisory Control and Data Acquisition (SCADA) development for the past 10 years. In 1994, the WCFSP encouraged the ITRC to develop concepts for district modernization to improve water delivery efficiencies. Dr. Charles Burt and the staff at ITRC observed that in many instances, water delivery systems were operated as more of an art than a science. Every canal or pipe system was different and required intricate knowledge and visual observations by the operators to maintain relatively crude levels of flow balance. The development of affordable, non-proprietary automation systems were considered feasible as SCADA applications were becoming common in other industries such as the automotive manufacturing industry. Coupled with mechanical canal level management equipment design improvements over the years, the industry has made large advances in affordable district level water technologies over the last decade.

MOVING FROM ART TO SCIENCE

"If it isn't broken, don't fix it". A common response when talking with districts is: "We've been doing this for a hundred years, and it's worked so far, so why should we change now?" The response to this could be another question: What comprises "broken"? Broken might be perceived as the lack of response to changing water supply and demand conditions. Those practices that "worked" fifty or a hundred years ago might not work as well today because of the overwhelming public, agricultural, and environmental demands on a fixed and occasionally deficient water supply. While the terminology and definitions may

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be debated, the need for increased efficiency and conservation has undeniably accelerated significantly in the past fifteen years.

Albert Einstein said, "The significant problems we face cannot be solved at the same level of thinking we were at when we created them." This principle also holds true for irrigation distribution systems. Dr. Burt (Chairman of the Board, ITRC) once shared with us his theory of, "moving from art to science." Art is like an artist's stroke on canvas, where each one is unique. Science, on the other hand, is repeatable, constant, understandable, and lends itself to explanation. For decades, water management has been dependent on the skill of the ditch tenders to manipulate an artistic balance between canal supply and farm turnout diversions. Each canal requires a different "stroke". This has worked for a hundred years, but with a highly competitive demand for water, we are now challenged to improve management efficiency. Art does not lend itself well to consistent and repeatable efficiency improvements. Science, however, does.

The first step towards a scientific approach to water management requires a consolidation of information. While parallel efforts on modernization have been on-going at Reclamation's Denver Technical Services Center and in other Reclamation Regions, the ITRC afforded the Mid-Pacific Region professional and student staffing that provided expanded opportunities for literature and technological research. Testing and prioritizing SCADA systems or components that were non-proprietary, the researchers prepared lists of available equipment and software for review and testing. The equipment was tested and subsequent component ratings and recommendations were made available for the development of conceptual modernization plans.

SCADA systems have been around for over twenty-five years. Systems constructed in the 1970's and 1980's were unique and were comprised of hand-constructed components and proprietary programming which tied the district user to the single provider. The proprietary nature of these early systems was the primary hurdle. Parts were expensive because of lack of competition and interchangeability. Likewise, if the programmer ceased business or moved out of the area, there was a problem when it came time for program maintenance.

Recent systems were first used for reporting information. While the architecture of the systems was designed for expansion and automation uses, the early applications were utilized on monitoring propeller meters fitted with electronic heads. The SCADA equipment would send the information to the district office, collecting and displaying real time flow, totalized meter flow, and accumulated (multiple meters) flow measurements. Where pumps were used to divert water, the SCADA equipment was used to monitor pump operation and supply stage status. Alarming was also a capability of the SCADA systems. Alarms were used to call attention to low or high water levels, electrical shut-downs, and pump, operational, or measurement malfunctions.

In the beginning, planning was, and continues to be, a challenge. Like building a house one room at a time, it is vital to have a conceptual plan to work from. Designing a SCADA system that is expandable has proven to save time and significant amounts of resources. Today, non-proprietary programs and equipment are available that can be accessed and understood by a wide sector of the workforce. Parts are interchangeable, highly competitive, and robust.

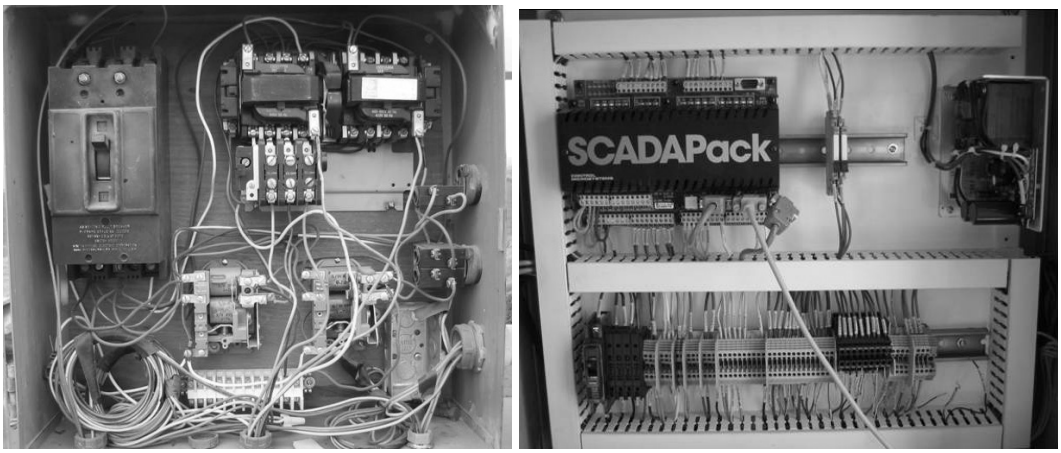

Figure 1. SCADA panels then (left) and now (right)

Water Districts have been encouraged to take a phase-in approach to implementing SCADA and automation technology. It has been Reclamation's experience that many district boards were initially reluctant to move to a system built around computer automated systems. The usual concerns are initial cost, personnel training requirements, reliability, maintenance, and trust. As a result, working through Reclamation and California water conservation grant programs, cost-share funding was provided to assist the districts in initiating demonstration programs.

These base programs usually included setting up the district office with a computer and connectivity (radio or wire), at least one pump station (usually with multiple pumps), and a SCADA package. This would allow the districts to see how the system operates, provide information on a real-time basis, save operator travel time, improve information accuracy, and give the district an opportunity to become familiar with the programming. In this stage, although capable, the SCADA unit is not yet tasked with full operational automation. Rather, it is used for remote turn-on, turn-off, monitoring information and alarms. This provides an opportunity for the operators to verify and develop a level of confidence and understanding of the equipment's operational capabilities.

Finding an Integrator

SCADA system installation requires an electrical engineer or other professional with equivalent experience in system electronics integration. Early integrators

were few. There was little demand and even fewer trained integrators available who had knowledge of irrigation district needs. A "request for proposals" for a district's integration would bring one established integrator from Nevada, one from Central California, and several proposals from turf system "integrators". It was important and very necessary to review the experience of the integrator in making a selection.

Over the years we have determined that all integrator bids should require cost breakdowns as well as identification of manufacturers of component parts. If the integrator is not willing to provide that, it may be appropriate to have a specification sheet from which all applicants can bid. This keeps the field level for the competition and makes sure that the reviewer knows what the district is getting. It also is a way of assuring the district that the equipment for this portion of the project will communicate with the later additions.

A complete SCADA package includes the screens that allow both information-at-a-glance, and automation control. When designing the interface that communicates the essential information to the district's office staff, it is important that the integrator/programmer has all the requested data points that are anticipated to be needed. The district staff should visit other districts with SCADA systems and note the information being collected. A complete package also must include full documentation of wiring schematics, input/outputs and programming specifications for future maintenance.

APPLICATION RESULTS

SCADA has proven to be a vital tool in overcoming common challenges faced by irrigation districts. For example, gravity pipe systems often struggle to "keep the pipe full". When filters become plugged, supply canal levels fall too low or a pump fails to start, a priority situation is created. Or a pipe rupture may result from the water hammer caused by entrained air or sudden valve closure. SCADA monitoring can provide 24/7 immediate alarming phone calls with a description of the problem, as well as collect historic data on the events that led up to the problem. District field staff now have the potential of utilizing mobile internet technology to connect to the office, which will allow them to evaluate the problem from wherever they happen to be at the time. Remote SCADA monitoring also provides simple but timely opportunities to adjust diversion flows or turn on a pump that was stopped due to a power interruption.

From the district office, managers and supervisors can monitor flows, fluctuations, flow totals, pump status and efficiencies, line pressures, reservoir or tank stage, canal level status, upstream or downstream canal conditions, alarms, alarm resets, diversions, demands, power fluctuations, and history. Along with improving supply reliability, these systems provide opportunities to improve operational efficiencies and save electricity, man hours, fuel, and vehicle mileage.

The historic data also proves valuable in management decisions such as contract discussions, delivery disputes, identifying maintenance priorities, and overall system supervision.

Reclamation and District SCADA Interface

In Northern California, Reclamation has responsibility for metering Federal water supply contract diversions from the Sacramento River. In 1996, with the Area Manager's support, the water conservation program developed what was referred to as a "lead the field" program. In this program we looked at how Reclamation in Northern California served its customers and how diversion information was gathered for which Reclamation was responsible. Following guidelines similar to those developed for districts, Reclamation looked at metering accuracy, maintenance schedules, and how we might modernize to better improve efficiency. This was a parallel effort to the WCFSP where we encouraged the districts to do the same.

While most of the over 300 meters along the Sacramento River were the standard propeller meters, we found a few sites with less than desirable measurement results and set priorities for modernizing these sites. In keeping with implementing change slowly, the water meter staff are still going to the field each month and gather the meter data as before. However, things are changing, significant improvements have occurred in data accuracy at many sites, and the confidence in the reported numbers is likewise improving. Erroneous meter functions are recognized much sooner with less travel and oversight. Many of the needed measurement sites that were once considered difficult for quality measurement are now providing good, reliable and highly accurate measurements.

In order to capture the diversion data at Red Bluff Diversion Dam, Reclamation installed SCADA monitoring to the Tehama-Colusa Canal to monitor the pumping and diversion flow activities at the canal diversion and research pumping plant (test site of two 350 hp Archimedes Screw lift pumps for river diversions). With SCADA on the Tehama-Colusa Canal diversion and on many of the Sacramento River districts, it became evident that with a little more effort and expense, it was possible to set up a system with district cooperation that allowed Reclamation to view data from pumping sites in near real-time. Agreements were reached that allowed the Reclamation office to link to district offices for instantaneous flow, flow totals, river stage, and short-term use forecasts. In order for Reclamation to link to districts, agreements were made that the information would be considered draft and confidential, and not be publicly released until verified by and through both office managers. Upon agreement, the district's SCADA computers were programmed with virtual firewalls to prevent access to sensitive data, and thus allowing Reclamation to access the districts for the water information.

Figure 2. Red Bluff Diversion pumping plant

Currently, with the SCADA monitoring function, the districts and Reclamation's Northern California Area Office can respond significantly faster to discrepancies in function or operation. Reclamation staff can view diversion flows, totals and stage data on a near real-time basis (hourly, or more frequent if needed). The target for this office was to have 85% of the diversions monitored from the office; currently we are monitoring over 81% of the total water diversions allocated under federal contract from the Sacramento River by monitoring just 10 districts and one canal diversion representing an additional 17 districts. While there are 7 more districts with potential to be included, diversions by these seven districts represent only 4% of the total water under contract. River stage data is now available for approximately 160 miles along the river from Anderson to near Sacramento.

Figure 3. HMI computer at district control office

SPREADING THE KNOWLEDGE

Throughout the process, the Cal Poly ITRC staff has continued gathering data on new measurement and automation technologies. As the new technologies were identified, tested and recommended, Reclamation encouraged demonstration sites at the districts, implementing recommended modernization measures and devices. Through these programs, districts have installed SCADA systems into their main offices by which they monitor pump stations' flow and operational data.

Cal Poly State University, San Luis Obispo, has provided excellent training facilities for many years. However, it has not been feasible for many Northern California water district staff to travel to San Luis Obispo (in southern California) to participate in the programs offered there. As a result, Reclamation has explored the development of satellite teaching facilities for district and industry participation. With oversight from Cal Poly (ITRC), and the cooperation of California State University at Fresno, Center for Irrigation Technology, California State University, Chico now has a training facility that provides opportunities for training on district, canal and on-farm level SCADA, pumps, flow monitoring and canal flow and level control devices. This makes it convenient for both district personnel and farm managers, located in the Sacramento Valley, to attend modernization classes and industry presentations. As a result of expanded educational programs, training facilities, and SCADA training and integration curriculum in the universities, the number of user districts and pool of integrators is growing. It is rapidly becoming much less difficult to plan, build, and find integrators for district SCADA system water control programs.

CONCLUSION

Over the last decade, advances in SCADA systems have lent to a highly efficient means of remote water monitoring and control. The user-friendly technology has gained a foothold in the Sacramento Valley due to the financial and technical assistance from Reclamation and ITRC. Districts have expanded their use of SCADA, primarily for data acquisition, emergency notification of delivery system malfunctions and automated controls; however, several other benefits have ensued. The use of SCADA improved operational and staff efficiency, decreased operation and maintenance costs, increased water delivery reliability, and significantly improved water measurement at diversion sites along the Sacramento River.

In the next several years, Reclamation envisions a continued acceleration in SCADA implementation throughout the Sacramento Valley. As competition for limited water resources increases, there will be mounting pressure on districts to manage their allocations as efficiently as possible. This work done by Reclamation and ITRC provides a solid foundation for SCADA automation throughout the Valley.