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GLENN-COLUSA IRRIGATION DISTRICT FLOW MONITORING PROGRAM

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ABSTRACT

In 1996, the United States Bureau of Reclamation (USBR), Mid-Pacific Region, Northern California Area Office began the Willows Flow Monitoring Program. The program objective was to monitor, in near real-time, 85% of the Sacramento River Diversions from Shasta Dam to Sacramento. Several site visits were conducted to the Districts and their diversion points along the Sacramento River by USBR and Irrigation Training and Research Center (ITRC) staff from California Polytechnic State University (Cal Poly), San Luis Obispo. One of the sites identified for flow monitoring was the Glenn-Colusa Irrigation District (GCID) canal at the Stoney Creek Siphon. At question was the application and functionality of the Acoustic Doppler Flow Meters (ADFM) inside the siphon channels. Data were relayed through a Supervisory Control and Data Acquisition (SCADA) system provided by Sierra Controls of Carson City, Nevada.

The maximum volume of flow in the GCID canal siphon (3200 cfs) called for three (3), 12'×14' rectangular tubes over 200 feet in length. Each tube required an individual flow meter. Three ADFMs were installed to measure the flow of the water through the siphons. The sensors were placed far enough into the downstream end of the siphon to insure constant submergence. Final installation appeared to work best with the sensor mounted on the side of the rectangular tubes. A structure was constructed for the SCADA equipment that was used for data management and access. As a result of program efforts, the USBR and GCID were set up with the capabilities to poll the GCID Stoney Creek Siphons site and monitor the real-time flow data at their respective office computers.

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BACKGROUND

The new flow measurement equipment installed at the GCID Stoney Creek Siphon is a state-of-the-art implementation of several infant technologies that show great promise for the future of flow measurement for irrigation districts. Three ADFMs were connected to a single computer where the information would be logged into a newly developed SCADA System. The data developed from the site could then be downloaded to the USBR office in Willows or to the GCID main office. This makes a very useful tool for monitoring and recording flow rates into the GCID canal system, providing the Bureau with river diversion data and the district with canal management data.

Several designs were reviewed for the new structure, but the early estimates for the more common acoustic velocity metering in a lined section rapidly grew from $350,000 to over $1.1 million. The USBR, Mid-Pacific Region, Northern Area Office, opted to try a new design that resulted in a cost saving of some $900,000.

SACRAMENTO RIVER FLOW MONITORING PROGRAM

The Sacramento River Flow Monitoring Program was developed to monitor real-time flow and river level data at as many districts as practical on the Sacramento River between Shasta Dam and Sacramento. Presently, the program has succeeded in monitoring real-time flows of 80% of the diversions, with a target of 85% of the river's diverted flow. The USBR continuously works to improve the flow measurement with each of the districts involved and with several more districts becoming involved. Diversions from the Sacramento River are important not only for the USBR, but for each of the districts as well.

The program allows the Willows office to call each of the sites and collect the flow data. The sites use different types of meters to monitor the flow. The most common are propeller meters fitted with electronic heads; but the older technology is giving way to new acoustic and acoustic Doppler technologies. All of the metering equipment produces either a 4-20 mA analog signal or a Digital pulse for reporting flow. The SCADA equipment receives, accumulates, records and provides either a workstation or a reporting station for polling.

Starting in 1996, a base (office) system and one or two remote diversion sites were installed at a couple of districts and at the USBR Willows office. Annually, as funding allowed, programs at these districts have grown and the USBR program has expanded to additional districts. Since neither the districts nor the USBR could bear the burden of "turn key" systems, the program has been a cost-share, joint effort between the districts and USBR. It has been designed to expand as each district recognizes opportunities for applications and essential funding.

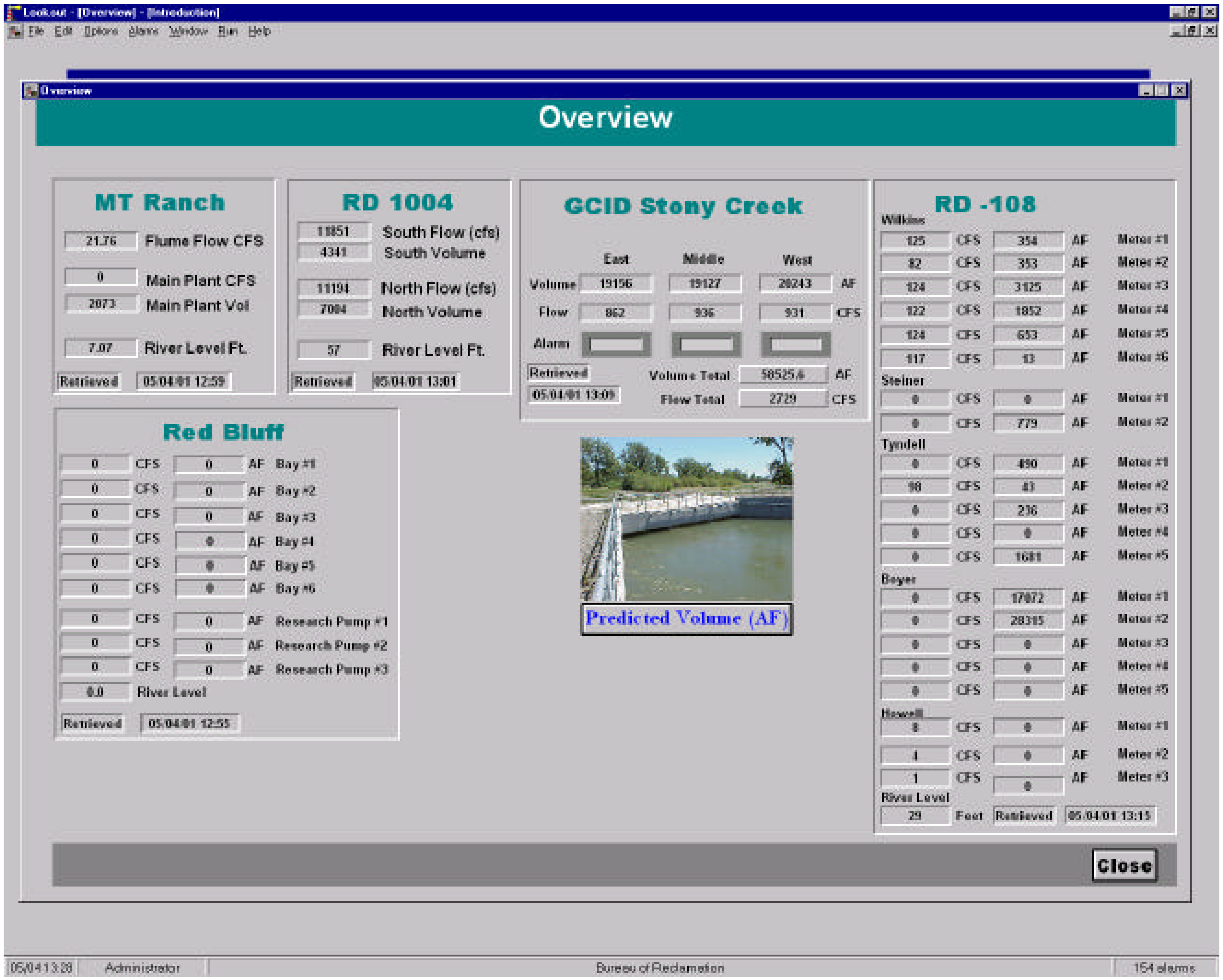

Figure 1. Willows Flow Monitoring "Overview" screen

To utilize the communications available in the system, a flow prediction screen was developed. This screen allows the districts to project diversions seven to ten days in advance and to make updates, as additional information is available. The information is collected at the Willows USBR office as a flow-polling activity, with polling frequency (hourly) and updates being shown on separate predictions screens. The information is then available to the river operations office for use in river flow management. Presently, the information is only requested in years of reduced (drought) flows.

Typically, an integrator works with the districts to program and install the equipment and to train district staff. The integrators being utilized in the Sacramento Valley have been willing to provide services cooperatively with the districts (i.e., allow the districts to bury pipe and run wires, etc.) to keep costs at a minimum. Many hours have been required to get a coordinated program up and running to draw flow data from the many pumps and districts along the river. Annual site visits have been made to most of the districts involved to make adjustments to fix communication problems that have been encountered. Each year more districts and water users are in the process of connecting into the Sacramento River Flow Monitoring Program. The success of this program will be visible at many levels: first, at the river management level; second, at the diverter's management level; and third, at the intra-district canal and water release (turnout) management level.

The GCID Stoney Creek Siphon site is unique because it is a relatively new application of the Acoustic Doppler technology. A housing structure was designed and built to enclose all of the flow monitoring equipment needed. The housing structure includes an air conditioning system to offset the hot summer weather environment of the Sacramento Valley. All of the computer equipment, the ADFM equipment, and the remote monitoring equipment are housed in the housing structure. The structure can be seen in Figure 2.

The housing structure allows the equipment to be stored in a safe place and in an environment ideal for the computer equipment. Any work necessary, from programming the meters to records back up and communications, can be conducted on the computer equipment within this structure. Figure 3 shows the inside of the new structure, along with the computer equipment.

Using the SCADA System, the USBR and GCID can monitor and record real-time flow values at the Stoney Creek Siphon site. The GCID structure houses the computer equipment needed to communicate with the USBR Willows office and with the GCID office. Also housed in the new structure are the ADFM digital electronics and the analog converters for the inputs to the SCADAPack. Figure 4 shows the screen on the Willows computer for the GCID Stoney Creek Siphons.

Figure 2. New flow-measurement structure at GCID Stoney Creek Siphons site

Figure 3. Housing structure at GCID Stoney Creek Siphons site

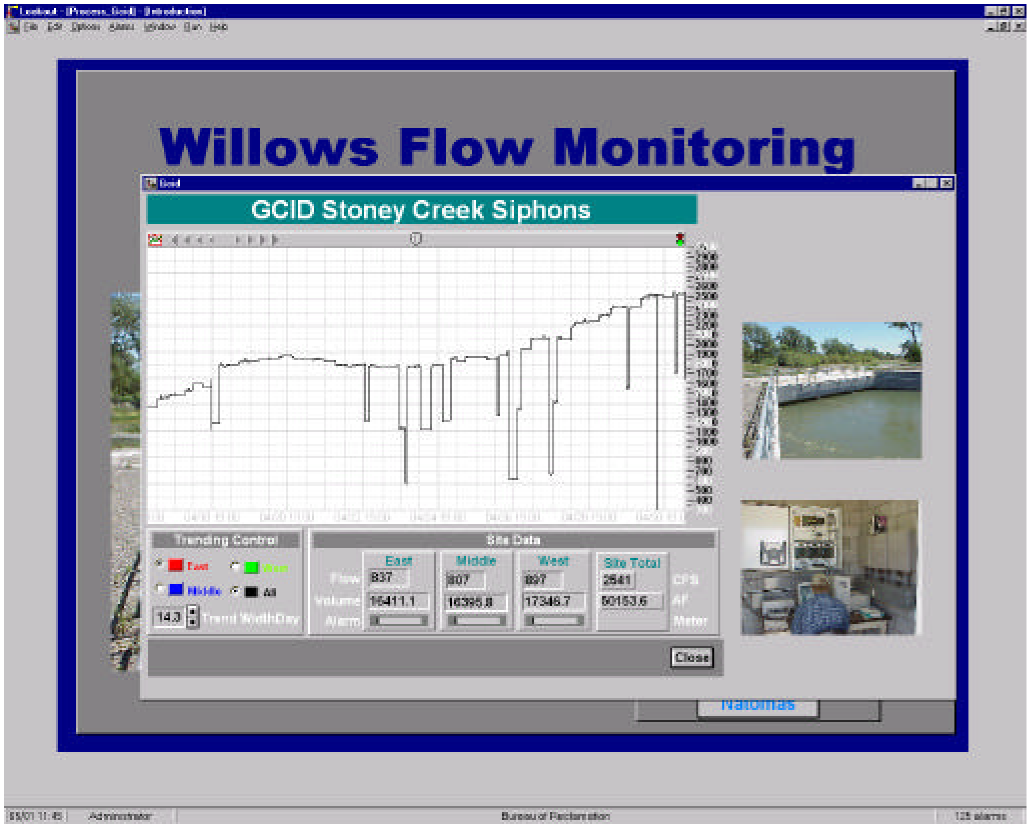

Figure 4. Willows flow-monitoring screen for GCID Stoney Creek Siphons site

MGD ADFM

The ADFM has four piezoelectric ceramics that emit short pulses along narrow acoustic beams pointing in different directions. Echoes of these pulses are back scattered from material suspended in the flow. Since this material has motion relative to the transducer, the echoes have a Doppler shift in frequency (MGD Technologies, 2002). Measurement of this frequency enables the calculation of the flow speed. A fifth ceramic mounted in the center of the transducer assembly, and aimed vertically, is used to measure the depth.

The ADFM divides the return signal into discrete regular intervals that correspond to different depths in the flow. Velocity is calculated from the frequency shift measured in each interval. The result is a profile, or linear distribution of velocities, along the direction of the beam. The profiles are generated from velocity data measured by an upstream and downstream beam pair. Data from one beam pair are averaged to generate Profile #1, and a beam pair on the opposite side of the transducer assembly generates Profile #2 (MGD Technologies, 2002).

Velocity data from the two profiles are entered into an algorithm to determine a mathematical description of the flow velocities throughout the entire cross-section of the flow. The algorithm fits the basis functions of a parametric model to the actual data. The results, which predict flow velocities at all points throughout the flow, are integrated over the cross-sectional area to determine the discharge.

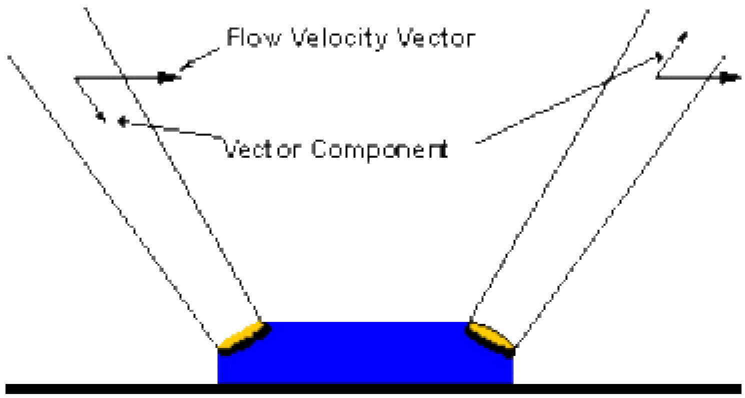

Figure 5. ADFM beam geometry

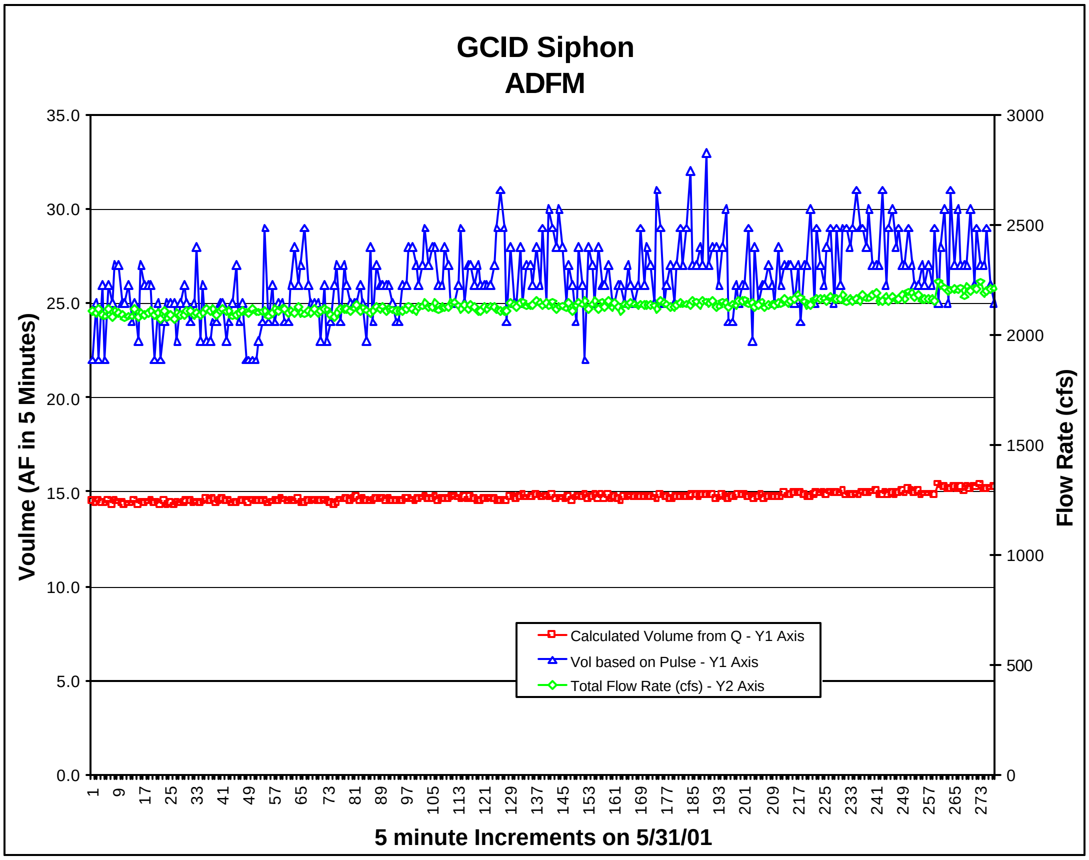

Figure 6. ADFM data at GCID Siphons site on May 31, 2001

KEY ISSUES AT THE SITE

The new flow meters encountered a few problems when first installed. The meters were installed on the top of the cross-section, facing down, for water to flow by. With this configuration, debris that floats on top of the water's surface caught on the ADFM and interfered with the velocity profile measurements. To help alleviate this problem, the USBR hired a diver to clean off any debris that may catch on the meters. In the end, to eliminate the problem with floating debris, the meters were moved from the top to the side of the cross-section.

Another problem that had to be fixed was encountered on one of the meters. While the flow rate could be obtained, the totalizer pulsing was not working correctly. A consulting SCADA integrator (Concepts in Controls, CIC) reprogrammed the code for the totalizer, and it is currently working correctly. Two of the three digital electronics sensor controllers for the MGD device have required repair by the manufacturer (over a two-year period). MGD has replaced the units via overnight response, and the units have been quick and easy to trade in and out.

There have been times when the telecommunications between the Northern California Area Office and the Siphons site have become disabled. The modem has had to be replaced and programming reestablished. The experience in this program effort is that radio communication has been more reliable than telephone. Selection of either depends on availability and functionality.

Use of non-proprietary SCADA equipment has facilitated quick and easy access to maintenance personnel. The use of modular equipment makes it easy for someone with limited electronics background to make many of the replacements necessary for malfunctioning equipment.

SUMMARY

The Sacramento River Flow Monitoring Program began with a concept that real-time information related to flow diversions and corresponding river levels would be beneficial to USBR's management of the Sacramento River. Additionally, the diverters of river water would benefit from having real-time pump operation, flow data and operation automation, as well as having monitoring capabilities at control sites such as their office or homes.

The Water Conservation program can see the relative benefit of improved water management at nearly all levels due to those control and automation capabilities. The program started with a few districts in 1996, adding a couple of districts each year. The Sacramento River Flow Monitoring Program has expanded to include the nine districts that are the major water diverters from the Sacramento River. These nine districts represent over 80% of the water diverted from the river between Shasta Dam and Sacramento. The program has continued to generate interest from other districts with a desire to become involved in this new state-of-the-art flow measurement program.

The new structure at the GCID Stoney Creek Siphons site has been a key factor in the expansion of the program to other districts. This new site allowed the USBR to evaluate an emerging flow measurement technology. Some modifications have been made, such as moving the sensors to the side of the siphon instead of on top. Knowledge gained from this site has encouraged the USBR to move forward in its efforts to include electronic water measurement and SCADA programs at other districts.

Because of the Sacramento River Flow Monitoring Program, diversions from the Sacramento River will be monitored more closely in the years to come. As more districts come on-line to the program, the program approaches the target of 85% monitoring that was originally considered financially feasible, and the ability to accurately measure and monitor the diversions will increase. With these improvements, the foundation is provided for improved water management both on the larger scale of river management and at the district and farm levels.