RECLAMATION

Managing Water in the West

Hydraulic Laboratory Technical Memorandum PAP-1177

Reservation Division of the Yuma Project:

USBR-BIA Cooperative Effort for Measurement/Monitoring of Flows Passing into the Indian Unit from the Bard Unit

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

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Introduction

The Reservation Division of the Yuma Project is located in extreme southeastern California directly north of Yuma AZ. Under this cooperative effort the Bureau of Indian Affairs (BIA) agreed to provide funding for equipment and materials to establish flow measurement and/or flow monitoring capability at selected locations where delivery canals pass from lands in the privately-owned Bard Unit into Quechan Tribe lands in the Indian Unit of the Reservation Division.

Under this agreement the US Bureau of Reclamation (USBR) designed and installed components needed at the respective sites to attain flow measurement capability and/or the ability to remotely monitor, datalog and archive measured flows. The USBR was assisted in installation tasks by staff of the Bard Water District (BWD).

Selected Sites

The three sites selected for this project were reviewed and agreed upon by BIA and USBR. At each of the selected sites water is conveyed westward across Baseline Road from the Bard Unit into the Indian Unit. The selected sites are located on the Pueblo, the Supai and the Waco canals. The sites each presented differing conditions to be taken into account as part of planning and installation of appropriate equipment to achieve the project objectives.

Figure 1 shows the locations of the respective canals, each of which receives flow from the Cocopah canal. Measurement/monitoring locations for each canal are identified by a red circle on the Figure 1image.

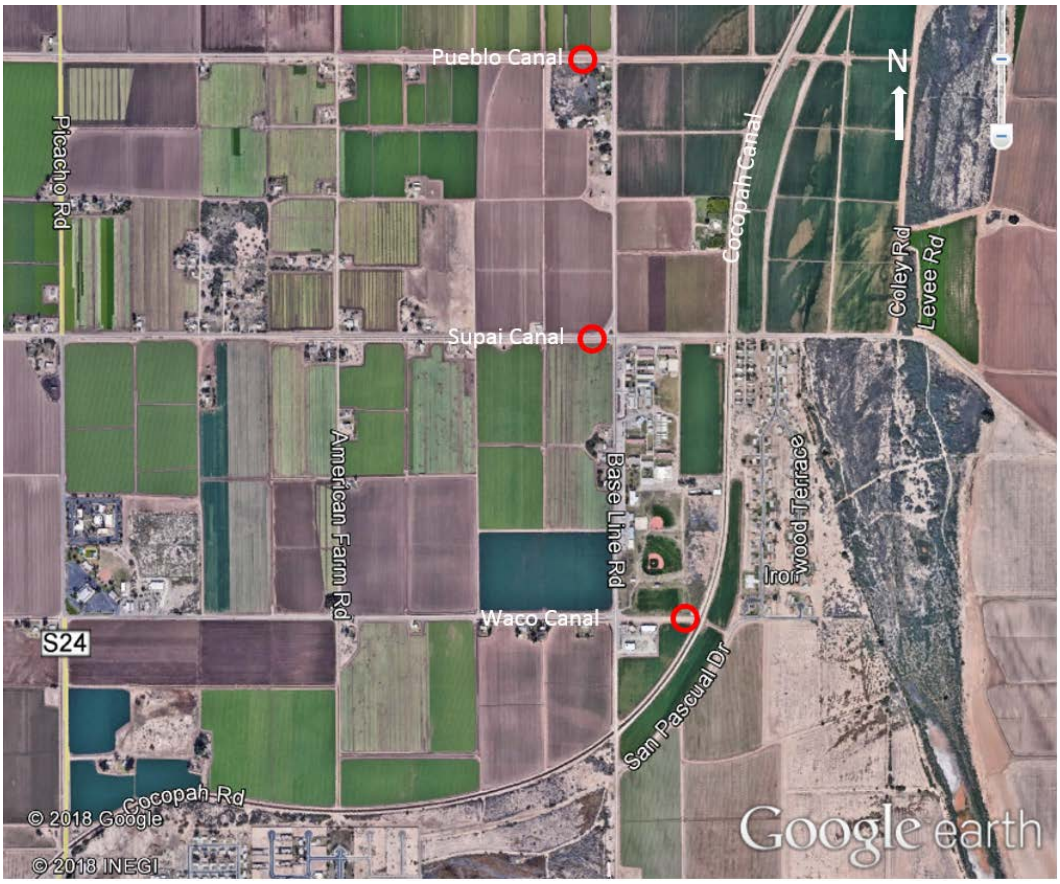

Figure 1. Project Flow Measurement/Monitoring Sites

(Map Data: Google, INEGI)

Flow Measurement Structures

Pueblo Canal

There was no previously existing flow measurement structure on the Pueblo canal in the vicinity of the Baseline Road crossing. The reach of the Pueblo canal westward from Baseline Road to the first turnout location approximately 650 ft. downstream provided a suitable length of straight canal for installing a measuring flume. A laterally-contracted long-throated flume was designed for this location following consultation with BWD staff.

BWD staff indicated that many of the ramp-type long-throated flumes that have been installed at various locations in the Reservation Division have presented on-going maintenance issues. These include sediment accumulation upstream of the ramp flumes and complications with dewatering canal sections upstream from ramp flumes in a timely manner to address canal maintenance issues. A laterally-

contracted flume with a flat bottom will pass sediments and allows the upstream canal section to be readily drained.

A concern for standard operation of a flume in the Pueblo canal at this location was the potential for excessive backwater. This reach of the Pueblo frequently contains ponded water under "no-flow" conditions. When smaller flow deliveries are being made – which is commonly the case for sprinkler irrigation of winter vegetables – downstream users often keep the canal checked up at a relatively high level. It was anticipated that excessive submergence at this site would be an issue for "critical flow" operation of a flume.

Taking the backwater concerns into consideration, the flume for this site was designed for "two level" flow measurement by which water levels in both the approach and throat sections of the flume are measured. With both water level measurements, the flow may be calculated using the same computations utilized for measuring flow in a pipe venturi meter. Figure 2 and Figure 3 show the Pueblo-Baseline Road flume site before and after the flume concrete placement.

Figure 2. Pueblo-Baseline Road Flume Site Prior to Concrete Placement

Concrete "forms" shown in Figure 2 for the laterally-contracted long-throated flume consisted of two aluminum bars on either side of the canal that are bolted to steel "legs" anchored to the concrete canal lining. The aluminum bars define the prismatic geometry of the flume throat. The contraction and expansion sections of the flume were shaped using the aluminum bars along the inner edge and expanding out to meet the concrete canal lining in line with the wooden stakes driven into the canal bank on either side of the canal at the upstream and downstream ends of the flume.

The arrow in Figure 2 points to a section of PVC pipe that was positioned to be imbedded in the concrete at the center of the flume throat. An air tube for a pneumatic level sensor was installed in the PVC pipe after the concrete had cured.

Figure 3. The Pueblo-Baseline Road Flume after Concrete has been Placed

Figure 3 is a view looking downstream at the Pueblo-Baseline Road flume after the concrete placement. The electrical enclosure mounted on a pipe pole, shown on the right side of Figure 3, will house the electronic monitoring and communications equipment. The galvanized pipe on the ground to the right of the pole will be attached to the concrete canal lining, parallel to the concrete lining expansion joint, near the location of the instrument pole. An air tube linked to a pneumatic level sensor was installed in the galvanized pipe for measuring water level in the approach section of the flume.

Supai Canal

For the Supai canal water is conveyed from the Cocopah turnout to the west side of Baseline Road in a buried pipeline. Approximately 45 ft. downstream from the pipeline outflow a ramp-type long-throated flume had previously been installed in the Supai. For this project, the existing flume was retrofit with electronic

monitoring and communications equipment. Figure 4 shows the Supai flume viewed from upstream.

Figure 4. Existing Ramp Flume in the Supai Canal

The existing ramp flume in the Supai seen in Figure 4 was a pre-fabricated metal flume designed for installation in the concrete-lined channel. The "pre-fab" flume consists of a sloped ramp section and a horizontal flume crest section. The sediment accumulation concerns with this type of flume expressed by the BWD staff are evident in the foreground of the Figure 4 photo. For the current project a pipe pole on which the electronic instrumentation enclosure will be mounted was installed in the area shown in the lower right hand corner of Figure 4. In addition, a galvanized steel pipe was attached to the concrete lining near and parallel to the joint in the concrete lining, visible in the bottom of Figure 4, in which an air tube for a pneumatic level sensor was installed for measuring the depth of water above the flume crest.

Waco Canal

Like the upstream section of the Supai canal, the section of the Waco canal which extends from the turnout off the Cocopah canal to the west side of Baseline Road was buried pipeline. The Waco canal pipeline was approximately 790 ft. long. Unlike the Supai canal there was a check gate and a field turnout from the Waco

canal immediately downstream from the pipeline outflow. Thus, there was no suitable location for a flume that would measure all flow delivered by the Waco canal into the Indian Unit.

Given the limited flow measurement options available, the selected alternative was to equip the vertical slide gate that controls flow into the piped section of the Waco canal for submerged orifice flow measurement. Required measurements to obtain the submerged orifice flow measurement are the head pressure both upstream and downstream of the gate and the vertical position of the gate. Figure 5 shows the Cocopah turnout and the pipe entrance location for the Waco canal.

Figure 5. Waco Canal: Cocopah Turnout and Pipe Section Entrance
(Map Data: Google, INEGI)

In order to establish the capability to measure head pressures on both sides of the pipe entrance gate, BWD staff provided machine work to excavate the area along the left side of the upstream end of the piped section. A hole was bored through the concrete pipe for the downstream pressure tap. A second hole was bored through the wall of the rectangular concrete structure to which the pipe entrance gate is mounted for the upstream pressure tap. Flexible plastic pipes were installed and sealed into each of the concrete bore holes. The opposite ends of the plastic pipes were then attached to stilling wells made of PVC pipe.

BWD staff performed backfill and compaction after the stilling wells were installed and linked to the respective pressure taps. In conjunction with the concrete placement for the Pueblo-Baseline Road flume, a concrete pad was placed around the Waco stilling wells. After the concrete had cured, a small

building of welded steel construction was provided and installed by BWD over the stilling wells to provide a secure location for the electronic equipment.

Electronic Equipment

Radios and Programmable Controllers

Programmable control units with integral radios manufactured by Control Design Inc. (CDI) of Placitas NM were utilized for this project. In similar previous projects, USBR engineers have found the CDI equipment to be highly cost competitive and well suited for canal monitoring and control functions. CD110 units equipped with 450-470 MHz UHF radios were installed at each of the three sites. Figure 6 is an image of a CDI CD110 radio/control unit.

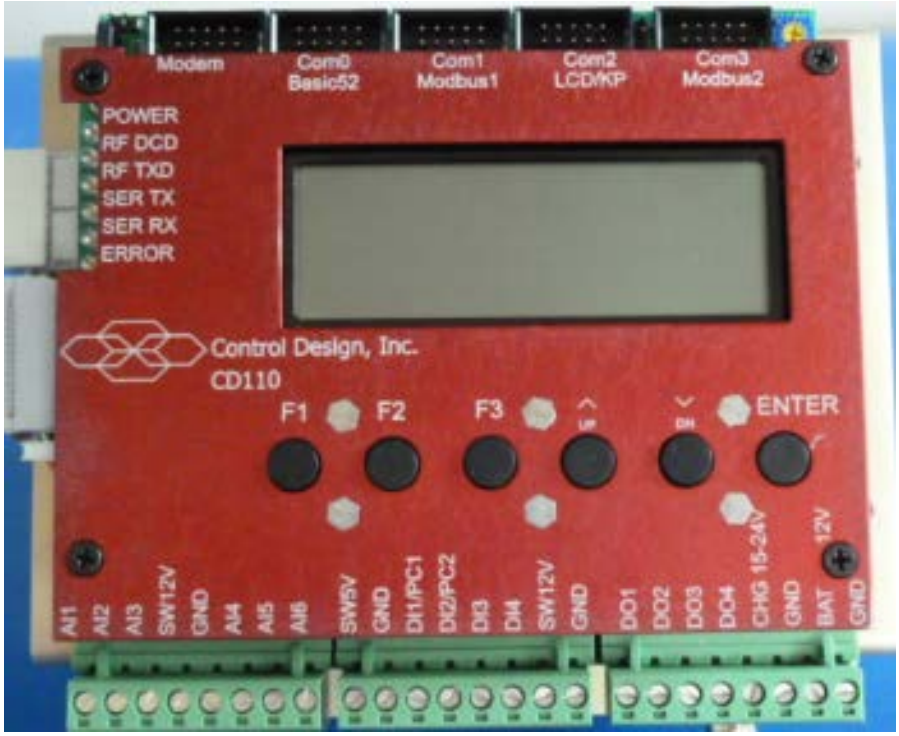

Figure 6. Control Design Inc. CD110 Radio/Control Unit

The CD110 units installed at each of the sites in this project were configured as shown in Figure 6 with an on-board 4-line x 20-character LCD display and 6 button keypad. For this project the CD110 units were programmed to poll for current conditions at 5 minute intervals and to log measured values at 15 minute intervals. The CDI radio/control units utilize the Modbus communications protocol. The circular log buffer utilizes 15920 Modbus registers. This allows

approximately three weeks of on-site data storage before the oldest values begin to be overwritten.

Water Level Sensors

CD103 pneumatic water level sensors manufactured by CDI were installed at each of the three monitoring sites. Program code installed on the CD110 units directs operation of the air pump and reading of the CD103 pressure transducer. At the Waco and Pueblo sites where two water levels are being measured the CD103 pneumatic sensors are equipped with a two output solenoid valve that enables water levels at two locations to be monitored by a single sensor. Figure 7 includes side-by-side photos of single output and two output CD103 water level sensors.

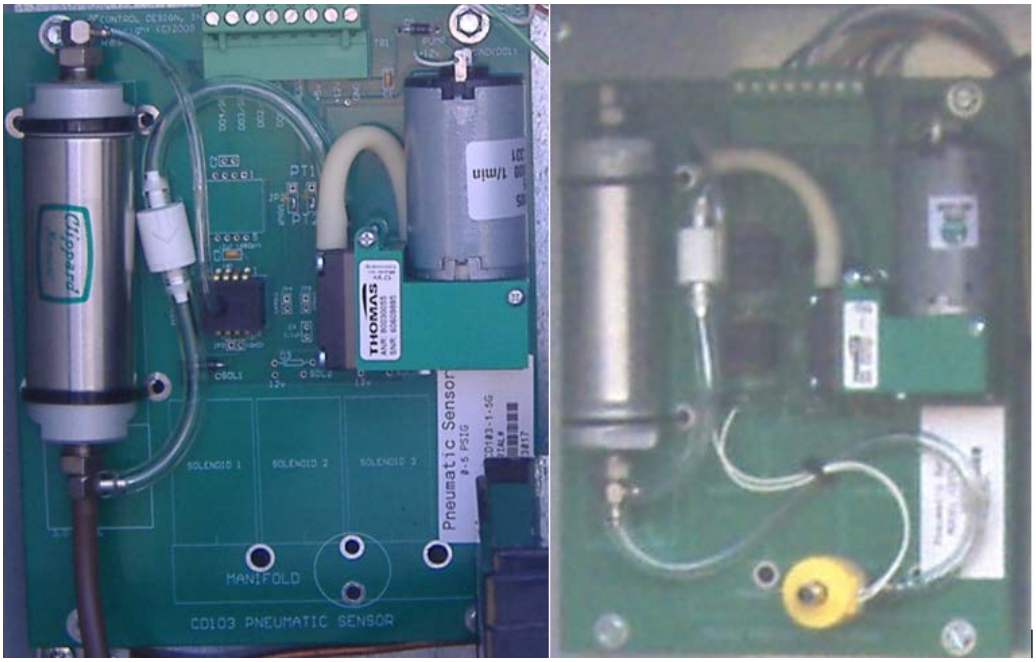

Figure 7. Control Design Inc. CD103 Water Level Sensors

(Left – single output sensor; Right – two output sensor)

Pneumatic water level sensors utilized for similar applications have consistently provided a high level of reliability when all electronic components have been contained within an electrical enclosure with the radio/control units. The dual output solenoid valve option available with the CD103 is a cost effective enhancement considering the additional cost of the valve being significantly less that the cost of a second sensor. Accuracy in measuring water level differentials is enhanced due to the fact that both levels are measured using the same sensor. Thus any electronic “drift” in sensor signal output is expressed equally in both level readings.

Solar Panels and Batteries

Each of the three field sites in this project were set up to operate on solar-charged 12V DC power. A 20-watt 12V (nominal voltage) solar panel was installed at each site. Batteries utilized were 12V deep cycle batteries which were rated at 12- or 14-amp hours. Battery charge is monitored by an on-board charge controller that comes standard with each of the CDI radio/control units. The CD110 radio controllers, the CD103 pneumatic sensors and the 12V batteries were all housed in a NEMA 4 rated steel electrical enclosure at each location. Figure 8 shows images of a mounted solar panel, antenna and electrical enclosure, as well as a 12V deep cycle battery.

Figure 8. Solar Panel and 12V Deep Cycle Battery

Remote Data Collection

Data logged in the CD110 circular log buffers may be retrieved by radio. Data collection is directed by CDI developed software that may be downloaded at no charge from the CDI website. This software program is to be run on a PC linked to a base radio unit. Retrieved data is written to the PC hard drive. The software automatically creates a new file at the beginning of each month for each field site that has been entered into the program. The frequency at which the base station polls the field units to retrieve data may be set by the user.

The CDI data collection software was structured to enable up to five entities to independently collect data from the same field units without interfering with the data collection capability of the other entities. The three monitoring sites of this project were set up to add on to the existing demonstration scale monitoring project established at the Reservation Division in 2015, which includes three additional field sites in the Indian Unit and one site in the Bard Unit. For the demonstration project a base station was installed at the BWD office.

The most recently acquired data may also be retrieved remotely using a mobile "Ditch Rider" radio unit. Data taken at 5 minute intervals is written to Modbus registers organized as "polling" registers. Values in these registers are over-written with new values following the completion of each 5 minute cycle. Values in the polling registers may also be accessed on-sight using keypad input following on-screen prompts.

USBR project engineers have been in communication with Quechan Tribe representative Brian Golding Sr. regarding setting up a base station to enable the Tribe to collect logged data directly from sites monitoring flow entering the Indian Unit. Radio and antenna equipment have been acquired for a Quechan Tribe base station. Plans for installation of a base station are awaiting a pending decision by the Tribe for the desired base station location.

Summary

This project required structural installations at the two of the three sites – the Waco pipe entrance and the Pueblo-Baseline Road flume – in addition to the installation of solar-charged electronic equipment at each of the three sites. At the Waco and Pueblo canal sites contributions of manpower and equipment by BWD played a key role in achieving project objectives.

At the Waco and Pueblo canal sites, determination of flow rates is dependent on operation of the electronic equipment at the sites. The previously existing Supai flume is not impacted by excessive submergence. Electronic flow data at the Supai flume site may be readily compared with the staff gage reading to verify accuracy.

For electronically measured flow data at the Waco and Pueblo canal sites there is not a practical visual means of verifying measurement accuracy. For periodic measurement verification checks it will require making stream gauge measurements in the respective canals at a location downstream from the electronic measurement stations.