PAP-737

Water Measurement Problems and Reclamation's Newlands Demonstration Project

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September 1996

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WATER MEASUREMENT PROBLEMS

The need to measure water is driven by different forces: cost accounting, project operations, water conservation, water rights issues, streamflow requirements, etc. Many problems can arise when trying to measure water quantity, particularly when the delivery system is not designed for water measurement devices, as is the case with many older irrigation projects.

The Newlands Project, located east of Reno, Nevada, is a good example of an irrigation project in need of water measurement. Currently, there are a few permanent water measurement devices on the main canals but no devices on small laterals or farm turnouts. Experience of the ditch riders is relied upon to set flows delivered to each user. Attempts to provide water measurement broadly across the project have encountered the following very typical barriers:

- Miles of unlined canal sections with weed and algae growth, sediment problems, and uncharted seepage
- Very low available head throughout the entire system
- Aging system of manually operated wooden head gates on the turnouts
- A large number of unmetered turnouts and short distances between turnouts and farm delivery gates
- Few sites with power and minimal automation
- Limited funding

Many of these problems are encountered on other Bureau of Reclamation (Reclamation) irrigation projects, particularly those constructed early in our history. This article describes a new cooperative program between the project, district, and the Water Resources Research Laboratory (WRRL) working toward breaking the barriers of water measurement at Newlands. This program is jointly funded using Reclamation water measurement research funds for the demonstration of water measurement and recording devices. Perhaps this effort can provide some solutions for your project.

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INTRODUCTION

The Newlands Project, formerly the Truckee-Carson Project, was one of the first Reclamation projects built to stabilize or store, supplement, and distribute the natural flow of the Truckee and Carson Rivers. The project was authorized in 1903 and is located in the high desert of Nevada at an elevation of about 4000 feet. The project began with construction of the Derby Diversion Dam on the Truckee River and grew in scope with the completion of Lahontan Reservoir that impounds the Carson River flow. The project provides irrigation water from the Truckee and Carson Rivers for the lower Carson Valley near Fallon and Truckee River water to the Truckee diversion near Fernley in western Nevada. The drainage basins contain almost 3,400 square miles with total project diversion of about 350,000 acre-feet of water. The only year that the project recorded using the entire allotment of water was in 1989. The project includes major storage reservoirs, diversion dams, and 326 miles of canals of which only 7 percent are lined. The Truckee-Carson Irrigation District (TCID) has operated the project under contract with Reclamation since 1926.

There are approximately 1,500 unmetered irrigation head gates on the Newlands Project. Most of these sites are not well suited for standard water measurement devices. Many require low head, loss measurement devices that will not be easily fouled by filamentous algae, debris, or sediment. The devices must be easily used with farm head gates and simple enough to be maintained and monitored by the local farmers. The devices should be able to be linked to data loggers that at a future date can be incorporated into a telemetry system. There currently are few permanent measurement sites and no actual remote operation capability of gates or telemetry of flow volumes.

Turnouts on the project are similar in design. Most have a concrete head wall with a rectangular opening about 4-feet wide by 3-feet high with a wooden slide gate. During deliveries the gates are usually pulled out of the water. Generally, only one diversion is open on a lateral at a time. Ditch riders try to supply 25 cubic feet per second for a requested duration to the farmers. Through experience, the ditch riders have established how to set flows into the canal laterals to approximate the discharge needed. Spot checks on the flow are made with hand-held velocity meters. However, the extensive lengths of unlined canal sections producing seepage losses and varying canal water elevations often hinder sustained accurate accounting of water supplied to farm turnouts.

NEWLANDS PROJECT OPERATING CRITERIA AND PROCEDURES

Water rights on the Newlands Project are associated with specific parcels of land. Unlike many irrigation projects, Newlands' water users are charged a delivery fee based on a per-acre basis of water-righted land. A court decree specifies the annual acre-feet of water allotted per acre of land as a function of land classification. Water allotments are accounted for based on the water delivered to the farm head gate.

Similar to most irrigation systems, demands on the Carson and Truckee riverflows can quickly outpace available water. As a large diverter, the irrigation project must operate as a partner with several communities and smaller diverters to meet domestic water needs while protecting the rivers and several large wetlands and lakes that are part of the natural river systems.

The operating criteria and procedures (OCAP) were instituted with this water use partnership in mind. OCAP require that annual maximum decreed water entitlements be calculated, and that conservation measures be implemented to improve project efficiency. Incentives and penalties are provided to encourage TCID to achieve efficiency improvements. Efficiency target levels are currently being phased in with the goal of reaching 75-percent efficiency.

COOPERATION

The first phase of determining whether efficiency levels are met is to provide for accurate measurement of the water deliveries. As mentioned, the existing project was not designed with water measurement facilities, and many technical and financial barriers exist to providing adequate measurement.

In 1996, Reclamation's WRRL, along with the Fallon Field Office, entered into a cooperative agreement with TCID to design, install, and test water measurement devices for farm turnouts. Reclamation water measurement research funds are used to partially fund this field demonstration of water measurement technology. Our organizations are collaborating to investigate low cost, low head loss measurement devices that can be used throughout the Project. Farmers at selected sites within the project are also being asked if they would like to participate in the study. As a first step, the study is setting up a field evaluation program of several water measurement devices.

SITE SELECTION

Various sites throughout the project have been visited and information gathered about suitability of water measurement devices. Initially, priority is given to those sites that will provide measurement of several turnouts and those with the greatest available head and freeboard. In general, most of the farm turnouts are closely coupled to field water distribution ditches, have about 0.2 foot to 0.3 foot of head available between the water level upstream of the turnout and flow into the field, and frequently pass filimentatous algae and other weed debris.

Obviously, there are any number of water measurement devices [1] that could be considered at each site. Not all devices are appropriate, however, based upon their expected performance in relation to the design constraints that will be encountered. In addition, each device should be used easily in conjunction with an electronic flow totalizer that will store, and perhaps at a later date, transmit the data to a control center.

Once sites are selected, an important aspect of the project is obtaining the dimensions of the canal sections, including the bottom slope, for selection and design of a water measurement device. A field assessment of the available head is also needed. Therefore, water surfaces upstream and downstream of the potential installation sites for a water measurement device are needed. Measurement of the water surfaces and the top of the canal banks will determine if adequate freeboard is available.

DESIGN AND INSTALLATION OF WATER MEASUREMENT DEVICES

A list of feasible water measurement devices was compiled. Each device was ranked according to how well it would function given the design constraints outlined. The lack of available head, coupled with weed and debris problems and requirements to keep costs low, led to the conclusion to use long-throated flumes wherever possible in the system. These flumes, also referred to as ramp flumes or Replogle flumes, are very easy to install, are accurate, and offer the flexibility of being removable and easily modified to fit the site situations.

Site Description—The first demonstration site is NT22, the 20-second turnout on the N canal. It was chosen because it is a typical site with a concrete-lined trapezoidal canal with 1.25:1 side slopes and a 2-foot bottom width. The canal is 2.5 feet deep and will only require a small flume. Upstream from the turnout is a long unlined section with a 90-degree bend leading to a check structure for an unlined wasteway canal going back to the river. This check gate will allow flexibility in the operation of the flume during the demonstration. Immediately downstream from the turnout is a wooden bridge spanning the farmer's canal. The flume structure is located 20 feet downstream from the turnout in a slightly curved portion of the canal, upstream from any farm turnouts. The upstream geometry is shown in figure 1.

Figure 1.—Geometry upstream from demonstration site NT22 showing the check structure leading to the wasteway back to the river, the turnout, and the bridge over the farmer's canal.

Flume Design—Flume design is based upon the work by the Agricultural Research Service (ARS) and Reclamation [2, 3]. The flumes are critical flow devices, meaning that when critical flow occurs in the throat section of the flume, a unique relationship is established between the upstream head and the discharge. The long-throated flume consists of an approach channel, upstream transition, horizontal throat section, downstream transition, and tailwater channel. The parts of the flume design are shown on figure 2. Any of the flume components may be customized for an individual site. Normally, a rating curve or table can be computed with an error of about 2 percent or less.

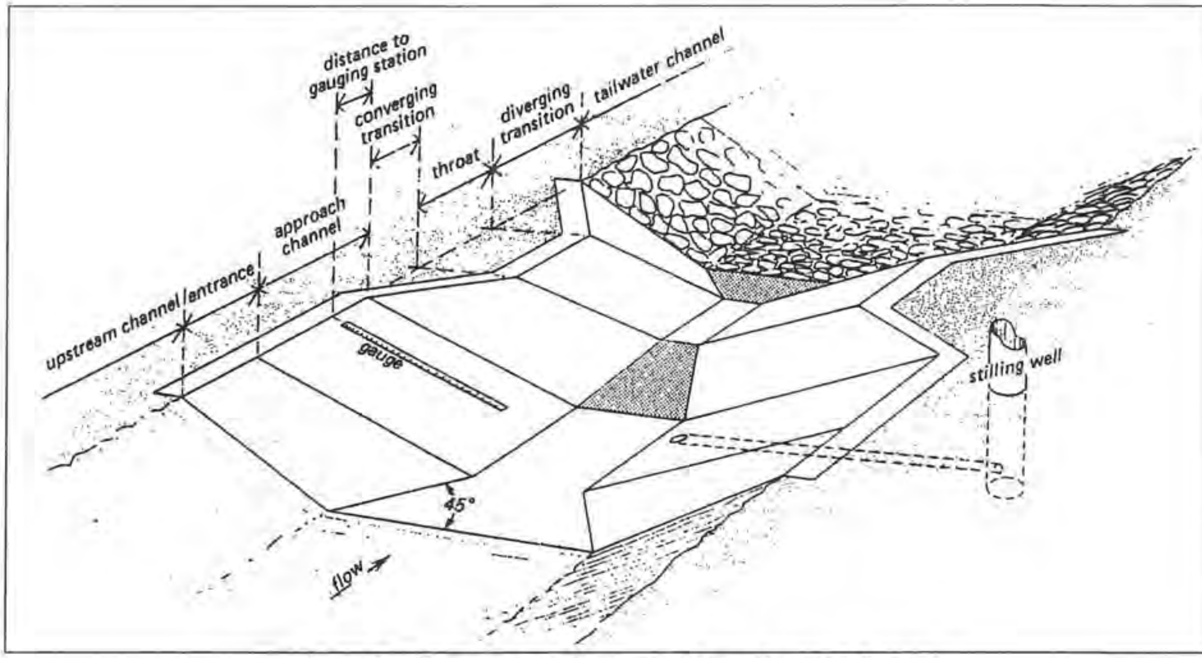

Figure 2.—Components of a general long-throated flume.

A computer program, FLUME, developed by ARS, is being used to design flumes for the Newlands Project [2]. The FLUME program was used to determine the dimensions of the sill in the throat by modifying the sill height and minimizing head loss. No side contractions were used to simplify the construction. Canal geometry and estimates of the water surfaces were used to design a flume for a discharge range of 10 to 30 cubic feet per second, with a target discharge of 25 cubic feet per second.

Freeboard requirements can be varied to minimize or maximize the height of the sill in the throat. Setting the sill height is critical to preventing submergence of the flume and maintaining accuracy. In general, submergence should be limited to 90 percent or less.

A number of sill heights and overall flume lengths could be used for this design. Some flexibility was wanted in the design because of the uncertainty in the canal water surfaces. Therefore, an initial concrete flume section was constructed to a height of 1 foot and two 3/4-inch plywood caps for the sill will be available to be attached on top of the base flume. The flume has a 3:1 upstream slope, or ramp, that transitions up the side slopes to the 2.75-foot-long throat section. The width of the throat sill is 4.5 feet, and the downstream transition slope was omitted. A vertical drop for the downstream transition produces additional head loss but will be cheaper to construct and easier to modify. The head loss produced by flow over the flume for this site is only 0.12 foot. Use of the plywood caps to vary the sill height will allow optimization of the measurement device for this site and information for other canal applications of similar geometry so that additional flumes can be constructed with confidence.

Flume Construction—The flume is shown under final construction in figure 3. This flume is typical of an installation where a bottom sill is added to a lined canal section and is often referred to as a Replogle flume. The flume is 1 foot high with a 3:1 upstream transition and no downstream transition section. The upstream transition and throat follow the 1.25:1 canal side slopes with no side convergence. Two 1-inch diameter polyvinyl chloride pipes were

Figure 3.—Flume under construction at demonstration site NT22. The flume is 1 foot high with a 3:1 upstream transition and a 2.75-foot-long throat. The 1.25:1 canal side slopes lead to a 4.5-foot-wide sill from a 2-foot bottom width.

installed underneath the sill to permit drainage of the canal. The length of the throat section was designed to allow attachment of the plywood shims. A 20-mil plastic sheet was laid over the canal liner before placement of the flume to prevent bonding and permit the flume to be lifted out of the canal, if desired. The total weight of the concrete and the low differential head expected across the flume will prevent movement of the flume under flowing water conditions. Flume construction was completed in a day at a total cost of $425.

Instrumentation—Instrumentation is needed to measure the total flow delivered to the farmer. This includes the startup filling of the canal and the decay in delivery as the upstream turnout is closed and the canal downstream drains. To accomplish total flow measurements, an open channel flow meter was purchased. The meter is an electronic instrument, housed in a tough polycarbonate box with a remote ultrasonic transducer and temperature sensor. These are mounted above the water surface at a specific distance upstream of the flume based upon a function of the head. The instrument measures the water surface by transmitting a pulse signal to the transducer which then emits ultrasonic pulses that echo off the water surface. The time for a pulse to echo back from the water surface is temperature compensated and converted into a head measurement. A discharge equation is programmed into the instrument that was developed during the flume design. The instrument then uses this equation to convert the head measurement into flow rate. The flow rate is totalized and stored in a comprehensive data log for manual access, printing, or remote telemetry. The instrument provides continual readout of the actual and totalized flow. Programming is simple with a removable keypad. The cost of this instrument is $2,500.

At our sites there is no electricity, so the unit is powered by a solar panel and a car battery. There is a backup battery inside the electronic box to provide backup power should the power be lost.

A staff gauge has also been installed at the site. The staff gauge reading can then be used to determine the flow rate once the flume is calibrated. This will allow the electronic instrumentation to be moved to another site and used to determine the total flow. The instrumentation and solar power supply are shown in figure 4.

Figure 4.—Flume instrumentation including the transducer and temperature sensor, solar cell and battery, and the electronic flow meter mounted at site NT22.

CONTINUING WORK

The Newlands Project offers many unique and challenging opportunities for water measurement. The combination of unlined and lined canals, weed growth and debris, manually operated gates, and low available head will continue to require careful application of water measurement technology.

REFERENCES

[1] *Water Measurement Manual*, Bureau of Reclamation, Denver, Colorado, 1975 edition.

[2] Clemmens, A.J., Bos, M.G., Replogle, J.A., "FLUME Design and Calibration of Long-Throated Measuring Flumes" version 3.0, International Institute for Land Reclamation and Improvement (ILRI), publication 54, P.O. Box 45, 6700 AA Wageningen, The Netherlands, 1993.

[3] Dodge, R.A., "Ramp Flume Model Study - Progress Summary," GR-82-14, Bureau of Reclamation, Denver, Colorado, 1982.