Broad-Crested Weir Application on 15,000-Acre Farm

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Abstract

Growers in California have been subjected to increasing pressure to account for water used on the farm due to limited water supplies and increasing energy costs. Water measurement capability provides for equitable distribution of assigned costs and enables effective water management to be accomplished. Broad-crested weirs are proven water measurement devices, especially when applied to on-farm applications. The broad-crested weirs and published data were developed by the USDA Agricultural Research Service in Phoenix, Arizona. This paper is a discussion of an application of these weirs.

Introduction

The corporate farm where the water measurement project was initiated comprises about 15,000 acres located near Firebaugh, California. Approximately 9,000 acres of the area is currently leased to a variety of tenants. Field sizes are typically separated into 60- to 80-acre blocks with cotton and alfalfa the primary crops grown. There are about 200 fields on the ranch. The fields are supplied with irrigation water from a combination of surface canals and deep well turbines. In addition, the ranch has a slough system that allows tailwater to be collected and pumped through booster pumps to other locations on the ranch. Due to a high

degree of flexibility in the delivery of water to the fields and collection of tailwater, the operating efficiency of the ranch is high relative to many other ranches in this region.

Due to increasing energy and water costs, a method to equitably distribute ranch operating costs is required. Initially, a method of measuring the flow through individual furrows was utilized to determine the magnitude of water use for each irrigation of each field. This method proved to be time consuming, and concerns over absolute accuracy prompted the ranch staff to seek alternative methods of measuring water.

An investigation of alternative methods of on-farm flow measurement included canal gate differential head measurement, propeller meters, broad-crested weirs (Replogle flumes), weirs, and orifice plates. The ranch has utilized propeller meters in the past and has experienced problems with moss buildup in the supply canals clogging the propeller. The ranch staff desired a method of flow measurement that would simplify paperwork and provide a long-term solution to equitably distribute operating costs.

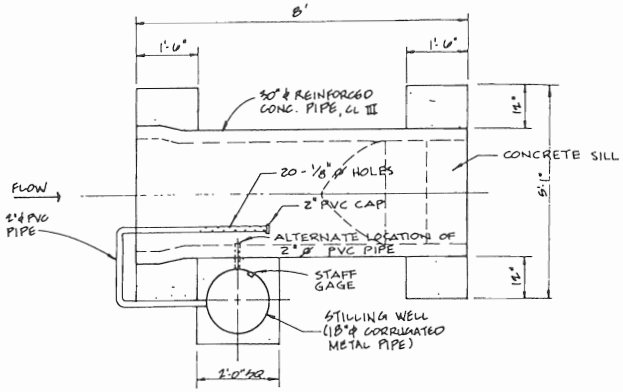
The water measurement plan was impacted the most due to the ranch's numerous dirt-lined ditches. A unique design was required to take advantage of the Replogle flume in a dirt ditch application without having to use portable devices.

Water Metering Plan

Boyle Engineering Corporation provided agricultural engineering services to aid in the creation of a water metering plan. The design selected for use throughout the ranch was a Replogle flume modified for a 30-inch concrete pipe (Figure 1). Based on an investigation of alternative water measurement methods and the construction of several test structures, the broad-crested weir or "Replogle" flume design was selected to provide an acceptable degree of absolute accuracy, yet remain economical for construction.

Based on laboratory measurements of this type of structure, published by Bos et al. (1984) and measured field data, the instantaneous flow measurement can be expected to be within 5 percent accuracy.

Each field has been investigated, and a Replogle flume has been be installed where applicable. Replogle flume design was done by Boyle Engineering and surveying



PLAN VIEW

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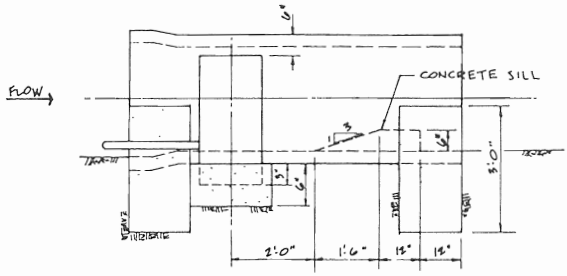
NOTE:
RCP FLOWLINE SHALL BE INSTALLED LEVEL.



ELEVATION VIEW

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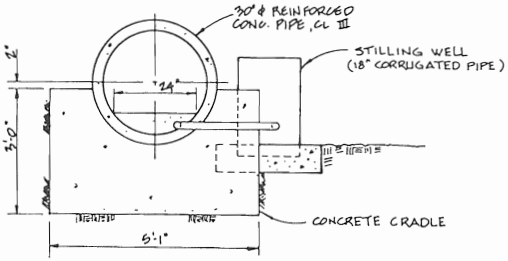

END VIEW

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FIGURE 1
30" DIA. CONC. PIPE REPLOGLE FLUME

by another professional. Sites were reviewed for applicability and suitability. Upon approval, Replogle flumes were constructed by the farm's staff during the winter months. At peak production, one four-man crew would install three Replogle flumes per day.

Replogle Flume Design

A standard Replogle flume design, as shown in Figure 1, was selected for each of the new flume construction sites. The elevation at which the inside of the bottom of the 30-inch-diameter concrete pipe is set will vary from site to site, depending upon average flow conditions. The standard design flow rate was 3.0 cfs.

There are advantages associated with using a standard design:

- Ease of Construction. Dimension repetition consequently enhances work quality.
- Ease of Measurement. Only one rating table is required for these new flumes to translate staff gauge readings into flow measurements.
- Standard Equation. The standard Replogle flume design includes a 6-inch sill height with the following discharge equation:

$$Q(cfs) = A * [SH1(ft) + B]^{U}$$

where:
- Q = flow rate in cubic feet per second
- SH1 = Reference head above sill in feet
- A = 6.904
- B = 0
- U = 1.564

Approximately 25 percent of the proposed flume sites did not appear suitable for a Replogle flume installation. These sites needed further evaluation. The difference between the canal high water mark and downstream ditch high water mark was less than 0.6 feet, which may not provide a sufficient head for adequate flow through a Replogle flume. Further investigation of flow conditions was required before a design recommendation could be made.

The flume accuracy is susceptible to the fluctuating heads in the surface canals. Since the flumes are used to totalize water use, the farm is investigating several

solutions to the problem of varying water levels during irrigation events.

- Multiple staff gage readings per day.
- Stilling well recorders for continuous measurement.
- Stricter controls on irrigation event timing.
- Modification to canal controls to limit head fluctuations.

Conclusion

The growers raising crops on this farm have reported good results with the new installations. The growers report the devices are an improvement over other water measurement systems. Growers are now utilizing the devices to improve overall water management of individual fields.

Reference

Bos, M.G., J.R. Replogle, and A.J. Clemmens, 1984. Flow Measuring Flumes for Open Channel Systems. John Wiley & Sons, New York, NY.