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Measuring Water Flow and Rate on the Farm

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Introduction

Proper water management involves two basic considerations: *when* and *how* much irrigation water to apply. The timing of an irrigation event (*the when*) involves utilizing information on plant needs and soil water conditions. *How much* depends primarily on the soil's water holding capacity, the depletion level and the rooting depth of the crop.

Once you have calculated how much water to apply, how can you be sure that you have accurately applied that amount? Or, if you miss your target amount, how do you determine how much water you actually applied?

The amount of water applied to a field is a function of time, flow and area. The time of an irrigation is easily recorded. The amount of area irrigated is also easily calculated. However, estimating flow rate in an open ditch is often guess work, at best. In this bulletin we shall discuss ways to measure water flow in an open ditch.

Considerations in Selecting a Measuring Device

Selecting the proper device for measuring water flow is often difficult due to several factors. Possibly the most limiting factor for most growers is cost. This includes the cost of the device itself as well as costs for installation and maintenance. Quite often, the materials needed to construct the device are less expensive than the cost of installation.

Accuracy is another important factor, although most may say that "some information is better than none." Growers should be aware that many devices yield great accuracy in a laboratory setting, yet fail in the field. Be sure to ask about the field accuracy of the device.

The ***flow range*** of the device must also be taken into account. Devices such as sharp-crested weirs, short-throated flumes or submerged orifices do not operate well in high flow situations.

Head loss is another consideration when choosing a water flow measurement device. Sharp-crested weirs usually require more head loss than do broad-crested weirs or acoustic flow meters (ultrasonic). However, sharp-crested weirs cost less and can measure much lower flows.

The ***condition of your site*** is also a factor. Is the canal or ditch that you are measuring lined or unlined? Is it concrete or plastic? Is the ditch geometry common or was it custom designed for your farm? Ultrasonic meters, for example, do not work well when the geometry of the ditch is irregular, but portable flumes can often be installed with acceptable results.

Different devices yield different types of information. Instruments such as weirs and flumes are used to measure the flow rate, but do not include volume. Most meters measure total volume. Some new ultrasonic devices give accurate measurements of both rate and volume. Decide whether you want ***rate or volume***.

The ***quality of the water*** needs to be considered when choosing a water measurement device. The device's ability to pass sediment and debris can become critical when working with open channel flows. Although flumes and weirs pass debris easily, they often have difficultly with sediment. Sediment can build up in the flume or weir, giving a false reading.

Another component in measuring water flow is ***operation and maintenance***. All too often, devices are installed properly—but poorly maintained. Poorly maintained equipment yields poor measurements and erroneous information. Factors to be considered include the need for electricity and the number of moving parts that may wear after time.

Construction and installation are always integral concerns, as equipment varies greatly. Installation of flumes does not require a high level of precision, but proper installation of an ultrasonic meter may take time and patience.

Having the ability to ***verify*** your device in the field can be very important. Slight differences in installation procedures often cause these devices to be misread and require field calibration. Also, be sure to check on the ease of troubleshooting and repair when choosing a measurement device

Finally, consider how many of these devices you need and then decide which one will give you the best ***repeatability.*** It is difficult to obtain an instrument that gives you the same standard error from one device to another. Devices vary from one another, each requiring it's own calibration. However, with proper installation and maintenance, most devices will yield acceptable results.

Other Considerations

There are other aspects that also need to be considered. Consider the potential for vandalism in your area. Devices such as ultrasonic meters have high replacement costs; so you will want to protect these as much as possible. Flumes and weirs that are built into a ditch are less likely to be vandalized because there isn't a great deal of equipment to attract vandals.

You may also want to weigh environmental concerns against longevity, maintenance, construction, field verification and standardization. For example, some devices require high maintenance and frequent visits. If the site is located in a pristine wildlife area, you may opt for a device that requires fewer maintenance trips in order to rminimize impact to the surrounding area.

All of these factors have been consolidated into a table developed by the Bureau of Reclamation (Table 1). This table summarizes how various devices compare with each other in terms of cost, accuracy, flow, etc.

The table is presented on two pages. The first page lists the devices and some of the considerations previously mentioned. The second page is a continuation of the same table. The same devices are listed, but with additional information. To use the table effectively, you need to know what flow rates you will have, what you want to measure and whether you are measuring in an open ditch or closed conduit (pipe). For example, what would be a good device for measuring flow rate in a concrete ditch on a farm that usually carries about 5 cfs? (See Table 1-Part 1, check the column marked "Flows < 10 cfs.") The sharp-crested and broad-crested weirs work well in this flow range, as do the long-throated flumes and submerged orifices. The "differential head meters for pipe" also work well, but are intended for pipe.

Next, consider the canal type. The canal is concrete lined and both the broad-crested weir and the long-throated flumes perform best. Both devices have similar accuracy, but the broad-crested weir is less expensive.

Table 1-Part 2 illustrates that both devices will measure rate but not volume. Both pass debris and have similar maintenance needs. In fact, these two devices are the same in Table 1-Part 2 except for construction where the broad-crested weir is considered to be easier to construct.

The decision is now left to you. If you want to save money, install the broad-crested weir. If you want to save time and effort in construction, install the long-throated flume. Either way, you will be helping yourself by measuring the amount of water flowing into your fields. With this information, you will be able to determine how much water you have applied and/or how long your irrigation set time should be. For information on these aspects of irrigation, contact your local Cooperative Extension office.

Reference

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Table 1 - Part1. Water measurement device guidelines from "Water Measurement Manual". 1997. A Water Resources Technical Publication, U.S. Dep. of the Interior, Bureau of Reclamation, 3rd ed. Symbols +,0,- are used as relative indicators for comparison. A (+) symbol indicates positive features associated with the selection criteria. A (-) symbol indicates negative aspects. A (0) means there are no strong negative or positive attributes associated with the selection criteria. A "v" denotes device suitability varies widely, "na" denotes not applicable to criteria).

Device	Accuracy	Cost	Flows > 150 cfs	Flows < 10 cfs	Flow span	Head loss	Site conditions			
							Lined canal	Unlined canal	Short full pipe	Closed conduit
Sharp-crested weirs	0	0	-	+	0	-	-	0	na	na
Broad-crested weirs	0	+	+	+	+	0	+	0	na	na
Long-throated flumes	0	0	+	+	+	0	+	0	na	na
Short-throated flumes	0	-	-	0	0	-	-	0	na	na
Submerged orifices (in channels)	0	0	-	+	-	-	0	0	na	na
Current Metering	-	-	+	-	-	+	0	-	na	na
Acoustic velocity meters in an open channel	-	0	0	-	0	+	0	0	na	na
Radial and sluice gates	-	+	0	0	-	-	+	+	+	na
Propeller meters at pipe exit	-	+	-	0	0	+	0	0	+	+
Differential head meters for pipe[1]	0	-	-	+	-	v	na	na	0	+
Mechanical velocity meters for pipe[2]	0	+	-	0	0	+	na	na	0	+
Magnetic meters for pipe	0	0	-	0	0	+	na	na	-	+
Acoustic Doppler ultrasonic meters for pipe	-	0	-	-	-	+	na	na	-	+
Acoustic flowmeter pipe (single path)	0	-	0	0	0	+	na	na	-	+
Acoustic flowmeter pipe (multipath)	0	-	+	0	+	+	na	na	-	+

[1] Venturi, orifice, pitot tube, shunt meters, etc.
[2] Propeller meters, turbine meters, paddle wheel meters, etc.

Table 1 - Part 2. Water measurement device guidelines from "Water Measurement Manual". 1997. A Water Resources Technical Publication, U.S. Dep. of the Interior, Bureau of Reclamation, 3rd ed. Symbols +,0,- are used as relative indicators for comparison. A (+) symbol indicates positive features associated with the selection criteria. A (-) symbol indicates negative aspects. A (0) means there are no strong negative or positive attributes associated with the selection criteria. A "v" denotes device suitability varies widely, "na" denotes not applicable to criteria).

Device	Measure-ments		Sediment/Debris		Longevity		Maintenance	Construction	Field Verify	Standardiza-tion
	Rate	Volume	Sediment pass	Debris pass.	Moving parts	Electricity needed				
Sharp-crested weirs	+	-	-	-	+	+	0	-	0	+
Broad-crested weirs	+	-	0	+	+	+	+	+	+	0
Long-throated flumes	+	-	0	+	+	+	+	0	+	0
Short-throated flumes	+	-	0	+	+	+	+	-	-	+
Submerged orifices (in channels)	+	-	-	-	+	+	+	0	+	0
Current Metering	+	-	+	+	0	0	0	+	0	+
Acoustic velocity meters in an open channel	+	0	+	+	0	-	-	+	-	-
Radial and sluice gates	+	-	0	-	+	0	+	+	-	-
Propeller meters at pipe exit	0	+	0	-	-	0	-	+	0	0
Differential head meters for pipe[1]	v	-	-	v	+	0	0	0	+	+
Mechanical velocity meters for pipe[2]	+	v	-	-	-	0	-	0	0	0
Magnetic meters for pipe	+	0	0	0	0	-	-	0	-	0
Acoustic Doppler ultrasonic meters for pipe	0	0	0	0	0	-	-	0	-	-
Acoustic flowmeter pipe (single path)	+	+	0	0	0	-	-	-	-	0
Acoustic flowmeter pipe (multipath)	0	+	0	0	0	-	-	-	-	+

[1] Venturi, orifice, pitot tube, shunt meters, etc.

[2] Propeller meters, turbine meters, paddle wheel meters, etc.