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Monitoring Flow with Water Level Loggers:

A Best Practices Guide

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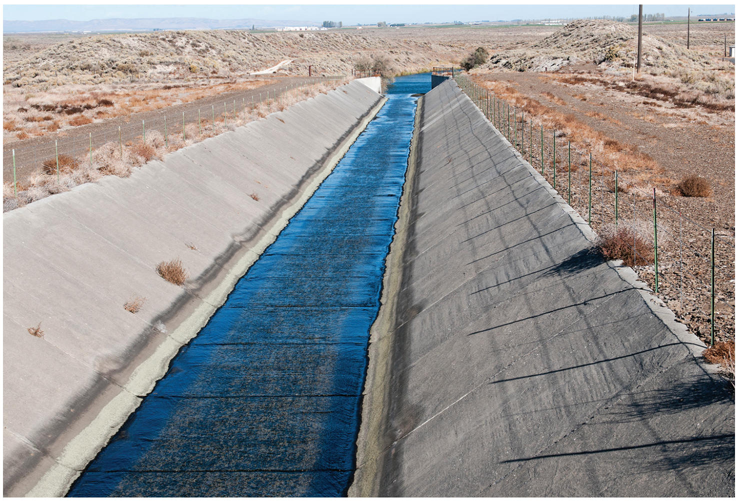
IEI

One of the challenges facing irrigation organizations and individual farms is the accurate monitoring and recording of irrigation water usage in open-channel applications. By using the HOBO MX2001 to record water depth we can then use that depth data to calculate flow rates and water usage in a variety of open channel applications.



Broad-crested weir

Accurately measuring water flow in a canal or small irrigation ditch has always been a challenge. Consequently, many state water departments and engineer offices now require the installation of a measuring device to record a digital log of water usage. Also, water delivery organizations, such as canal companies, are increasingly calling for real-time (or near real-time) records of water usage. They then refer to these records when making decisions concerning water-right deliveries, and sometimes decisions pertaining to water conservation for potential coming dry seasons.

To accurately measure flow in an open ditch often requires the use of a primary measuring device known as a flume. Although there are many types of flumes, those most commonly used in irrigation monitoring are: the Parshall flume, the Cutthroat flume, and the Ramp flume, which is also called a broad-crested weir.

A flume works by forcing the flow of water into a certain relationship between upstream and downstream water levels, thereby creating a known velocity to be used in the calculation of flow rate based on the area (i.e., size) of the flume. Using a flume allows an irrigator to measure the flow rate by simply measuring the depth of water at a certain location within the flume.

A weir, which is another common measuring device, generally requires more upstream freeboard (canal depth) and often can't be used as effectively as a flume.

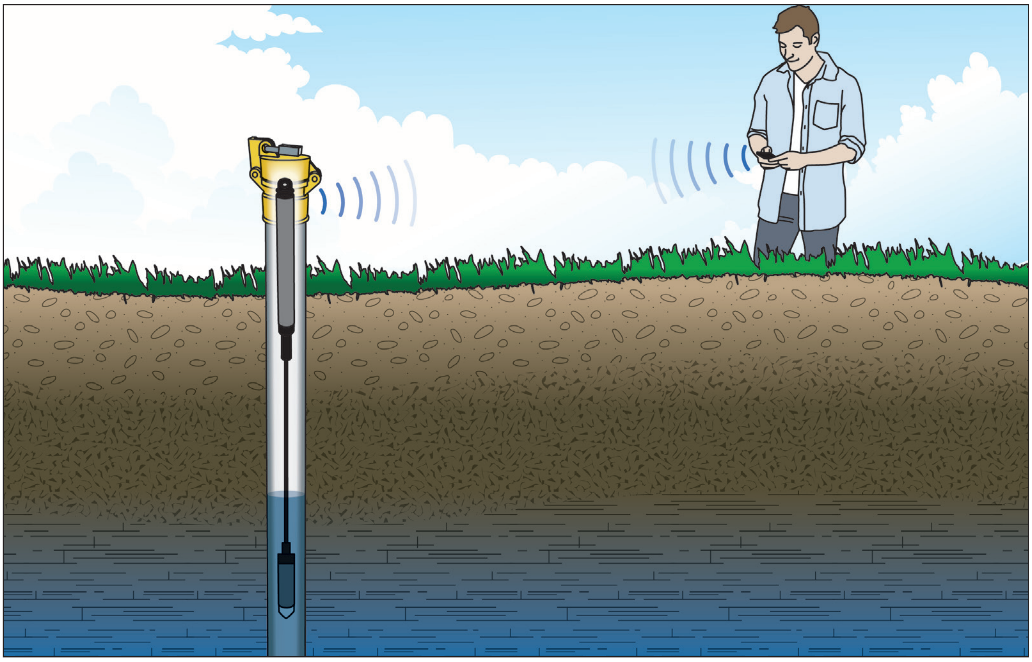
A weir, which is another common measuring device, generally requires more upstream freeboard (canal depth) and often can't be used as effectively as a flume. A weir impounds or dams the water behind the weir structure and then, based on a notch in the weir face, allows the water to pour out of the structure in a free-flowing condition. Using the formula for that specific type and size of weir, a water user can measure flow rate based on the depth of water upstream of the weir.

The depth value used is referenced to the bottom of the weir plate, but depth is measured upstream of the weir plate in the pool of water created by the plate.

HOBO MX2001 & free HOBOmobile App

Other sites, without a flume or weir, may have a rating curve created for the channel at the point of measurement. This involves taking manual water velocity readings using a hand-held water velocity probe, such as a top-set wading rod, with a AA or Pygmy style current meter. This is a popular device used by the U.S. Geological Survey to measure flow rates. By measuring the velocity of the water in the channel, at a variety of depths, it's possible to use an equation to calculate the flow rate at those different depths.

This is not the ideal way to measure long-term flow rates, as accuracy can be compromised due to factors such as plant growth in the channel or other physical changes that happen upstream or downstream. These factors will change the velocity condition of the water. Generally, this option is used when an estimate is all that's needed, or when a water user is willing to make multiple velocity readings throughout the season and over the years to adjust the flow equation to fit more accurately with changes in channel velocity conditions.



The purpose of the following project is to test the feasibility of using the HOBO® MX2001 data logger to provide a digital record of the water level throughout the water season, and then using the data to calculate the water flow usage. Many organizations are interested in collecting this data for the purpose of water conservation, water use records, and water rights issues.

Site 1, 10' parshall flume and stilling well

To begin, three HOBO MX2001 Bluetooth water level data loggers were deployed at three different open channel locations. The MX2001 records the water depth in a stilling well, and the water depth is then calibrated to represent the depth of water in the flume.

Site 1 – Concrete Parshall Flume with 10-foot throat

Site 1 has a steel corrugated stilling well, as seen in the photo. The HOBO MX2001 was installed inside the stilling well to measure the depth of water that represents the depth in the flume.

The 10-foot throat Parshall flume has the following flow formula.

CFS flow rate = 39.38 * Headft^1.6

Headft is the depth of water in the flume at the measurement point.

Site 2, corrugated stilling well next to a 12 ft wide weir

Site 2 – Rectangular Weir 12-foot width non-contracted (suppressed)

Site 2 has a steel corrugated stilling well located at the side of the channel across from the measurement point behind the weir. The HOBO MX2001 was installed inside the stilling well.

A 12-foot suppressed rectangular weir has the following flow formula:

CFS flow rate = 3.33 * 12 * Headft^1.5

Headft is the depth of water in the flume at the measurement point.

The weir creates a pool upstream and then allows the water to free-flow over the weir to create the conditions needed to measure a flow over the weir. It’s critical to have enough drop after the weir to allow for the free-flow condition.

Site 3 – Rated Concrete Box – Flow Curve

Site 3 is like a box culvert without a top

Site 3 is like a box culvert without a top. There are two sections of the box. Each is six feet wide in the inside, with a flat bottom throughout the length.

A rating curve formula was completed to allow the water users to estimate flow rate based on water depth. A flow rating curve is only as accurate as the manual measurements that are made. A larger number of manual measurements made at different water depths can greatly increase the accuracy of the formula.

Free curve-fitting programs available on the internet allow a user to enter manual readings into a table, from which the software creates a polynomial to represent the flow curve in mathematical form. The formula provided is:

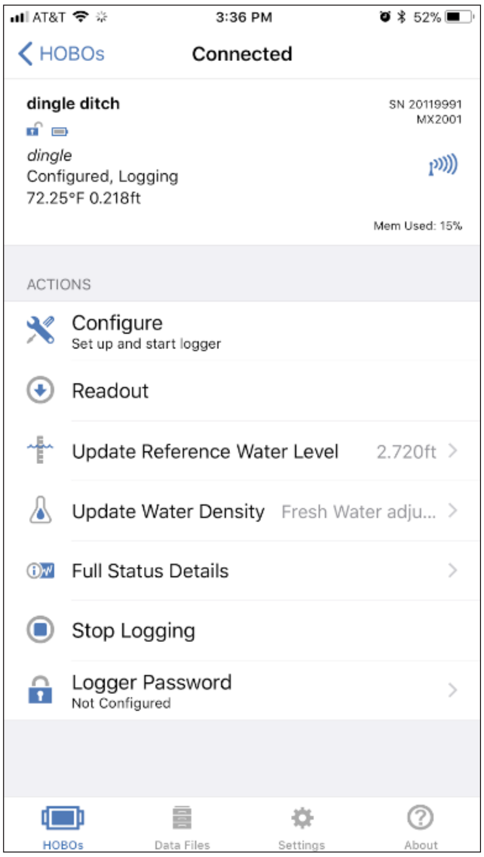
CFS flow rate =
-.0890175591718645 + (5.99420325736907*Headft) + (20.0518587255568*(Headft^2)) + (-8.04345462269369*(Headft^3)) + (2.3918729740769*(Headft^4)) + (-0.295615736427955*(Headft^5))

Deploying the Bluetooth HOBO Water Level Data Loggers

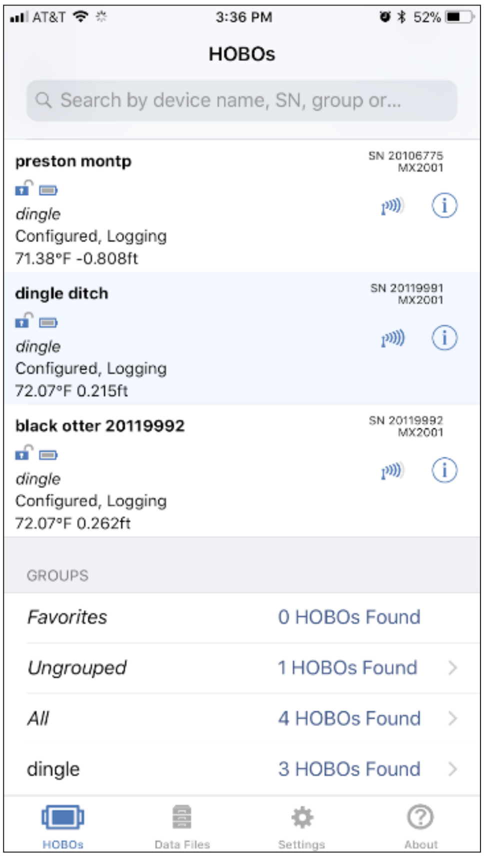
MX2001 shown fastened to the underside of the wooden shelf in a stilling well

To measure the water in the stilling wells, the HOBO MX2001s were installed by fastening the logger to an eye-hole screw attached to the underside of the wooden shelf in each stilling well.

Using Bluetooth Low Energy (BLE) technology, the MX2001 communicates to a mobile device (smart phone or tablet) via the free HOBOmobile® app, which is available for either Apple or Android products. Bluetooth communication proved to be very convenient, as one simply had to be within a dozen feet or so of a stilling well to collect the data wirelessly, without having to open the well. It also allowed for checking the accurate real-time water level to compare to the visual staff gauge in the canal.



Phone screen capture above shows configured data loggers in the HOBOmobile app



Phone screen capture above shows the Connected screen in the HOBOmobile app

Site Setup & Data Collection

Once the HOBO MX2001s were deployed, the HOBOmobile app was used to set up each site and calibrate the water level reading with an offset to match the visual reading of the water level in the canal, flume, or weir. The offset makes it so that the water level that's recorded is the actual water level needed for calculating the flow rate. Since it's nearly impossible to set the sensor at the exact zero location in the water column, this is a very important feature.

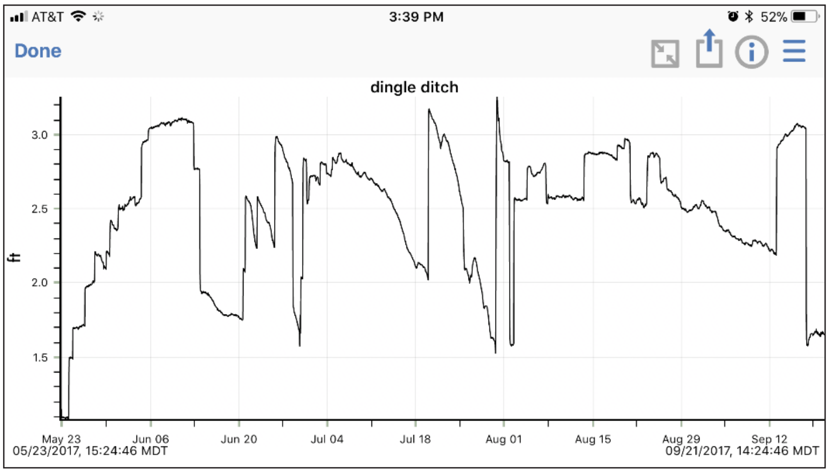
When your smart phone or tablet is near one of the loggers, the logger automatically appears in the app, as shown on the left. You can see that the logger is configured and that it's logging. The recent water level reading and battery status are also displayed.

It's easy to connect to a site; simply tap on the name of the station (the name given when setting up the site for the first time). Once connected, you'll see a screen like the one on the bottom-left.

To configure the logger, simply tap on Configure and you'll see a screen that allows you to name the site, record the GPS location (if desired), and calibrate the water level by entering the actual depth of water into the Reference Water Level. Under Logging Setup, enter the frequency of the logging interval – that is, the time between records in the data file (for example, hourly).

Collecting data is simple. Once connected to the station, tap the Readout menu item as displayed in the Connected screen. Once the data file is connected to the phone or tablet, you'll see a screen showing a graph of the data.

The graph shows the fluctuations in water level and allows for a quick verification that the site is recording correctly. You can easily export the data by clicking the Share icon. You can email the data to yourself, or upload to a cloud drive like Google Drive or Dropbox. You can export the data in an Excel compatible file format or in a HOBO file to be opened in HOBOware on your computer.



HOBOmobile graph shows the fluctuations in water level and allows for a quick verification that the site is recording correctly

Below is an example of a data file that we opened in Excel and then applied the flow formula to the water level data from the HOBO MX2001. We were able to create a spreadsheet showing the water level in the flume, weir, or rated section and then add the formula to calculate flow rate in CFS.

This is the water level data from the site that's a rated section of box culvert.

We used the polynomial formula that was created by making manual flow readings at different depths in the channel. Then, by taking an hourly reading of water level, we can have a data file that shows an hourly flow rate at that location.

This is the same process to create a data file for the sites with the Parshall flume and the weir. By using the water level from the HOBO MX2001 logger and the mathematical formula for those primary measuring devices, we created data files showing hourly flow rate for those canals. With this data, it's also possible to calculate acre feet used over a time – which is useful for billing for water usage or for regulating usage amongst water users.

	A	B	C
1	**Date Time, GMT -0600**	**Water Level, ft**	**CFS Flow**
2	2017-05-23 15:24:46	1.142	24.43
3	2017-05-23 16:24:46	1.086	22.64
4	2017-05-23 17:24:46	1.089	22.76
5	2017-05-23 18:24:46	1.093	22.87
6	2017-05-23 19:24:46	1.090	22.77
7	2017-05-23 20:24:46	1.091	22.80
8	2017-05-23 21:24:46	1.088	22.73
9	2017-05-23 22:24:46	1.092	22.82
10	2017-05-23 23:24:46	1.090	22.76
11	2017-05-24 0:24:46	1.089	22.74
12	2017-05-24 1:24:46	1.086	22.66
13	2017-05-24 2:24:46	1.089	22.74
14	2017-05-24 3:24:46	1.088	22.70
15	2017-05-24 4:24:46	1.088	22.72
16	2017-05-24 5:24:46	1.083	22.56
17	2017-05-24 6:24:46	1.085	22.63
18	2017-05-24 7:24:46	1.080	22.46
19	2017-05-24 8:24:46	1.081	22.50
20	2017-05-24 9:24:46	1.090	22.78
21	2017-05-24 10:24:46	1.090	22.77
22	2017-05-24 11:24:46	1.090	22.76
23	2017-05-24 12:24:46	1.093	22.86
24	2017-05-24 13:24:46	1.088	22.70
25	2017-05-24 14:24:46	1.086	22.65
26	2017-05-24 15:24:46	1.093	22.87
27	2017-05-24 16:24:46	1.081	22.48
28	2017-05-24 17:24:46	1.095	22.94
29	2017-05-24 18:24:46	1.080	22.46
30	2017-05-24 19:24:46	1.384	32.58
31	2017-05-24 20:24:46	1.493	36.47
32	2017-05-24 21:24:46	1.488	36.29
33	2017-05-24 22:24:46	1.485	36.19
34	2017-05-24 23:24:46	1.488	36.29
35	2017-05-25 0:24:46	1.488	36.28
36	2017-05-25 1:24:46	1.496	36.58
37	2017-05-25 2:24:46	1.491	36.40
38	2017-05-25 3:24:46	1.495	36.55
39	2017-05-25 4:24:46	1.492	36.43
40	2017-05-25 5:24:46	1.490	36.39
41	2017-05-25 6:24:46	1.492	36.44
42	2017-05-25 7:24:46	1.487	36.26
43	2017-05-25 8:24:46	1.489	36.33
44	2017-05-25 9:24:46	1.483	36.13
45	2017-05-25 10:24:46	1.682	43.61
46	2017-05-25 11:24:46	1.694	44.08
47	2017-05-25 12:24:46	1.692	44.01
48	2017-05-25 13:24:46	1.696	44.16
49	2017-05-25 14:24:46	1.688	43.83
50	2017-05-25 15:24:46	1.690	43.93
51	2017-05-25 16:24:46	1.689	43.89
52	2017-05-25 17:24:46	1.693	44.04
53	2017-05-25 18:24:46	1.695	44.10
54	2017-05-25 19:24:46	1.693	44.02
55	2017-05-25 20:24:46	1.691	43.96

Excel® spreadsheet showing water level in the flume

About Onset

Onset is a leading supplier of data logger and monitoring solutions used to measure, record and manage data for improving the environment and preserving the quality of temperature-sensitive products. Based on Cape Cod, Massachusetts, Onset has been designing and manufacturing its products on site since the company's founding in 1981.

Visit Onset on the web at www.onsetcomp.com.

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About Intermountain Environmental

Intermountain Environmental, Inc (IEI) sells and supports instrumentation for research and resource management. IEI has been working in the water and weather monitoring industries since 1993. One of our specialties is canal and irrigation monitoring, including canal control systems. IEI has been selling the Onset HOBO line of products for more than 20 years.

Visit IEI at www.inmtn.com.

Other informational resources available from Onset:

Data Logger Basics

In today's data-driven world of satellite uplinks, wireless networks, and the Internet, it is common to hear the terms "data logging" and "data loggers" and not really have a firm grasp of what they are.

Most people have a vague idea that data logging involves electronically collecting information about the status of something in the environment, such as temperature, relative humidity, or energy use. They're right, but that's just a small view of what data logging is.

Choosing A Water Level Logger: 5 Things You Should Know

As the demand for water resources continues to grow in the United States and abroad, the ability to assess the impact of urban development and agriculture on water resources is more important than ever. To meet this growing demand, water resource managers, engineers, and hydrologists have a greater need to monitor groundwater and surface water levels with water level data loggers in order to document baseline and changing water levels over time.

This paper provides hydrology, ecology, stormwater, and waterworks professionals with valuable tips on how to evaluate specific water level data loggers, and points out key factors to keep in mind during the product selection process.

Choosing a Temperature Data Logger

This guide details features to consider when choosing a temperature data logger, including accuracy requirements, data access needs, software packages, and power requirements. Explore real-world application examples that illustrate how users have incorporated portable data loggers into their temperature monitoring projects.

Whether you are an experienced data logger user or just getting started, this guide can help you choose the ideal temperature logger for your application.

Choosing a Conductivity Logger

Whether you are selecting a conductivity logger for the first time or have experience measuring conductivity, this paper can help you determine the type of logger that best suits your needs. It highlights the five most important considerations in selecting and deploying a conductivity logger: measurement range and accuracy, other factors that affect accuracy, ease of deployment and offload, software capabilities, and cost of ownership..

Robust, low-cost data loggers for stream temperature, flow intermittency, and relative conductivity monitoring

Water temperature and stream flow intermittency are critical parameters influencing aquatic ecosystem health. Low-cost temperature loggers have made continuous water temperature monitoring relatively simple, but determining stream flow timing and intermittency using temperature data alone requires significant and subjective data interpretation.

Electrical resistance (ER) sensors have recently been developed to overcome the major limitations of temperature-based methods for the assessment of streamflow intermittency. This technical note introduces the STIC (Stream Temperature, Intermittency, and Conductivity logger); a robust, low-cost, simple-to-build instrument that provides long-duration, high-resolution monitoring of both relative conductivity (RC) and temperature.

Underwater Temperature Loggers: Considerations For Selection & Deployment

Researchers and resource managers working in the world's rivers, lakes, and oceans often need to monitor water temperature over time. Most researchers today rely on electronic underwater temperature logging devices for their monitoring needs, rather than on human data collection.

This report provides general information about monitoring water temperature, and serves as a guide to selecting underwater temperature loggers. It also identifies some of the challenges specific to particular field sites, and provides tips on deploying loggers in such environments.

Monitoring Wetlands with Data Loggers: A Best Practices Guide

Wetlands act as a natural filter for polluted water and thus play an essential role in water quality protection. They serve as floodwater storage to help minimize erosion, and create a habitat for many fish and wildlife.

While a variety of factors have decreased the number of wetlands in the U.S. by half since 1950, many organizations are restoring wetlands back to their original flourishing ecosystems. To ensure success, it is necessary to monitor wetland factors such as water level, temperature, and rainfall.

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