Cuyama Basin Well Metering Program:
Guidance for Meter Installation and Data Collection

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April 2021

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Abbreviations and Acronyms

Basin	Cuyama Valley Groundwater Basin
CBGSA	Cuyama Basin Groundwater Sustainability Agency
DWR	California Department of Water Resources
gpm	Gallons per minute
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
SGMA	Sustainability Groundwater Management Act

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Section 1. Introduction

The Cuyama Valley Groundwater Basin (Basin) has been identified by the California Department of Water Resources (DWR) as subject to critical conditions of overdraft (DWR 2016). As such, in accordance with California's Sustainable Groundwater Management Act (SGMA), the Cuyama Basin Groundwater Sustainability Agency (CBGSA) was formed to develop and implement a basin-specific Groundwater Sustainability Plan (GSP). The Cuyama Basin GSP was completed and submitted to DWR in January 2020. The general purpose of the GSP is to facilitate a long-term groundwater withdrawal rate less than or equal to the sustainable yield of the Subbasin within the maximum 20-year implementation period mandated by SGMA.

The CBGSA has utilized groundwater extraction fees to promote sustainable extraction volumes of groundwater from the Basin and help fund the implementation of the GSP. Since the GSP was adopted in January 2020, groundwater pumping volumes were calculated using evapotranspiration data from remote sensing to determine estimated water use on irrigated lands, as this was the only Basin wide method for data collection available at the time. During the November 4th, 2020 CBGSA Board Meeting, a motion was passed to require all non-de minimis[1] groundwater users to install water measuring devices (flow meters) on all groundwater extraction wells no later than December 31, 2021.

Collection and reporting of well flow data are integral to enable proactive and adaptive management of groundwater resources and documentation of seasonal fluctuation in water demand. This data is more accurate than evapotranspiration estimates and will provide additional data for model calibration. In addition to providing an estimate of groundwater production, groundwater flow data may be used by the CBGSA in conjunction with groundwater level data to improve understanding of groundwater basin conditions. This is especially important for sustainable regional management of groundwater resources.

The purpose of this document is to provide guidance and protocols for groundwater well flow metering for well owners in the Basin. This includes instructions on how to install a flow meter and to collect flow data.

Section 2. What is a Flow Meter and Totalizer?

In the context of groundwater, a flow meter is a device or instrument used to measure water properties (such as velocity or pressure) of water flow. A totalizing meter (or totalizer) measures the volume of water pumped from a well. The two instruments can often be found in a single device (**Figure 1**). For the purposes of this document, a flow meter refers to a device that measures, at a minimum, the total volume of groundwater extracted from a well: a totalizing flow meter.

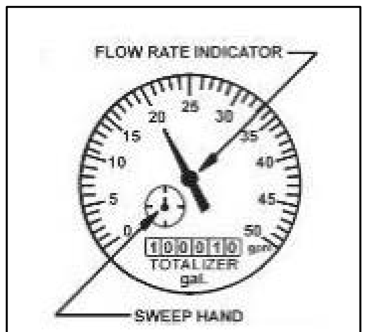

Figure 1: Flow meter with totalizer.

[1] A de minimis groundwater user pumps less than 2 Acre-feet per year

A flow meter works much like the speedometer in your car, with the needle on the meter face registering the instantaneous rate at which water is moving through the meter (typically in gallons per minute [gpm]), like a speedometer. At the same time, the "totalizer" counters near the bottom of the meter face show the cumulative total volume of water that has moved through the meter (typically in cubic feet or gallons), similar to an odometer in your car. The volume of water passing through the totalizing meter during a given monitoring period is calculated by reading the numbers on the totalizer at the end of the monitoring period, and subtracting the numbers recorded at the end of the previous monitoring period.

Section 3. Purchasing and Installing Totalizing Flow Meter(s)

Totalizing flow meters can commonly be found at your local water pump supplier or from online equipment suppliers. Each flow meter should have a manufacturer's seal and should be installed, operated, and maintained to manufacturer's standards, instructions, and recommendations. Some types of flowmeters require a new flanged or welded section of pipe be installed in the pump discharge pipe. Others can be saddle-mounted over a hole cut in the discharge pipe, and others can be mounted on the outside of existing pipes with no cutting or welding required.

3.1 Selecting Flow Meter(s)

A flow meter may cost as little as under $1,000 to over $10,000, depending on the size of the system and the type of flow meter. Three common types of flow meters are described below.

- **Propeller meters:** Propeller flowmeters are a common type of flow meter used for measuring pressurized water delivery systems. A propeller is mounted in the well discharge pipe, and rotational speed of the propellers translates to a flow rate and volume in the attached meter via a magnetic pick-up, photoelectric cell, or gears. Propeller meters are sensitive to turbidity wearing or plugging up the bearings, so they should ideally be used in relatively clean water such as typical well water. Propeller meters also can spin (and potentially overestimate groundwater pumping) in cases where entrained air (created by internally cascading water in the well or other sources) moves through the discharge pipe.

- **Electromagnetic meters:** Electromagnetic flowmeters can measure the flow of electrically conductive liquids, such as water. These meters mount similarly to propeller meters but instead of a propeller they use a flow tube or sensor rod within the well discharge pipe. Faraday's law of electromagnetic induction states that a voltage will be induced when a conductor moves through a magnetic field. In this case, the conductive liquid (water) moves through the magnetic field created by energized coils outside the flow tube or contained within the sensor rod. The rate of flow is proportional to the produced voltage, which is registered and measured by electrodes mounted on the pipe wall or along the sensor rod. Electromagnetic meters are more expensive but have advantages compared to propeller meters, since they can measure flow in both directions, and do not have moving parts which can wear.

- **Ultrasonic meters:** Ultrasonic flowmeters send ultra-high frequency sound waves into the well discharge pipe and measure the frequency shifts or sonic velocity changes caused by liquid flow, which are proportional to the liquid's velocity. One or more transceiver sensors, mounted outside of the discharge pipe, send a sonic signal of known frequency into the pipe. The moving liquid causes the receiver element to detect a shifted pulse, which is used to calculate the water velocity and thus the volumetric flow. Two types of ultrasonic flowmeters can be used, depending on the characteristics of the discharge water. *Doppler ultrasonic flowmeters* require a small amount of particulate matter or small bubbles in the discharge, in order to bounce the sonic signal back to the transceiver. They measure the shift in frequency caused by reflection from a moving object. *Transit-time ultrasonic flowmeters* require the water to be mostly free of particles or bubbles, and measure the difference in time a sonic signal in moving water takes to move in an upstream versus a downstream direction.

The electromagnetic meter has typically been chosen over the other two methods due to reliability provided by a lack of moving parts, thereby minimizing the potential for wear and loss of calibration, or obstruction by solids that may be in the pumped groundwater stream.

Regardless of the type of totalizing flow meter selected, to be used for reporting to the CBGSA, the meter must meet the requirements presented below to support accurate measurement of flows:

- Warranted to register not less than 98% and not more than 102% of the actual volume of water passing the meter for all rates of flow within the meter size's range of flow.
- Equipped with a direct reading rate-of-flow indicator showing instantaneous flow in gallons per minute or a sweep hand indicator for which rate-of-flow can be determined by timing.
- Equipped with a visual, volume-recording totalizer recorded in gallons, cubic feet, acre-inches, or acre-feet.
- Calibrated prior to installation.
- Installed near the well (upstream of all connections to the main discharge line) to measure the entire flow from the well.
- Installed such that there is full pipe flow at all times. Full pipe flow can be achieved by elevating a downstream section of pipe, or constructing a gooseneck in the downstream pipe. Pressurized systems will normally have full pipe flow.
- Installed with a specific minimum length of unobstructed straight run of pipe without valves or elbows upstream and downstream of the meter, based on manufacturer's recommendations. Such recommendations may be as much as 10 pipe diameters upstream and 5 pipe diameters downstream, so that for a 12" discharge pipe, 120" would be required upstream and 60" would be required downstream. Usage of straightening vanes may be used to reduce the lengths. Lengths are generally longer for propeller meters than magnetic meters.

3.2 Establishing Flow Meter Locations

Prior to installing flow meters, several steps must be taken to determine appropriate locations for the flow meters. These steps are generally as follows:

Step 1: **Locate the well –** Take pictures of the site location and well before meter installation for documentation. Observe the surrounding environment and make notes for the well file.

Step 2: **Establish a data file for the well –** Collect any records you may have or have access to, including the well construction report (WCR) filed with the California Department of Water Resources (DWR), the local well permit number, hydrogeologic information (e.g., boring logs, electric logs, or well driller's logs prepared during well construction), pump details (e.g., type, make & model, intake depth, horsepower, capacity, etc.), pumping test data, and any groundwater quality data from samples from the well. Specifically, determine if the production capacity (flow rate) of the well was ever established, and measure the discharge pipe diameter; this information will be necessary to select the appropriate meter for installation.

Step 3: **Prepare the site for metering -** At the well location, identify the best location for the flow meter based on the specific requirements of the meter type and model to be used, and based on how it will be accessed once it has been installed. Production wells may have permanent well seals installed on the top; therefore you will need to identify how and where within the discharge stream you will install the meter. This may involve moving landscaping or hardscape around the well in order to have the necessary clearance and access.

Step 4: **Selecting the location for meter installation –** Selecting a flow meter location that truly reflects the amount of water being extracted from the well is critical for accurate flow measurements. There should be no obstructions and sufficient spacing around the meter to allow access for meter reading. Additionally, if the flow meter is installed outdoors, extra care should be taken to protect it from frost and to allow drainage.

For accurate meter performance, the measurements must be conducted at a point in the discharge pipe where it flows full. Turbulence will reduce the accuracy of flow measurements, so straight piping must be used both upstream and downstream of the meter. The straight sections must be free of valves, junctions, adapters, changes in pipe diameter, sand separators, or other sources of turbulence. A general rule of thumb for straight piping around the meter is to allow at least 5-10 pipe diameters upstream and 2-5 pipe diameters downstream of unobstructed straight run from the meter sensor, however this should be confirmed for the particular make and model of flowmeter used. If this design is not possible, straightening vanes may be used to achieve more laminar flow through the meters. **Figure 2** below shows an image and diagram of a straightening vane connected with a flow meter.

CBGSA recognizes there may be unforeseen challenges in measuring water flows and staff will address those issues with landowners as they arise (for example falling water, etc.).

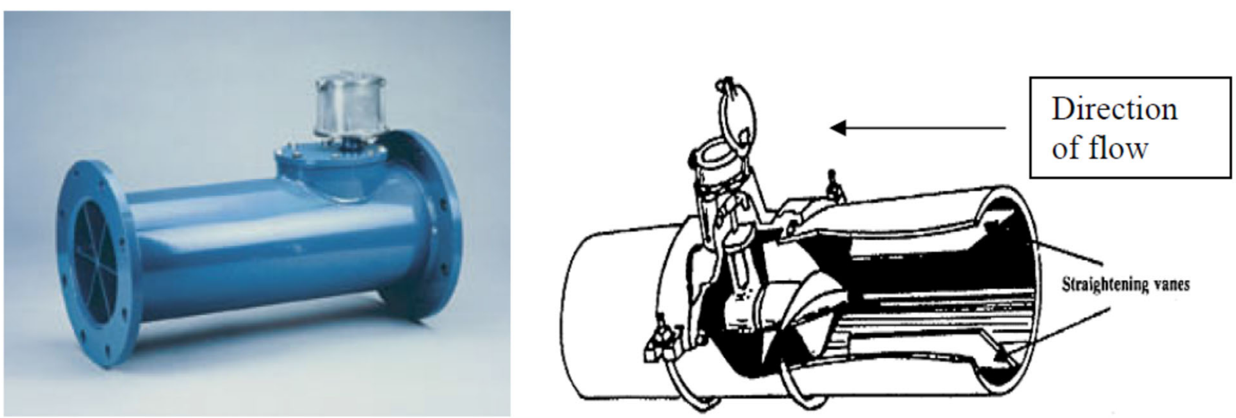

Figure 2: Flow meter with straightening vanes upstream of the meter.

3.3 General Procedures for Flow Meter Installation

General procedures for installing a flow meter after it has been purchased and its installation location has been determined are presented below. Well owners or users could potentially do this on their own, but assistance in flowmeter selection and installation from the flow meter supplier is recommended to improve the likely quality of installation and of future flow measurements.

1. Conduct a pre-installation site inspection to review well configuration and piping and potential hazards. Determine pipe diameters, run lengths, and locations of elbows, valves, and other obstructions.
2. Confirm installation design with supplier.
3. If necessary (e.g., if there is the potential for groundwater contamination), ensure that personnel have appropriate proper personal protective equipment (PPE) before proceeding.
4. Clear a 30' diameter area around the installation location to reduce the potential of grass fire during welding or grinding work, and have a water source available.
5. Turn off the power source/electrical main and any necessary pipeline valving.
6. Verify that water system is at zero pressure.
7. Install meter at established location, making sure that full flow and straightness of pipe at the meter sensor is achieved. Saddle mounting can be used for propeller meters and some types of magnetic meters, where a hole is cut in the pipe to install a saddle-mounted meter. Often when straightening vanes are required, a section of the existing pipe system is cut out and replaced by a flanged meter.
8. Resume normal operations after turning back on piping appurtenances and the power source/electrical main.
9. Conduct a post-installation site inspection.

Section 4. Collecting Flow Data

Manual groundwater well flow (totalizing) meter readings should be conducted in a prescribed manner in order to ensure consistency in the data collection process. The following provides a step-by-step process for collecting this data, as well as a section specifically on reading meters.

4.1 General Procedures for Collecting Data

General procedure for collecting meter measurements. Note that these instructions are for collecting totalizing (volume of flow) data, rather than velocity (flow rate) data.

1. Inspect the groundwater well and surrounding area. Note any new or changed conditions.
2. Refer to previous well meter readings to estimate the expected reading.
3. Access the totalizing flow meter. If vault entry is required, exercise precautionary safety procedures.
4. Read the meter directly where possible. If the meter cannot be accessed directly (e.g. it is located in a vault), read the meter using binoculars if possible, or carefully enter the vault to directly read the meter.
5. For consistent documentation, record measurement results on a standardized form. In addition to the total flow volume and instantaneous flow rate readings from the flow meter, the form should also include information such as: well identification and location, date and time of data collection, flow meter information (meter location, installation date, serial number, type, size, manufacturer, etc.). Note if the meter has "rolled over" and started counting from zero again. If possible, take a photo of the meter face that legibly shows the totalizer numbers.

6. For quality control, compare the meter reading to previous readings. Does the total flow difference make sense?
7. Re-secure the well and meter.

Figure 3 shows an example of a flow meter display. **Figure 4** is a diagram explaining how to read common types of flowmeters, which can be trickier than it sounds. Note that the units (e.g., gallons, cubic feet, acre-feet, acre-inches) on different flowmeters may vary, and decimal points often are implied instead of shown (digits after the decimal are commonly indicated by yellow numbers instead of white). The totalizer shown on **Figure 3** is measuring in thousandths (1/1000) of acre-feet rather than gallons. It is critical to always write down the flowmeter units that are being recorded during a monitoring period.

Figure 3: Example Flow Meter Display
(Totalizer reads 679.675 acre-feet)

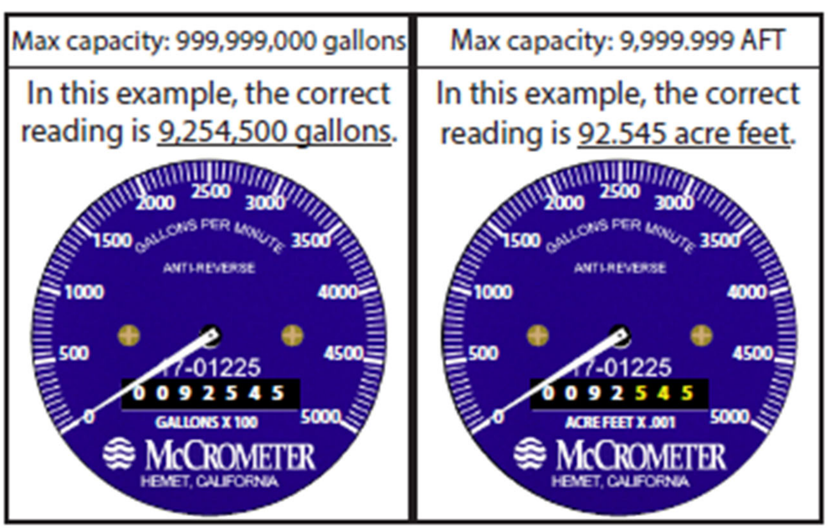

Figure 4: Examples of How to Read Different Types of Flow Meters
(image courtesy of McCrometer Corporation)

Section 5. Calibrating and Maintaining Flow Meters

Meters are initially calibrated by the manufacturer at the time of manufacture or refurbishing, prior to installation, and they should not need calibration immediately after installation. Any issues in the flow meters identified during meter readings or routine inspections should be reported to the manufacturer or supplier as soon as possible. Common issues to be aware of include worn bearings or sender cables (sometimes indicated by noise), propellers getting stuck due to mechanical failures or debris, and moisture inside the meter. With electromagnetic and ultrasonic meters, low battery, poor grounding, or software failure also can be potential problems.

Proper calibration and verification is important for ensuring data quality, and necessary for meeting the objectives of the Metering Plan. Well owners are responsible for costs for installation, calibration, verification, and maintenance of meters.

5.1 Initial Calibration/Validation of Existing Meters

New meters will require a certificate of calibration which must be provided to the GSA and recorded. Existing meters in the Basin will need to be inspected and validated to ensure proper function and calibration. These activities must be conducted by a California-licensed pump contractor. This initial calibration and validation will be conducted at the beginning of the schedule of routine metering activities, and a certificate of calibration must be produced and recorded. Certificates of calibration for new and existing meters must be submitted to the CBGSA.

5.2 Routine Calibration and Validation

The meters must be re-calibrated, rebuilt, or replaced at least every five years, except for electromagnetic meters which must be replaced after no more than 20 years, with periodic cleaning during the life of the meter. Note that installing filters ahead of the meter units help make the water cleaner and minimize fouling and wear on propeller meters; however, these filters may require periodic backwashing and/or replacement per manufacturer's instructions to maintain their effectiveness.

Section 6. Further Reading

Bureau of Drinking Water and Groundwater, Wisconsin Department of Natural Resources. 2012. *Guidance on Acceptable Means of Measuring or Estimating Water Withdrawals*. May.

Department of Ecology, State of Washington. *Liquid Flowmeters – A Guide for Selecting a Flowmeter for Pressurized Systems*. Available at: https://appswr.ecology.wa.gov/docs/WaterRights/wrwebpdf/gsfps.pdf. Accessed September 2016.

Department of Ecology, State of Washington. *The Basics: How to Read Your Meter*. Available at: https://appswr.ecology.wa.gov/docs/WaterRights/wrwebpdf/meters_thebasics1.pdf. Accessed September 2016.

Eastern Municipal Water District, Water Resources Management Department. 2004. Standard Operations Procedures: Groundwater Extraction Monitoring Program Meter Installation, Meter Reading, and Maintenance & Calibration Procedures. June 28.

Louisiana State University. 2013. *Measuring Irrigation Flow*. LSU AgCenter Pub. 3241-L. Available at: https://www.uaex.edu/environment-nature/water/docs/IrrigSmart-3241-L-Measuring-irrigation-flow.pdf. Accessed April 2021.

Oregon Water Resources Department. 2010. Water Well Owner's Handbook: A Guide to Water Wells in Oregon. March.

Southwest Kansas Groundwater Management District #3. 2011. *Flowmeter Maintenance and Issues*. February 22-23.

University of California Department of Agriculture and Natural Resources. 2007. *Measuring Irrigation Flows in a Pipeline.* Publication 8213. Available at: http://fruitsandnuts.ucdavis.edu/files/68955.pdf. Accessed April 2021.

Woodard & Curran. 2017. Guidance on Groundwater Well Level Monitoring. September 1.