FUNCTIONAL STANDARDS FOR MEASURING DEVICES

Division 6, Division of Water Resources
Department of Natural Resources

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COLORADO
Division of Water Resources
Department of Natural Resources

I. PURPOSE

These standards were developed by the staff of Division 6 of the Division of Water Resources to better define what is acceptable to the Division and to provide some suggestions when installing structures and devices deemed necessary for the proper administration of water within the Division pursuant to C.R.S. 37-84-112.

II. RELEVANT STATUTES

C.R.S. 37-84-112(1) - The owners of any irrigation ditch, canal, flume, or reservoir in this state, taking water from any stream, shall erect where necessary and maintain in good repair, at the point of intake of such ditch, canal, flume, or reservoir, a suitable and proper headgate of height and strength and with embankments sufficient to control the water at all ordinary stages and suitable and proper measuring flumes, weirs, and devices and shall also erect and maintain in good repair suitable wastegates where necessary in connection with such ditch, canal, flume, or reservoir intake. The framework of such headgate shall be constructed of timber not less than four inches square, and the bottom, sides, and gate shall be of plank not less than two inches in thickness, or said gate may be made of other material of equal strength and durability or may be made and constructed upon plans and specifications approved by the state engineer. No such headgate shall be deemed complete until provided with suitable locks and fastenings (except when the division engineer deems such locks and fastenings unnecessary therefor) and keys therefor are delivered to the division engineer of the division who has control thereof during the seasons of the distribution of water.

C.R.S 37-84-112(2) - If the owners of any such irrigation ditch, canal, flume, or reservoir fail or neglect to erect or maintain in good repair said headgate, measuring flume, weir, or devices, in the manner and form provided in this section, then the state engineer or division engineer, upon ten days' previous notice in writing, duly served upon such owners, or upon any agent or employee representing them or controlling such ditch, canal, flume, or reservoir, shall refuse to deliver any water from such stream to such owners, or to such ditch, canal, flume, or reservoir, until such owners erect or repair the headgate, measuring flume, weirs, or devices of such ditch, canal, flume, or reservoir. The owners of all such ditches, canals, flumes, or reservoirs shall be liable for all damages resulting from their neglect or refusal to comply with the provisions of sections 37-84-112 to 37-84-117. Such owners who divert water from any such stream and into any such ditch, canal, flume, or reservoir contrary to the orders of the state engineer or division engineer are guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine of not more than five hundred dollars, and each day of violation shall be deemed a separate offense.

C.R.S. 37-84-108(1) – A person shall not run through his or her ditch any greater quantity of water than is absolutely necessary to prevent the wasting and useless discharge and running away of water.

C.R.S. 37-92-502(5)(a) - The state engineer and the division engineers have authority to order any owner or user of a water right to install and maintain at such owner's or user's expense necessary meters, gauges, or other measuring devices and to report at reasonable times to the appropriate division engineer the readings of such meters, gauges, or other measuring devices.

C.R.S. 37-92-502(6) – The state and division engineers and their duly authorized assistants and staff have the authority and duty to enter upon, and order any person to permit the entry upon, private property at any reasonable time to inspect the various means or proposed means of diversion, transportation, and storage and the uses to which water is being, or is proposed to be, put and to read meters, gauges, and other measuring devices.

III. DEFINITIONS

Ordinary Stages - For the purposes of §37-84-112, "ordinary stages" shall mean any stage of flow up to the summation of the adjudicated water rights in the ditch and any additional flow diverted to a beneficial use that can and is controlled within the ditch. In no circumstance may a ditch divert water that is not applied to a beneficial use. Ordinary stages specifically include, but are not limited to, all stages of spring runoff and large precipitation/runoff events.

Headgate - For the purposes of §37-84-112, a controllable, lockable headgate shall be defined as any permanently installed combination of headgate, embankments, diversion dam, or any other means that prevents ANY diversion of water, intentional or otherwise, when not in priority or that cannot be beneficially used (the combination of which is sometimes referred to as the control structure); and which allows the Water Commissioner to accurately adjust the flow of water with reasonable effort and within a reasonable amount of time and to secure the structure at the adjusted condition so as to prevent any unauthorized diversion or adjustment.

Measurement Devices - Water measurement device shall mean any flow measurement device which can be demonstrated to accurately measure flows within ± 5% of the standard rating (or an empirically created custom rating) for the device throughout the full range of anticipated flows. This device must be co-located with the control structure to enable the Water Commissioner to promptly observe headgate adjustments, must be properly installed to engineering specifications to insure proper measurement, must be maintained in a condition to provide accurate measurement throughout full anticipated range of flows and shall not be deemed complete until such time that a rating table accurately calibrated to the measuring device has been made available to the Water Commissioner unless such measuring device is for a typical flume, weir or meter. Any measurement device that is not installed to manufacturer's specifications may be required to be verified at owners/operators expense or replaced.

Recording Devices - Recording device shall mean any device acceptable to the Water Commissioner which is capable of continuous recording of stage data at a resolution of .01 foot or other equivalent positive determinant of discharge at a resolution of comparable accuracy through an approved measurement device at no greater than 15-minute intervals over a period of time. The recording device must include a means to verify on-site that the device is properly calibrated to the gage height or other discharge determinant. Such recording device shall not be deemed complete and acceptable until all equipment and software necessary to download and process recorded data is supplied to the Water Commissioner and/or the Division Engineer.

IV. TYPICAL DEVICES

Headgate - Slide gate or turn wheel style gate installed in a concrete headwall (or other stable non-leaking frame structure) which has sufficient freeboard to prevent overtopping into the ditch.

Measuring Device – The standard measuring device for the Division is the Parshall Flume, though sharp crested weirs and ramp flumes are commonly used. These devices must be properly installed in a free-flow condition with sufficient upstream stilling basin to provide proper approach flow conditions and sufficient elevation to ensure hydraulic "jump" to prevent submergence at all anticipated stages.

Flow Meters – Any meter that is designed and manufactured for the purpose of measuring the flow of water, has a totalizing feature, and meets the minimum requirements listed herein is considered an acceptable totalizing flow meter (TFM).

Recording - Sutron Model SDR-0001-1 Data Logging Shaft Encoder or equivalent properly installed in a lockable protective shelter.

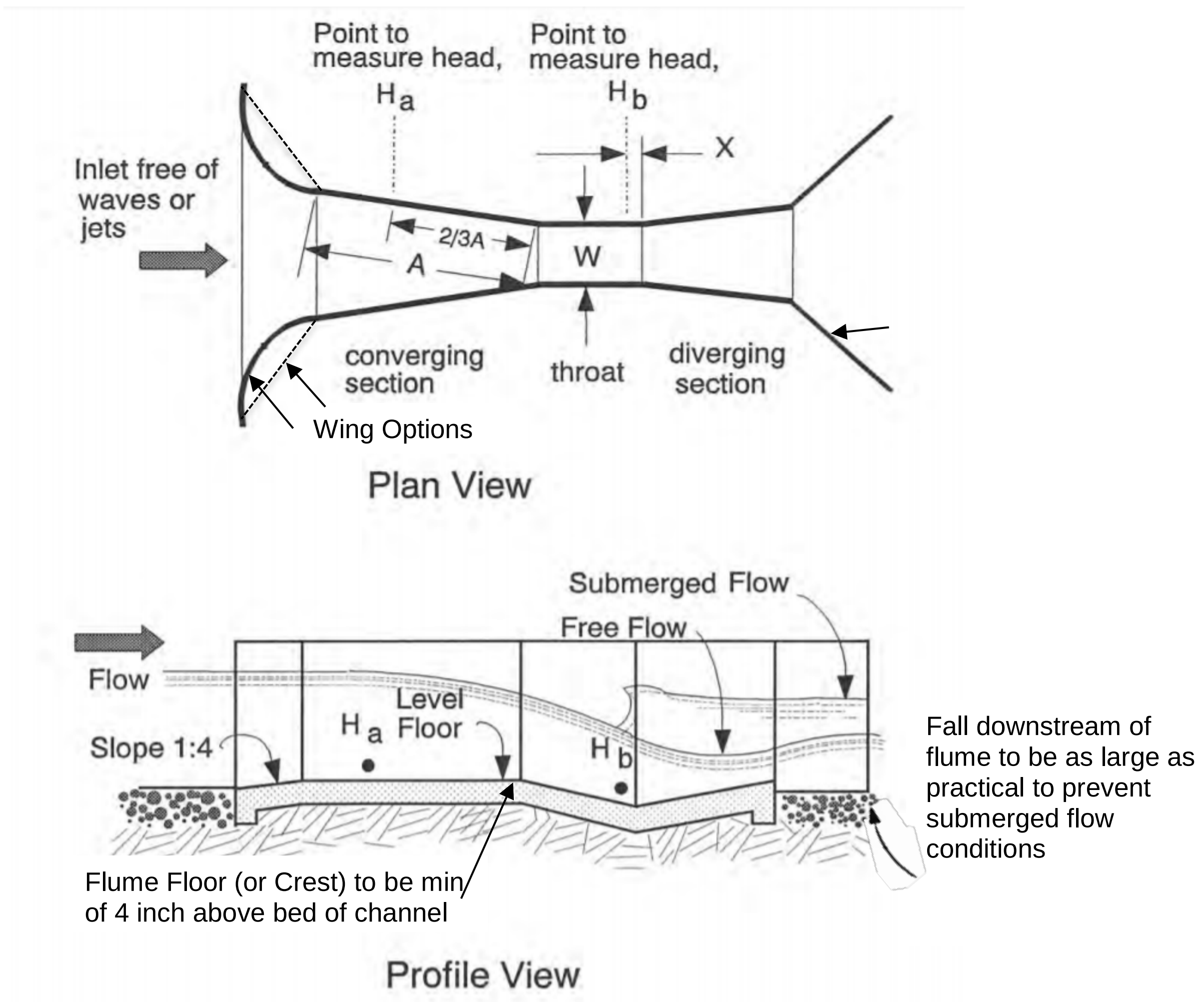
V. INSTALLATION AND SIZING SUGGESTIONS

A. PARSHALL FLUMES: Several things are necessary for the proper installation and maintenance of a Parshall Flume:

1. The ditch channel immediately upstream of the flume should be straight, level and free of obstructions to flow (such as culverts, drops, gates, etc.) for a distance at least 2 times the length of the flume.
2. The ditch channel upstream of the flume should be both wider and deeper than the ditch section at the flume. A stilling pool should be created and maintained in this upstream section (15-18" deeper than the flume floor) so that water flow is tranquil (smooth surface) and slow (less than 2.0 feet per second). The ditch should be at least 12 inches wider (six inches either side) than the entrance to the flume for a distance of at least 2 times the length of the flume. The transition from the wider ditch section to the flume entrance should be smooth and no shallower than a 45-degree angle.
3. The headgate should be at least 100 feet upstream of the mouth of the flume and no further than 600 feet.
4. The ditch channel downstream of the flume should be maintained so that water does not back up into the flume throat and at a lower elevation than the upstream ditch bottom.
5. The flume floor (or crest) should be a minimum of **4 inches higher** and as much as 8-10 inches higher (if the upstream ditch banks are high enough) than the ditch bottom. The higher the flume floor can be set above the ditch bottom, the less chance there is for submergence of the flume.
6. The flume floor must be level both side-to-side and front to back and maintained as such. In order to keep the flume level, it is suggested that:
   a. Railroad ties be placed under the flume, and at a minimum the material beneath the structure and on its sides be thoroughly compacted; or

   b. The flume should be set on a “formed “ section or pad of road base/aggregate, at least 12-15 inches thick, which fully supports the flume over its entire length and width, and is level.
   c. Concrete can be placed around and under the structure, but **<u>this is typically not recommended</u>** as the structure can heave making it impossible to reset.

7. Other items that are recommended for Parshall Flume installation are cutoff walls and wing walls. Cutoff walls both on the sides and on the bottom help keep flow from seeping around or under the flume. Wing walls provide a smooth transition of flow moving from the natural channel through the artificial structure. If wing walls are installed it is recommended that they be put in at an angle of 45° and be flush with the edge of the flume wall, NOT set back from it. The wing walls should be at least as wide as the widest part of the stilling pool upstream.



8. There are several factors to consider when determining the size of flume to select. Before starting the process, there is some important information that should be

collected. Determine the maximum and minimum flows desired, the dimensions of the ditch such as top and bottom width, maximum depth (depth of ditch where flow would first overtop ditch) and side slopes. Once this information has been collected, it can be provided to a manufacturing company, which will help provide an appropriate flume size. The below table shows the capacity of various flume sizes. Note, that flume capacity is considered reached when the water level is 3-inches from the top of the inlet sidewall. This flume table should not, in and of itself, be used to determine the size of flume needed. Several flume sizes may work and economically, one may want to choose the smaller flume, but such flume may or may not be the best option depending on channel conditions.

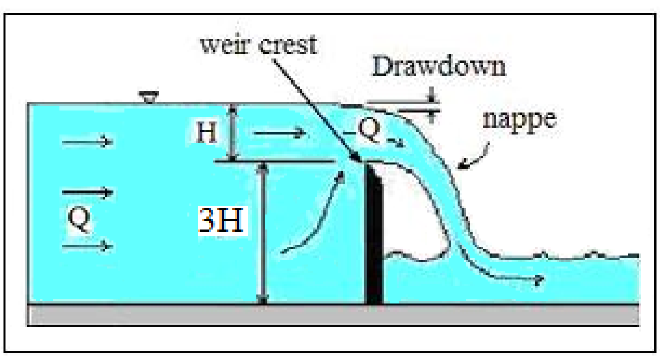
Parshall Flume Capacities

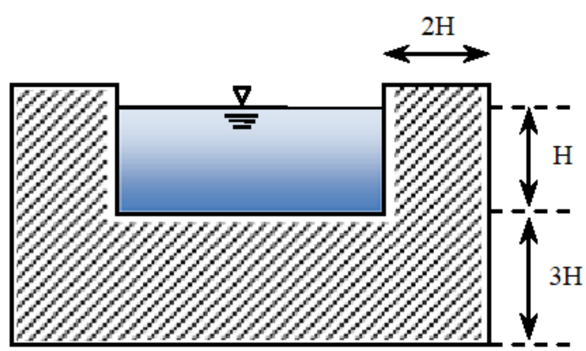
Throat Width (inches)	Wall Height (inches)	Capacity Maximum (cfs)	Capacity Minimum (cfs)
12	15	4.00	0.35
12	18	5.62	0.35
18	15	6.00	0.51
18	18	8.47	0.51
24	15	8.00	0.66
24	18	11.31	0.66
30	18	14.17	0.81
30	24	23.94	0.81
36	24	28.82	0.97
36	30	42.73	0.97
48	30	57.52	1.26
60	30	72.44	2.22
60	36	99.83	2.22
72	36	120.4	2.63
84	42	184.8	4.08
96	42	212.6	4.62

B. WEIRS: Weirs are not the preferred method of measurement for wide ditches, high flow diversions or flat ditches; however, for narrow and smaller diversions, weirs can be the simplest and most economical way of measuring open channel flows. Two of the most commonly used weirs include rectangular weirs and 90-degree or v-notch weirs. Below are some simple (contracted) rectangular weir sizing and installation suggestions.

1. The weir must be constructed with a width (1.0, 1.5, 2.0, 3.0, 4.0 feet, …).
2. The headgate should be at least 100 feet upstream of the weir and no further than 600 feet.
3. The upstream bottom and sides of the rectangular notch should be faced with a thin metal strip to give the necessary sharp edge.
4. When installing the weir, the weir should be placed such that the centerline of the weir is parallel to the direction of water flow.
5. The base of the notch over which the water flows is the crest of the weir. The crest of the weir must be level so water passing over it will be the same depth at all points.
6. The weir crest must be high enough above the ditch bottom so the water will fall freely below the weir leaving an air space (nappe) on the downstream edge. Place loose rock along the downstream edge to protect the ditch from erosion.
7. The distance from the bottom of the ditch to the crest (3H) should be approximately three times the expected maximum depth of the water flowing over the crest of the weir (H) to allow the water to freely fall and to avoid submergence.
8. The sides of the rectangular weir opening (2H) should be two times the maximum expected depth of the water flowing over the crest of the weir.
9. A staff gage measured in tenths of feet should be affixed to a 2x2 inch stake and placed along the ditch bank upstream of the weir a distance of four times the maximum expected depth of water over the crest (4H). The bottom edge of the staff gage (0.00) must be set at the same elevation as the crest of the weir.

V-notch weirs, also known as 90-degree weirs, can handle a large range of flows, though are ideal in measuring small flows. Installation of a v-notch weir is the same as that for a rectangular weir including the requirement that the crest be sharp and the staff gage is installed far enough upstream of the weir not to be affected by the drawdown of water over the weir.





C. METERS: Totalizing flow meters (TFM) are commonly used with pumps. For very small pumps (less than 15 gallons per minute), a TFM that only records the total volume of water diverted is acceptable; however for larger diversions, the TFM must provide both the instantaneous reading of the diversion and total volume of water diverted. The State Engineer may adopt written standards and specifications for the installation, calibration, testing, repair, and maintenance of TFMs.

MINIMUM REQUIREMENTS

1) The TFM must have nonvolatile memory
2) The TFM must have a totalizing function
3) The TFM must be sealed from the factory and be tamper resistant
4) The TFM must not have a reset button
5) The totalizing measurement readout must be in acre-feet or gallons
6) The TFM must be maintained so it is in compliance at all times such that it provides a continuous, accurate, and readable record of withdrawals of water.
7) A TFM is considered in Accurate Operating Condition when the flow measured is within 5% of an independent field measurement made by a Qualified Tester
8) A TFM is considered in Acceptable Operating Condition when the flow measured is between 5% and 8% of an independent field measurement made by a Qualified Tester.
9) A TFM is considered in Provisionally Acceptable Operating Condition when the flow measured is between 8% and 10% of an independent field measurement made by a Qualified Tester
10) A TFM is considered not acceptable when the flow measured is greater than 10% of an independent field measurement made by a Qualified Tester.
11) TFMs are to be installed in accordance with manufacturer's specifications and recommendations.

METER CERTIFICATION

TFM certification tests may be required to be performed by a Qualified Tester and shall be executed in the field with the TFM in its actual plumbing configuration. TFMs should be recertified to be in accurate operating condition by a Qualified Tester. This should occur at a minimum every four years from the date of the last valid certification. A TFM should also be recertified if: (1) there are any damages, repairs, or alterations to the TFM, (2) there are any other modifications, repairs, or alterations that may affect whether a TFM is in Accurate Operating Condition; or (3) the Division Engineer has evidence to suggest the meter is not operating properly. The owner should provide written proof of the certification to the Division Engineer within 30 calendar days from the date the TFM is installed or 30 days from the date of initial certification, as applicable, and within 30 calendar days of any subsequent re-certification.

SCREEN BOX

It is suggested that a screen box be used to protect the meter and pump. Depending on the amount of debris in the river, the screens may need to be checked and cleaned daily.

A screen should not be placed directly on the end of the intake as it can plug easily, impede flow and potentially destroy the pump.

MAINTENANCE

1) The TFM should be removed before freezing weather
2) The TFM impeller should be inspected for damage yearly because even a small nick in one blade will alter the operation of the meter and affect its accuracy

The Division Engineer has the authority to order any measuring device to be recalibrated or replaced under C.R.S. 37-92-502(5)(a) if evidence suggests it is no longer operating properly.