Water Measurement

MT 9128 (AG)

Montana (Short Parshall) Flume (Part 2)

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A general description of the Montana (short Parshall) flume appears in MT 9127. This bulletin gives flume dimensions and describes sizing, locating and building the flume. This information is quite technical and intended for use by technicians, contractors, and engineers.

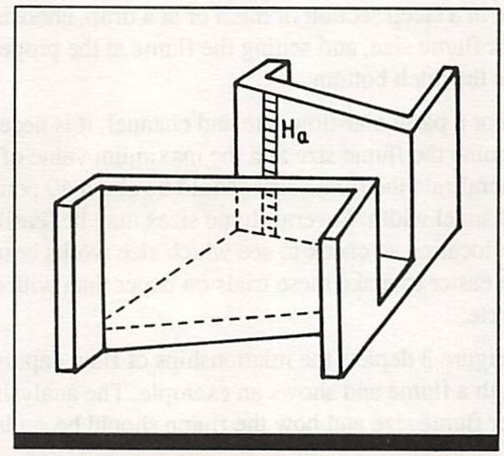

Figure 1. A typical Montana flume.

Flume shape and dimensions

A Montana flume is shown in Figure 1. The flume consists of a converging section and throat also called a crest. The flume size is designated by the crest width and is normally in one-foot increments. Section and plan views are shown in Figure 2. Montana flumes do not protect the channel downstream of the crest from erosion and can not measure partially submerged flows as the Parshall flume can.

Table 2 gives flume dimensions with the letter designation corresponding to those in Figure 2. The height G equals three feet or less depending on the required capacity and flow depth.

Locating and sizing the flume

When installing a flume the following recommendations should be followed.

• Locate the flume in a straight section of ditch so the water will flow smoothly into the converging section.

Water Should Be Measured Because . . .

Water measurement is the foundation of water management and economical crop production. Measuring and applying the proper amount of water saves you money and protects water resources by decreasing soil erosion, fertilizer leaching, and waste water problems.

Montana law requires measuring devices on all streams for which water commissioners have been appointed. A commissioner cannot deliver water unless measuring devices are in place. Eventually all Montana waters will be decreed. You can protect your water right by accurately measuring and recording flow rates and times of use.

Water measurement also helps conserve energy by enhancing fertilizer use and reducing the need to pump. Optimizing water use can lessen local and regional shortages. And minimizing water and energy use nationally will help decrease dependence on foreign energy and conserve our own water and energy supplies.

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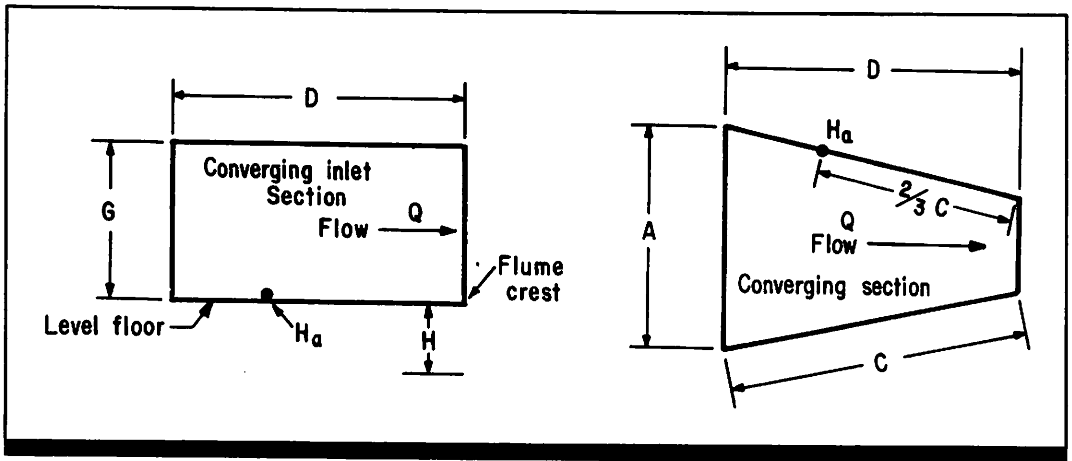

Figure 2. Section and Plan views of a Montana Flume.

• Locate the flume where flow will not be submerged by backwater from downstream.

• Provide for easy accessibility for maintenance and measurement.

The most difficult aspect of flume location is setting the flume at the proper height in relation to the ditch bottom and banks. The flume is an obstruction in the channel and causes a rise in the water elevation upstream. The water must rise from the ditch bottom, pass through the converging section, then drop over the crest. Submerged flows cannot be measured with the Montana flume and must be avoided.

You can avoid submerged flows if you know the downstream water levels at which submergence occurs. A flume is submerged when the depth of water in the throat divided by the flow depth in the converging section exceeds a certain percent. The allowable percent value depends on the size (throat width) of the flume. The flume size in feet with allowable percent shown in parentheses are:

1 (62), 1.5 (64), 2 (66), 3 (68), 4 (70), 5 (72), 6 (74), 7 (76), and 8 (78).

In other words, a particular size flume should be set so that the water does not back up into the throat to a depth greater than the stated percentage multiplied by the upstream head. Submergence can be avoided by setting the flume in a steep section of ditch or at a drop, choosing the proper flume size, and setting the flume at the proper height above the ditch bottom.

For a particular flow rate and channel, it is necessary to determine the flume size and the maximum value of H_a. As a general rule the flume size should be about 40 percent of the channel width. Several flume sizes may be feasible at a given location so check to see which size works best. It is much easier to make these trials on paper than with steel or concrete.

Figure 3 depicts the relationships of flow depths through a flume and shows an example. The analysis of proper flume size and how the flume should be set is hard to

Throat Width	A	B	C	D	Flow rate, cfs Min.	Max.
1 ft	2 ft 9¼ in	2 ft	4 ft 6 in	4 ft 4⅞ in	.11	16.1
1.5ft	3ft 4⅜in	2ft 6in	4ft 9in	4ft 7⅞in	.15	24.6
2ft	3ft 11½in	3ft	5 ft	4ft 10⅞in	.42	33.1
3ft	5ft 1⅞in	4ft	5ft 6in	5ft 4¾in	.61	50.4
4ft	6ft 4¼in	5ft	6ft	5ft 10⅝in	1.3	67.9
5ft	7ft 6⅝in	6ft	6ft 6in	6ft 4½in	1.6	85.6
6ft	8ft 9in	7ft	7ft	6ft 10⅜in	2.6	103.5
7ft	9ft 11⅜in	8ft	7ft 6in	7ft 4¼in	3.0	121.4
8ft	11ft 1¾in	9ft	8ft	7ft 10⅛in	3.5	139.5

Table 2. Parshall flume dimensions for various throat widths and flow capacities.

Units of Measurement

Water is measured in volume and flow rate units. The choice of units depends on what is customary and legal and on how water is purchased or delivered.

Common volume units used in irrigation are: cubic foot (cu. ft., ft^3), gallon (gal.), acre-inch (ac.in.), and acre-foot (ac. ft.). Flow rate units simply add a time dimension to these volume units. These are: cubic feet per second (cu. ft./sec or cfs), gallons per minute (gpm), acre-inches per hour (ai/hr), and acre-feet per day (af/day).

A common flow rate unit in Montana is the miner's inch (M.I.). Water users often refer to a flow rate as a certain number of "inches," when they actually mean miner's inches. Remember that miner's inches are a measure of flow rate, not length.

Conversion factors between the various units are simple. One cubic foot per second (cfs) is equal to 448.8 (often rounded to 450) gallons per minute (gpm). One cfs is also equal to 40 miner's inches (m.i.).

follow and complicated, but there are no shortcuts. If you don't understand the following, seek help.

The steps in analysis are:

1. Determine the approximate maximum channel discharge in cubic feet per second.

2. Estimate the desired flume size.

3. Determine the flow depth at the maximum discharge rate from inspection of the banks or from canal specifications.

4. From Table 1 in MT 9127, determine the upstream head (H_a) at the maximum discharge rate.

5. Determine the submergence percentage for the desired flume size.

6. Multiply the upstream head (H_a) by the submergence percentage to determine the distance the flume crest should be set below the original maximum flow depth.

7. Subtract the distance calculated in step 6 from the original flow depth to determine the height of the flume floor above the channel bottom.

8. Subtract the distance calculated in step 6 from the upstream head (H_a). Add the result to the original flow depth to calculate the rise in upstream water level after the flume is installed. Verify that the banks upstream can handle this increased depth.

This analysis is reiterated in the following example. Again refer to Figure 3.

Steps 1, 2, 3. Suppose you are considering a two-foot flume, a maximum discharge of 27.0 cubic feet per second, and an original flow depth of 2.5 feet.

Step 4. Using Table 1 in MT 9127 and interpolating, for a two-foot flume with a discharge of 27.0 cubic feet per second, H_a equals 2.19 feet.

Step 5. To prevent submergence for a two-foot flume, the allowable submergence ratio is 66 percent.

Step 6. Thus the flume crest (flume floor) should be set below the original maximum flow depth an amount equal to 2.19 x 0.66 or 1.45 feet.

Step 7. Subtract 1.45 feet from the original flow depth of 2.5 feet to determine that the crest floor should be 1.05 feet above the channel bottom.

Step 8. The increase in flow depth upstream of the flume is 2.19 feet minus 1.45 feet or 0.74 feet. The water flowing at a 2.5 foot depth upstream of the flume prior to installation will rise 0.74 feet to flow at a depth of 3.24 feet after installation. The banks upstream must be able to handle this greater water depth.

Several sizes of flumes can carry the 27.0 cubic feet per second flow rate used in this example. These sizes should be evaluated before construction to see which size would best fit the ditch and situation. The narrowest flume may not always be the most economical because of the wing wall length needed to span the channel and the increased upstream water depth.

Building a flume

Dimensions for the Montana flume are shown in Figure 2 and Table 2. The flume shape is simple but these dimen-

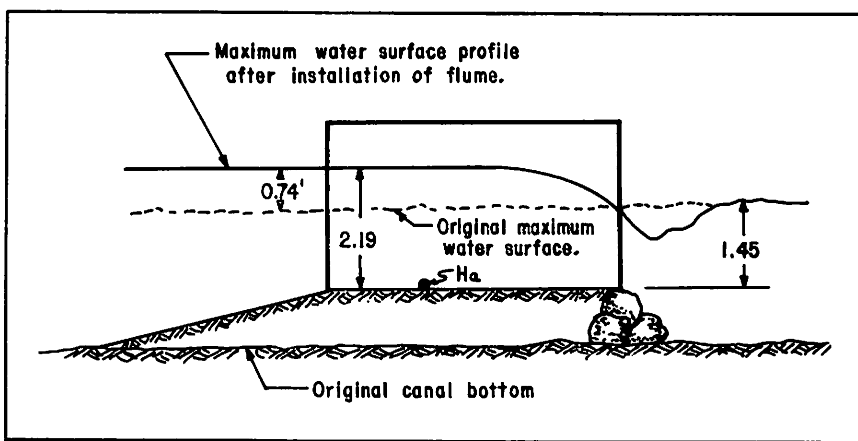

Figure 3. Analysis of upstream and downstream water elevations and crest elevation above the channel bottom.

sions must be followed exactly for the water measurement to be accurate. Prefabricated sheet metal flumes have the advantage of in-shop construction where pieces can be properly jigged and bent or welded. This is difficult in a farm shop when generally only one flume is built. Prefabricated flumes are the best choice for small sizes. Many fabricators only make the Parshall flume. You may be able to have the Montana flume built by special order. Flumes built in place are generally cheaper for larger sizes.

Flumes of treated lumber or concrete can be built in place. The floor should be level and the sides should be plumb. Adequate steel reinforcement should be used. The form work for the Montana flume is relatively simple and can be done by anyone with reasonable carpentry skills. The work cannot be sloppy, however, and a any contractor engaged should be required to guarantee exact dimensions and good workmanship.

The Montana flume usually requires erosion protection downstream of the crest because the water pours through freely and rapidly. A concrete apron, cobble, or other material can be used below the flume. An eddy will develop on each side of the streamflow and erosion protection may be required (depending on the stability of the bank material).

Depth Applied to a Field in Inches

$$= \frac{\text{flow in cubic feet per second x hours}}{\text{area irrigated in acres}}$$

$$= \frac{\text{flow in gallons per minute x hours}}{\text{450 x area irrigated in acres}}$$

$$= \frac{\text{flow in Montana miner's inches x hours}}{\text{40 x area irrigated in acres}}$$

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