Water Measurement

MT 9127 (AG)

Montana (Short Parshall) Flume (Part 1)

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This bulletin is composed of two parts. Part 1 should be used by those making a choice of measuring device, or who need information and tables for flume use. Part 1 describes the flume, gives its advantages and disadvantages, briefly discusses building a flume, and tells how to measure water. Part 2 (MT 9128) gives flume dimensions, and describes sizing, locating and building the flume. Part 2 is quite technical and intended for use by technicians, contractors, and engineers.

What is a Montana flume?

A Montana flume, shown in Figure 1, is a specially shaped structure that can be installed in a channel to measure the water flow rate.

The form of a Montana flume is the same as the converging section of a regular Parshall flume (discussed in MT 9129). It is simpler and handier than a Parshall flume, but is not adapted to as wide a range of conditions and will not measure submerged flow. Information to help decide whether a Montana or a regular Parshall flume is needed follows. Both flumes have been used extensively in Montana and other Western states. Many people confuse

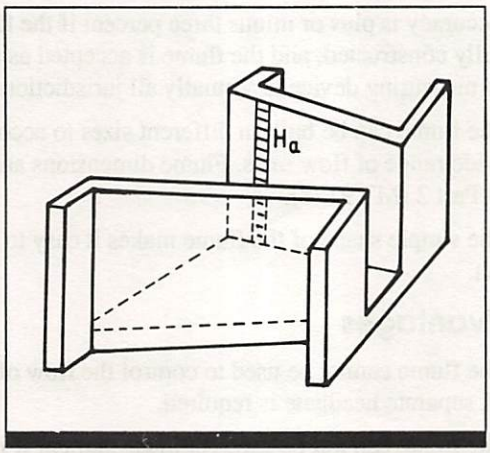

Figure 1. A typical Montana flume.

the Montana and Parshall flumes with weirs. Flumes and weirs are not the same. They should not be confused in discussion or when choosing tables to determine flow rates.

The Montana flume consists of a converging section and a throat also called a crest. The flume size corresponds to the crest width and is normally in one-foot increments.

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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Section and plan views are shown in Figure 2 (Part 2, MT 9128). 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.

Advantages

- The flume can operate with small head loss which allows use in flatter ditches than a weir. Locating and setting the flume is discussed in Part 2 (MT 9128).
- The flume is relatively insensitive to the velocity of the inflowing water. Thus it can be located in canals and ditches without a stilling pond immediately upstream.
- The water velocity through the flume is high enough to virtually eliminate sediment deposition.
- Accuracy is plus or minus three percent if the flume is carefully constructed, and the flume is accepted as an accurate measuring device in virtually all jurisdictions.
- The flume can be built in different sizes to accommodate a wide range of flow rates. Flume dimensions are given in Part 2 (MT 9128).
- The simple shape of the flume makes it easy to construct.

Disadvantages

- The flume cannot be used to control the flow of water. A separate headgate is required.
- The flume can not be used for measurement if it is submerged. Under submerged conditions water is not falling smoothly over the crest. The water is "backed up" from downstream.
- The structure does not provide erosion protection.

Locating the flume

Finding a suitable location for and determining the proper size Montana flume to install is easy as long as there is a place where free flow (non-submerged) conditions exist. Many canals or ditches have a natural drop or steep spot. These conditions are ideal for a Montana flume. If it appears that submerged conditions exist or could develop, another location should be selected. If you are having problems with locating or sizing a flume, seek help.

Although not as costly as a Parshall flume, a large Montana flume can cost thousands of dollars to build and be virtually impossible to move. Prefabricated metal flumes up to three or four feet in size can be moved and reset but this takes time and labor.

Building a flume

A Montana flume can be built by anyone with reasonable carpentry skills. Flume dimensions are given in Part 2, (MT 9128). These dimensions are critical and must be followed exactly. Prefabricated metal flumes are the best choice for flumes with a throat width of one to four feet.

Many fabricators only make the Parshall flume. You may be able to have the Montana flume built by special order. For sizes greater than four feet the best choice is to build the flume in place out of treated lumber or concrete.

Careful construction is required. 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 any contractor engaged should be required to guarantee exact dimensions and good workmanship.

The Montana flume usually requires erosion protection downstream from 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). Wing walls may be required on the upstream end.

Water measurement

A table can be used to convert linear measurements to flow rate. The steps for using a table to determine the flow rate through a Montana flume are:

1. Determine the flume size. The size is the width at the narrowest part which is the throat or crest of the flume.
2. Inspect the water flow through the throat. If downstream conditions have caused the water to back up and submerge the flow, the measurement will be inaccurate. A

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.).

Head, H_a (feet)	Discharge, Q, for throat widths, W, of__								
	1 foot	1.5 feet	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet
0.10	0.11	0.15	—	—	—	—	—	—	—
.15	.20	.30	0.42	0.61	—	—	—	—	—
.20	.35	.51	.66	.97	1.26	1.55	—	—	—
.25	.49	.71	.93	1.37	1.80	2.22	2.63	3.02	3.46
.30	.64	.94	1.24	1.82	2.39	2.96	3.52	4.08	4.62
.35	.80	1.19	1.57	2.32	3.06	3.78	4.50	5.22	5.93
.40	.99	1.47	1.93	2.86	3.77	4.68	5.57	6.46	7.34
.45	1.19	1.76	2.32	3.44	4.54	5.63	6.72	7.80	8.87
.50	1.39	2.06	2.73	4.05	5.36	6.66	7.94	9.23	10.5
.55	1.62	2.39	3.17	4.70	6.23	7.74	9.25	10.8	12.2
.60	1.84	2.73	3.62	5.39	7.15	8.89	10.6	12.4	14.1
.65	2.08	3.09	4.11	6.12	8.11	10.1	12.1	14.1	16.0
.70	2.33	3.46	4.60	6.86	9.11	11.4	13.6	15.8	18.0
.75	2.58	3.85	5.12	7.65	10.2	12.7	15.2	17.7	20.1
.80	2.85	4.26	5.66	8.46	11.3	14.0	16.8	19.6	22.4
.85	3.12	4.67	6.22	9.30	12.4	15.5	18.5	21.6	24.6
.90	3.41	5.10	6.80	10.2	13.6	16.9	20.3	23.7	27.0
.95	3.70	5.55	7.39	11.1	14.8	18.4	22.1	25.8	29.5
1.00	4.00	6.00	8.00	12.0	16.0	20.0	28.0	32.0	
1.10	4.62	6.95	9.27	13.9	18.6	23.3	27.9	32.6	37.3
1.15	4.94	7.44	9.94	14.9	19.9	25.0	30.0	35.0	40.1
1.20	5.28	7.94	10.6	16.0	21.3	26.7	32.1	37.5	42.9
1.25	5.62	8.46	11.3	17.0	22.8	28.5	34.3	40.0	45.8
1.30	5.96	8.99	12.0	18.1	24.2	30.3	36.5	42.6	48.8
1.35	6.32	9.52	12.7	19.2	25.7	32.2	38.7	45.3	51.8
1.40	6.68	10.1	13.5	20.3	27.2	34.1	41.1	48.0	55.0
1.45	7.04	10.6	14.2	21.5	28.8	36.1	43.4	50.8	58.1
1.50	7.41	11.2	15.0	22.6	30.3	38.1	45.8	53.6	61.4
1.55	7.80	11.8	15.8	23.8	32.0	40.1	48.3	56.5	64.7
1.60	8.18	12.4	16.6	25.1	33.6	42.2	50.8	59.4	68.1
1.65	8.57	13.0	17.4	26.3	35.3	44.3	53.3	62.4	71.6
1.70	8.97	13.6	18.2	27.6	37.0	46.4	56.0	65.5	75.1
1.75	9.38	14.2	19.0	28.8	38.7	48.6	58.6	68.6	78.7
1.80	9.79	14.8	19.9	30.1	40.5	50.8	61.3	71.8	82.3
1.85	10.2	15.5	20.8	31.5	42.2	53.1	64.0	75.0	86.0
1.90	10.6	16.1	21.6	32.8	44.1	55.4	66.8	78.2	89.8
1.95	11.1	16.7	22.5	34.1	45.9	57.7	69.6	81.6	93.6
2.00	11.5	17.4	23.4	35.5	47.8	60.1	72.5	84.9	97.5
2.05	11.9	18.1	24.3	36.9	49.7	62.5	75.4	88.4	101.4
2.10	12.4	18.8	25.3	38.4	51.6	64.9	78.4	91.8	105.4
2.15	12.8	19.5	26.2	39.8	53.5	67.4	81.4	95.4	109.5
2.20	13.3	20.2	27.2	41.3	55.5	69.9	84.4	98.9	113.6
2.25	13.7	20.9	28.1	42.7	57.5	72.4	87.5	102.6	117.8
2.30	14.2	21.6	29.1	44.2	59.6	75.0	90.6	106.2	122.0
2.35	14.7	22.4	30.1	45.7	61.6	77.6	93.8	110.0	126.3
2.40	15.2	23.0	31.1	47.3	63.7	80.3	97.0	113.7	130.7
2.45	15.6	23.8	32.1	48.8	65.8	82.9	100.2	117.6	135.1
2.50	16.1	24.6	33.1	50.4	67.9	85.6	103.5	121.4	139.5

Table 1. Free-flow discharge values for Parshall flumes in cubic feet per second.

Montana flume will not measure if it is even partially submerged. More information about submergence is given in MT 9128.

3. Measure the upstream head (H_a). H_a is measured at a point two-thirds of the distance from the crest to the flume entrance. For most irrigation measurements, a staff gage attached to the flume wall at this point is satisfactory. When precise measurement is required, a stilling well (a pipe set outside the flume but connected to the water in the flume) should be installed so that minor water fluctuations are dampened.

4. Table 2 gives the discharge rate for one- to eight-foot flumes for upstream heads in 0.05 foot increments. The figures can be interpolated when accuracy requires gage readings to 0.01 feet, or extended tables can be obtained. For example, the discharge rate through a two-foot flume with an H_a reading of 1.10 feet is 9.27 cubic feet per second.

Summary

A Montana flume is an excellent measuring device which has stood the tests of time and use. The flume can only be used in a steep ditch or where there is a natural drop so that it will not submerge. When conditions are appropriate it is an excellent choice.

Depth Applied to a Field in Inches

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

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

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

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A-5 (Devices and Methods)
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