State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720-9000
Phone: (208) 327-7900 FAX: (208) 327-7866

CECIL D. ANDRUS
GOVERNOR
R. KEITH HIGGINSON
DIRECTOR

May 3, 1994

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MAY 05 1994
De... Resources
Sou...e. Region Office

Jack Eastman
Watermaster, Water District 47C
106 Doral Dr.
Jerome, ID 83338

Re: Water Measurement Device Information

Dear Jack:

While reviewing some literature on submerged orifices I came across a diagram and reference to commercial headgates and stilling wells. The reference, which is attached, appears to be similar to the headgate and canister type stilling wells which we recently inspected on Deadwood and Devil Creeks.

It is possible that the Devil Creek Ranch headgates with the stilling wells were installed as both regulating and measuring devices. You will note from the attached literature that such gates may be used for water measurement, similar to a submerged orifice. The manufacturer calibrates the gates and provides tables for determining discharge based on different gate openings and head differentials. These types of gates are still made and sold today. I have attached some tables for different size gates made by Waterman.

In order for such gates to work properly, the culvert pipe must have full flow and be submerged on both sides of the gate opening. The canisters or stilling wells must be level, the culvert pipe must be fairly level, and the intakes must be clean and functional. It is possible that the Devil Creek headgates on the Crosscut Canal can be used as measurement devices. We would need to inspect these gates relative to the above criteria and determine if the attached tables could be used. If the intakes can be located and cleaned, we can check the gate measurements with current meter measurements in the diversion ditches.

Please contact me if you have further questions concerning these structures or if there is a need for the Department to require functional measuring devices for these or other diversions within the district.

Sincerely,

Tim

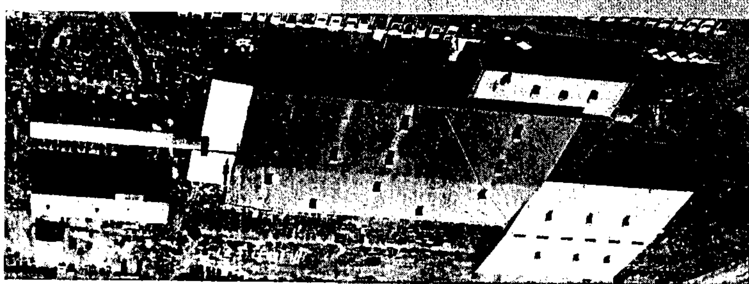
Tim Luke
Water Allocations

cc: Jim Stanton, Southern Region

Waterman Data Book

CM-10 Canal Gate

- INSTALLATION
- OPERATION
- DISCHARGE TABLES



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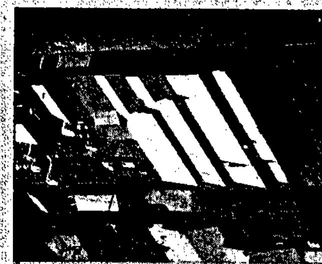
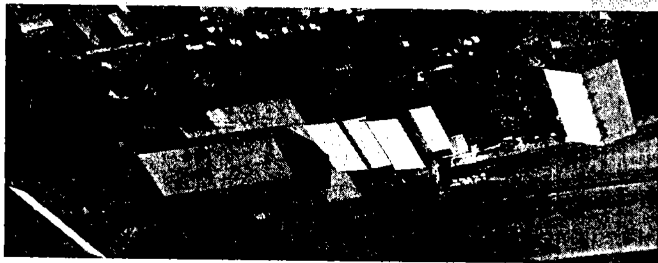
PRODUCTION FACILITIES
P.O. BOX 458, EXETER, CALIFORNIA 93221
(209) 592-3174



PATTERN SHOP



FOUNDRY

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Waterman INDUSTRIES, INC.

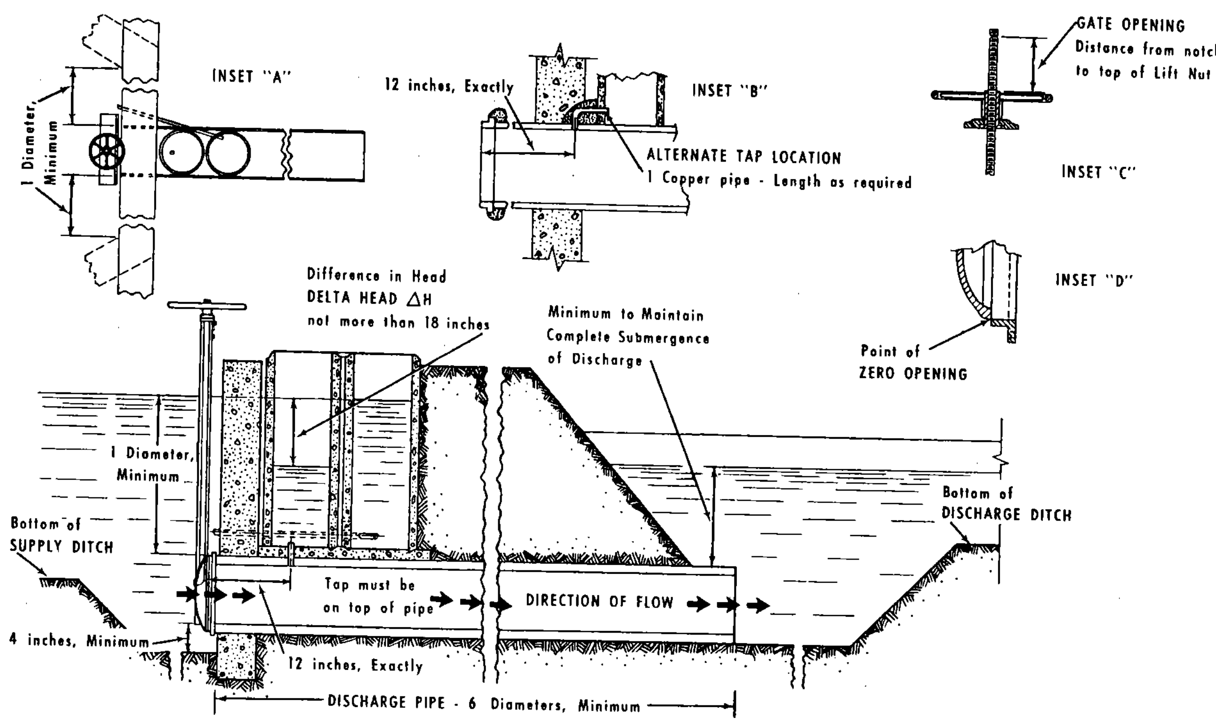

Figure 1. Installation Diagram

INSTALLATION. (See figure 1.)

MEASUREMENTS AND CONDITIONS. Install WATERMAN MODEL CM-10 CANAL GATE as diagramed in figure 1. Calibrations in this book have been made to these measurements and conditions, and any variation in the installation must be considered in the use of the calibrations. Standard settings and dimensions have been maintained to permit the immediate interchangeability with systems already in operation.

FIRST TAP. The tap to the first well, usually 3/4-inch diameter brass pipe, must be located exactly 12 inches from the face of the gate seat, and must be on the top centerline of the pipe. On corrugated metal pipe, the tap must be on the outside diameter of the crown, protrude to the average diameter, and be finished off smoothly on a horizontal plane with filler cement. Where the headwall thickness is 12 inches or greater, or where other conditions make a direct connection impracticable, the tap may be connected by a smooth bend as shown in Inset B.

SECOND TAP. The tap to the upstream stilling well can be made by normal plumbing practice. To facilitate measurements the taps of the metering wells should be level and the same height.

MINIMUM DISTANCES. Maintain the minimum distances as shown. Obstructions, such as log or trash stops, should not be placed immediately in front of the gate opening.

DISCHARGE PIPE. The discharge pipe should not be less than six diameters in length.

WATER LEVEL. Both inlet and outlet ends of the pipe must be submerged at all times. A mininum submergence of 12 inches is recommended. This may be insured on the outlet end by using a 90° elbow set with its discharge end straight up.

GATE OPENING. After the gate has been installed, raise the gate to the point of "zero opening", as shown in Inset C. At this point, file a notch in the gate stem to mark the top of the gate nut. Thereafter the gate opening can always be determined by measuring the distance from this notch to the top of the gate nut. (See figure 2.)

OPERATION.

WATER LEVELS. Both the inlet and outlet ends of the pipe must always be under not less than 12 inches of water. The coverage of the outlet end may be insured by using a 90° elbow set with its discharge end straight up.

DELTA HEAD. The Delta Head (ΔD) is determined by measuring the difference in the level of water in the two stilling wells. This can be done easily with a hook gage, or by any linear measuring stick, rod, or tape.

DISCHARGE RATE. After the Delta Head and the Gate Opening have been determined, the discharge rate in cubic feet per second can be found in the applicable table in this book. If desired, the cubic feet per second rate may be converted into Miner's Inches, Gallons Per Minute, Acre Feet, or other measurements shown in the tables on pages 3 through 24. No calibrations are made for more than 18 inches Delta Head. If the Delta Head is greater than 18 inches, a larger diameter gate should be used to avoid excessive velocity.

WATERMAN MODEL C-20 CANAL GATE is sometimes used in general metering installations. Tests have demonstrated that there is less than a four per cent variation of flow between the Model C-20 and Model CM-10 Canal Gates.

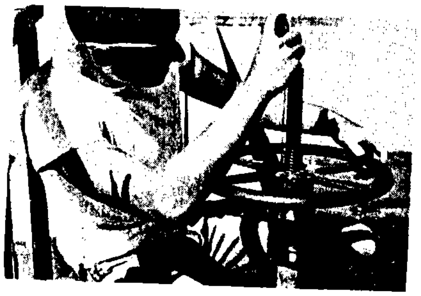

Figure 2.

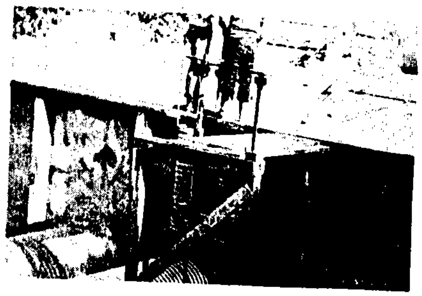

Figure 3.

Figure 4.

DISCHARGE DATA
8" WATERMAN RED TOP CANAL GATES WITH METERING WELLS — MODEL C-10

Head in Inches	Net Gate Opening in Inches / Discharge in Feet Per Second: 2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8
1	0.24	0.30	0.34	0.40	0.46	0.50	0.54	0.58	0.60	0.61	0.63	0.64	0.66
1¼	.26	.33	.38	.44	.51	.55	.60	.64	.66	.68	.70	.71	.73
1½	.29	.36	.41	.48	.56	.60	.65	.69	.73	.75	.76	.78	.80
1¾	.31	.39	.45	.52	.60	.65	.70	.75	.78	.80	.82	.84	.86
2	.33	.41	.48	.55	.64	.69	.75	.80	.83	.85	.88	.90	.92
2¼	.35	.43	.51	.58	.67	.74	.79	.84	.88	.90	.93	.95	.97
2½	.37	.46	.53	.62	.71	.77	.84	.89	.93	.95	.97	1.00	1.03
2¾	.38	.48	.56	.64	.74	.81	.88	.93	.97	1.00	1.03	1.05	1.08
3	.40	.50	.58	.67	.78	.85	.91	.97	1.02	1.04	1.07	1.09	1.12
3¼	.42	.52	.61	.70	.81	.88	.95	1.01	1.06	1.08	1.12	1.14	1.16
3½	.43	.54	.63	.72	.84	.91	.99	1.04	1.09	1.13	1.15	1.18	1.21
3¾	.44	.56	.65	.75	.87	.94	1.02	1.08	1.14	1.17	1.19	1.23	1.25
4	.46	.58	.67	.77	.89	.97	1.05	1.12	1.17	1.20	1.23	1.26	1.28
4¼	.47	.59	.69	.80	.92	1.01	1.08	1.15	1.20	1.24	1.27	1.30	1.33
4½	.49	.61	.71	.82	.95	1.03	1.12	1.18	1.24	1.27	1.30	1.33	1.36
4¾	.50	.63	.73	.84	.97	1.07	1.15	1.22	1.28	1.31	1.34	1.37	1.40
5	.51	.64	.75	.86	.99	1.09	1.17	1.24	1.30	1.33	1.37	1.40	1.43
5½	.54	.67	.78	.90	1.04	1.13	1.23	1.30	1.36	1.39	1.43	1.47	1.50
6	.56	.70	.81	.94	1.08	1.18	1.28	1.36	1.43	1.46	1.49	1.53	1.57
6½	.58	.73	.85	.98	1.13	1.23	1.33	1.41	1.48	1.52	1.55	1.58	1.63
7	.60	.75	.88	1.02	1.17	1.28	1.38	1.47	1.53	1.57	1.61	1.65	1.68
7½	.62	.78	.91	1.05	1.21	1.33	1.43	1.52	1.58	1.63	1.67	1.70	1.74
8	.64	.80	.94	1.08	1.25	1.37	1.47	1.56	1.63	1.68	1.72	1.75	1.79
8½	.66	.83	.96	1.11	1.29	1.40	1.51	1.60	1.68	1.72	1.76	1.81	1.85
9	.68	.85	.99	1.14	1.32	1.44	1.55	1.65	1.73	1.77	1.82	1.86	1.90
9½	.70	.87	1.02	1.18	1.35	1.48	1.60	1.69	1.77	1.82	1.87	1.90	1.95
10	.72	.90	1.05	1.20	1.38	1.52	1.64	1.73	1.82	1.86	1.91	1.95	2.00
11	.75	.93	1.09	1.26	1.45	1.58	1.71	1.81	1.90	1.95	2.00	2.05	2.09
12	.78	.98	1.14	1.32	1.52	1.65	1.78	1.88	1.98	2.04	2.08	2.13	2.18
13	.81	1.02	1.18	1.37	1.58	1.72	1.85	1.96	2.06	2.11	2.17	2.22	2.27
14	.84	1.05	1.23	1.42	1.63	1.78	1.92	2.03	2.14	2.18	2.25	2.30	2.35
15	.87	1.08	1.26	1.46	1.68	1.84	1.98	2.10	2.21	2.26	2.33	2.37	2.43
16	.90	1.12	1.30	1.51	1.72	1.90	2.04	2.17	2.27	2.33	2.39	2.45	2.50
17	.92	1.15	1.34	1.55	1.79	1.96	2.10	2.23	2.34	2.39	2.46	2.52	2.58
18	.95	1.18	1.38	1.59	1.83	2.01	2.16	2.29	2.40	2.46	2.53	2.59	2.65

DISCHARGE DATA
10" WATERMAN RED TOP CANAL GATES WITH METERING WELLS — MODEL C-10

Head in Inches	Net Gate Opening in Inches												
	2	2½	3	3½	4	4½	5	5½	6	7	8	9	10
	Discharge in Feet Per Second												
1	.31	.38	.45	.50	.56	.61	.68	.72	.78	.87	.94	1.00	1.04
1¼	.35	.42	.50	.56	.62	.68	.75	.80	.86	.97	1.06	1.11	1.16
1½	.38	.46	.55	.61	.68	.74	.82	.88	.94	1.06	1.15	1.22	1.27
1¾	.41	.50	.59	.66	.73	.80	.89	.95	1.03	1.14	1.24	1.31	1.37
2	.44	.53	.63	.71	.78	.85	.95	1.02	1.08	1.23	1.33	1.40	1.45
2¼	.46	.56	.67	.75	.83	.90	1.00	1.08	1.15	1.29	1.41	1.48	1.54
2½	.48	.59	.71	.79	.87	.95	1.06	1.13	1.22	1.37	1.48	1.55	1.63
2¾	.51	.62	.74	.83	.91	1.00	1.12	1.18	1.27	1.43	1.55	1.63	1.70
3	.53	.65	.77	.86	.95	1.04	1.16	1.24	1.33	1.48	1.62	1.70	1.77
3¼	.55	.67	.80	.90	.99	1.08	1.20	1.28	1.38	1.55	1.68	1.77	1.85
3½	.57	.70	.83	.93	1.03	1.13	1.25	1.33	1.43	1.60	1.74	1.83	1.90
3¾	.60	.72	.86	.96	1.07	1.16	1.28	1.38	1.48	1.66	1.80	1.89	1.96
4	.61	.74	.89	.99	1.10	1.20	1.33	1.43	1.53	1.71	1.85	1.95	2.04
4¼	.63	.76	.91	1.03	1.13	1.23	1.38	1.48	1.58	1.76	1.90	2.02	2.10
4½	.65	.79	.94	1.05	1.16	1.28	1.40	1.50	1.62	1.81	1.96	2.06	2.15
4¾	.67	.81	.96	1.08	1.18	1.30	1.44	1.54	1.67	1.85	2.01	2.10	2.20
5	.68	.83	.99	1.10	1.23	1.34	1.48	1.59	1.72	1.91	2.08	2.18	2.27
5½	.71	.87	1.04	1.16	1.28	1.40	1.55	1.66	1.78	2.00	2.17	2.28	2.38
6	.74	.91	1.08	1.21	1.33	1.46	1.62	1.74	1.86	2.08	2.26	2.38	2.48
6½	.77	.94	1.13	1.26	1.38	1.52	1.68	1.80	1.94	2.16	2.35	2.47	2.58
7	.80	.98	1.17	1.30	1.44	1.58	1.74	1.87	2.02	2.24	2.44	2.56	2.67
7½	.83	1.02	1.21	1.34	1.48	1.63	1.80	1.93	2.08	2.33	2.53	2.65	2.76
8	.86	1.04	1.24	1.38	1.54	1.68	1.86	2.00	2.14	2.40	2.60	2.74	2.85
8½	.88	1.08	1.28	1.43	1.58	1.73	1.92	2.05	2.21	2.46	2.68	2.82	2.94
9	.91	1.10	1.32	1.47	1.63	1.78	1.96	2.11	2.27	2.54	2.75	2.90	3.03
9½	.93	1.13	1.35	1.51	1.67	1.83	2.03	2.18	2.33	2.60	2.83	2.97	3.10
10	.95	1.17	1.39	1.54	1.72	1.87	2.07	2.22	2.39	2.67	2.90	3.05	3.18
11	1.00	1.22	1.45	1.63	1.79	1.95	2.17	2.33	2.50	2.79	3.06	3.19	3.33
12	1.04	1.27	1.52	1.69	1.87	2.04	2.25	2.43	2.61	2.91	3.20	3.37	3.48
13	1.08	1.33	1.58	1.75	1.94	2.12	2.36	2.53	2.72	3.02	3.32	3.49	3.63
14	1.12	1.37	1.63	1.82	2.02	2.19	2.43	2.62	2.81	3.13	3.44	3.64	3.76
15	1.16	1.42	1.68	1.87	2.08	2.27	2.51	2.70	2.91	3.24	3.56	3.76	3.94
16	1.20	1.46	1.74	1.94	2.14	2.34	2.59	2.78	3.00	3.34	3.69	3.89	4.11
17	1.24	1.50	1.79	2.00	2.21	2.42	2.68	2.86	3.09	3.45	3.79	4.01	4.16
18	1.27	1.54	1.84	2.05	2.27	2.48	2.74	2.94	3.18	3.55	3.89	4.11	4.25

DISCHARGE DATA
12" WATERMAN RED TOP CANAL GATES WITH METERING WELLS — MODEL C-10

Head in Inches	Net Gate Opening In Inches														
	2	2½	3	3½	4	4½	5	5½	6	7	8	9	10	11	12
	Discharge in Feet Per Second														
1	.35	.43	.50	.58	.66	.72	.79	.85	.91	1.03	1.15	1.24	1.31	1.33	1.40
1¼	.39	.48	.56	.64	.73	.81	.87	.95	1.02	1.14	1.28	1.37	1.46	1.54	1.57
1½	.43	.53	.61	.70	.80	.88	.95	1.04	1.10	1.25	1.40	1.49	1.59	1.68	1.73
1¾	.46	.57	.65	.75	.86	.95	1.03	1.12	1.19	1.34	1.50	1.61	1.72	1.81	1.87
2	.49	.61	.70	.80	.91	1.01	1.08	1.18	1.27	1.43	1.61	1.71	1.82	1.92	2.00
2¼	.52	.64	.74	.85	.97	1.07	1.16	1.26	1.34	1.52	1.70	1.81	1.93	2.04	2.10
2½	.55	.68	.77	.89	1.03	1.13	1.22	1.32	1.41	1.59	1.79	1.90	2.03	2.14	2.21
2¾	.57	.71	.81	.93	1.07	1.18	1.27	1.38	1.48	1.67	1.87	1.99	2.13	2.24	2.32
3	.60	.74	.84	.97	1.12	1.23	1.33	1.44	1.54	1.74	1.95	2.08	2.22	2.34	2.42
3¼	.62	.77	.88	1.01	1.15	1.28	1.38	1.50	1.60	1.81	2.03	2.16	2.30	2.44	2.51
3½	.65	.80	.91	1.05	1.20	1.32	1.43	1.55	1.66	1.87	2.10	2.24	2.40	2.53	2.60
3¾	.67	.82	.94	1.08	1.23	1.37	1.48	1.60	1.72	1.93	2.17	2.31	2.46	2.60	2.68
4	.69	.85	.97	1.12	1.28	1.40	1.52	1.66	1.77	2.00	2.24	2.38	2.55	2.69	2.77
4¼	.71	.87	1.00	1.15	1.31	1.45	1.57	1.70	1.82	2.05	2.30	2.45	2.62	2.77	2.85
4½	.73	.90	1.03	1.18	1.35	1.49	1.62	1.75	1.87	2.12	2.37	2.53	2.70	2.85	2.94
4¾	.75	.92	1.05	1.22	1.38	1.53	1.65	1.80	1.92	2.17	2.44	2.59	2.77	2.92	3.01
5	.77	.94	1.08	1.24	1.42	1.57	1.70	1.84	1.97	2.23	2.50	2.65	2.84	3.00	3.10
5½	.80	.99	1.13	1.30	1.48	1.64	1.77	1.93	2.06	2.34	2.61	2.78	2.97	3.13	3.23
6	.84	1.03	1.18	1.37	1.55	1.71	1.85	2.01	2.15	2.44	2.72	2.80	3.10	3.28	3.38
6½	.87	1.07	1.22	1.41	1.61	1.78	1.93	2.09	2.24	2.53	2.83	3.00	3.22	3.40	3.50
7	.90	1.11	1.27	1.47	1.67	1.85	2.00	2.17	2.31	2.62	2.94	3.12	3.35	3.52	3.65
7½	.93	1.15	1.31	1.51	1.73	1.90	2.06	2.24	2.40	2.70	3.03	3.22	3.45	3.65	3.76
8	.96	1.18	1.35	1.56	1.78	1.96	2.13	2.31	2.47	2.80	3.12	3.33	3.58	3.75	3.88
8½	.99	1.22	1.40	1.60	1.83	2.03	2.20	2.38	2.55	2.88	3.21	3.42	3.68	3.88	4.00
9	1.02	1.25	1.43	1.65	1.88	2.08	2.25	2.45	2.61	2.95	3.30	3.52	3.78	3.99	4.10
9½	1.04	1.28	1.47	1.69	1.93	2.14	2.31	2.51	2.68	3.02	3.40	3.61	3.88	4.09	4.21
10	1.07	1.32	1.51	1.74	1.98	2.19	2.37	2.58	2.75	3.10	3.50	3.70	3.98	4.20	4.32
11	1.12	1.38	1.58	1.82	2.07	2.29	2.48	2.70	2.88	3.25	3.65	3.90	4.15	4.39	4.51
12	1.16	1.44	1.65	1.90	2.15	2.39	2.59	2.80	3.00	3.40	3.80	4.05	4.32	4.57	4.61
13	1.21	1.49	1.71	1.97	2.25	2.48	2.69	2.93	3.12	3.52	3.95	4.20	4.50	4.75	4.90
14	1.26	1.55	1.77	2.05	2.33	2.57	2.79	3.01	3.22	3.65	4.10	4.36	4.67	4.90	5.08
15	1.30	1.60	1.83	2.11	2.40	2.65	2.88	3.12	3.33	3.78	4.23	4.50	4.81	5.09	5.24
16	1.34	1.65	1.89	2.18	2.49	2.75	2.96	3.22	3.45	3.90	4.38	4.65	4.98	5.25	5.40
17	1.37	1.70	1.95	2.24	2.55	2.82	3.05	3.31	3.55	4.00	4.50	4.79	5.11	5.40	5.56
18	1.42	1.75	2.00	2.31	2.63	2.90	3.15	3.41	3.65	4.12	4.61	4.92	5.27	5.55	5.72

for a given H_a. Any error that is introduced is on the side of safety and the accuracy obtained from this chart is adequate for many farm installations.

The Parshall measuring flume may be constructed of sheet metal, timber, or reinforced concrete. Sheet-metal flumes have proved very satisfactory, but since the cost usually exceeds that of either wood or concrete, their use has been restricted to the smaller sizes. While metal flumes up to 10 feet in throat width have been constructed, the most common and practical sizes are those of less than 2 feet. Sheet-metal flumes have the advantage of being portable, and they can readily be reset and readjusted as needed. They have a relatively long life and are immune to fire hazards such as are caused by ditch cleaning. Commercially made flumes of this type are available.

Flumes of all sizes except the smallest have been constructed of timber and have proved satisfactory. Timber flumes usually have an initial cost advantage over concrete flumes; however, their useful life is usually shorter. Timber pressure-treated with creosote or some other preservative will prolong the life of such structures and is economically justified. Timber flumes are subject to damage by fire and by floating ice.

Monolithic reinforced concrete flumes, constructed in sizes ranging from 3 inches to 50 feet, have proved satisfactory. Such flumes have the distinct advantage of permanence and are little subject to expansion or contraction, thus insuring uniformity of operation. They are not subject to fire and other hazards, as are timber structures. Their principal disadvantage is their relatively high initial cost.

<u>Submerged Orifices</u>

A submerged orifice is a hole or opening cut in a bulkhead through which water flows when the water surface on the downstream side is above the top of the opening. Submerged orifices may be divided into two types: (1) Those having fixed dimensions, and (2) those built so that the height may be varied. Those having fixed dimensions are called standard submerged orifices and are preferable to and more widely used than those of variable dimensions. Only the standard submerged orifices will be discussed in the following paragraphs.

The opening of a standard submerged orifice is sharp-edged and usually rectangular with the width two to six times its height. The orifice should have complete contractions, the sides and bottom of the opening being no closer to the sides or bottom of the channel than twice its least dimension.

Submerged orifices are used in channels having flat grades when conditions are not satisfactory for accurate measurement with free-flowing weirs. The submerged orifice is subject to the same disadvantage as the weir--collecting floating debris, sand, and sediment. If the pond on the upstream side of the orifice is allowed to fill with sediment, the accuracy of the measurement is destroyed.

Table 9-15.--Recommended sizes and dimensions for submerged-orifice structures[1]

Approximate range in capacity, sec.-ft.	Size of orifice			Height of structure, B	Width of head wall, A	Length E	Width W	Length of down-stream wing wall C
	Height D	Length L	Area					
	In.	In.	Sq.ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0.4 to 1.0	3	12	0.25	4.0	10.0	3.0	2.5	2.0
.5 to 1.4	3	16	.33	4.0	10.0	3.0	3.0	2.0
.8 to 2.1	3	24	.50	4.0	12.0	3.0	3.5	2.0
.5 to 1.4	4	12	.33	4.5	10.0	3.0	2.5	2.5
.8 to 2.1	4	18	.50	4.5	12.0	3.0	3.0	2.5
1.0 to 3.2	4	27	.75	4.5	12.0	3.0	3.5	2.5
.8 to 2.1	6	12	.50	5.0	12.0	3.5	2.5	3.0
1.0 to 3.2	6	18	.75	5.0	14.0	3.5	3.0	3.0
1.5 to 4.3	6	24	1.00	5.0	14.0	3.5	3.5	3.0
2.3 to 6.5	6	36	1.50	5.0	16.0	3.5	4.5	3.0
1.5 to 4.3	9	16	1.00	6.0	14.0	3.5	3.0	3.0
2.3 to 6.5	9	24	1.50	6.0	16.0	3.5	3.5	3.0
3.0 to 8.7	9	32	2.00	6.0	16.0	3.5	4.0	3.0

[1] Dimension letters shown in fig. 9-30.

Discharge through submerged orifices is determined by the formula

$$Q = CA\sqrt{2gh}$$

where Q = discharge in cubic feet per second
C = discharge coefficient equal to 0.61 for orifices with complete contractions
A = cross-sectional area of the orifice in square feet
g = acceleration due to gravity = 32.16 feet per second per second
h = head on the orifice in feet

For convenience, an orifice should be selected so that its cross-sectional area is equal to one of those shown in table 9-15. When this is done, the discharge for any head may be read directly from table 9-16.

Gates

Gates are openings in hydraulic structures. These gates permit the passage of water and are usually provided with some means of regulating outflow. Inasmuch as they have the hydraulic characteristics of orifices, gates of various designs afford an opportunity for discharge measurement. The discharge may either be free or submerged. When the discharge is submerged, gates have the advantage of being able to operate at a low head and can therefore be used in relatively level canals and streams where it is not possible to obtain enough drop for weir measurements. The principal use of gates is to measure the discharge from the canals of irrigation enterprises into individual farm laterals.

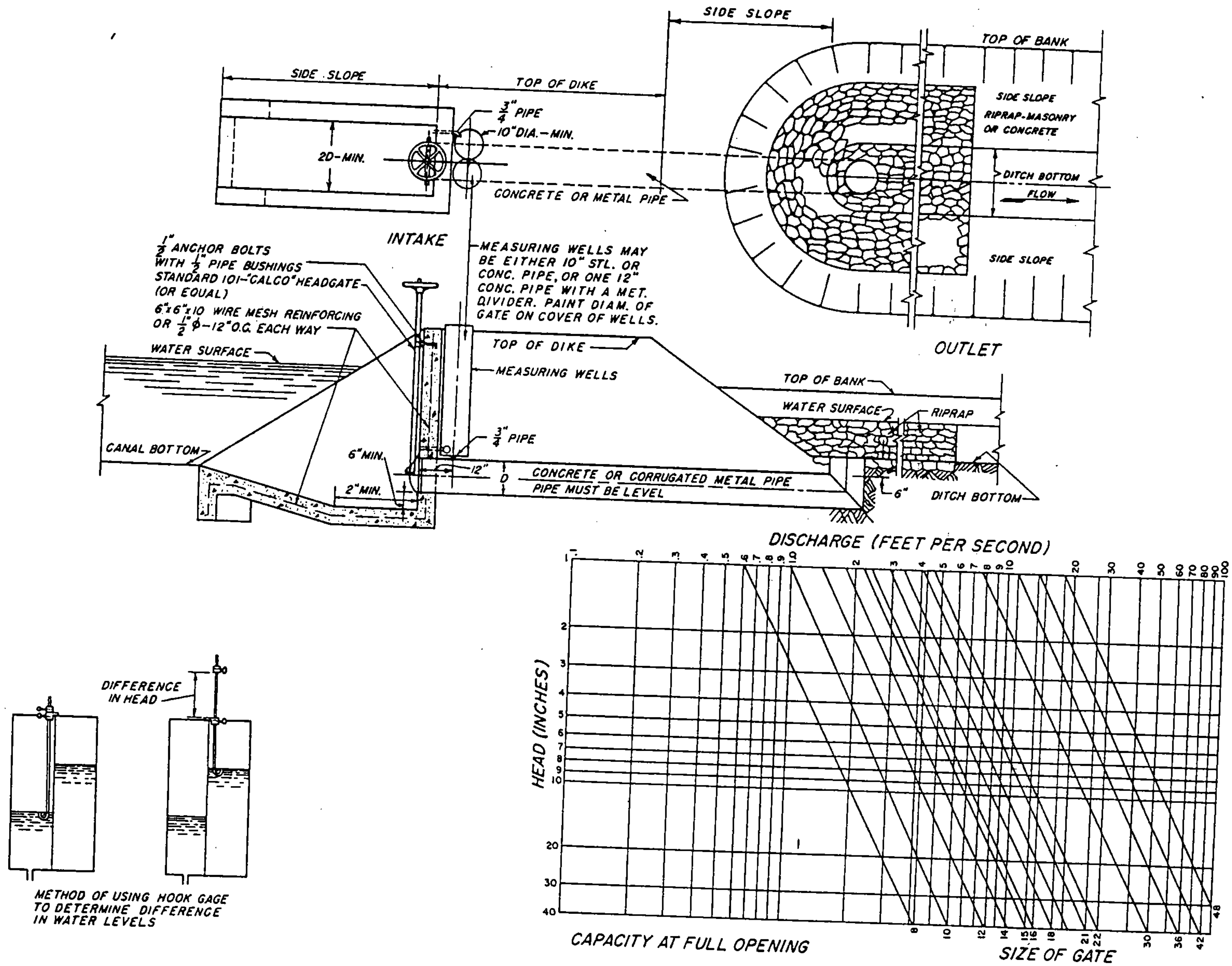

Figure 9-33--Metergate and chart for pipe size selection