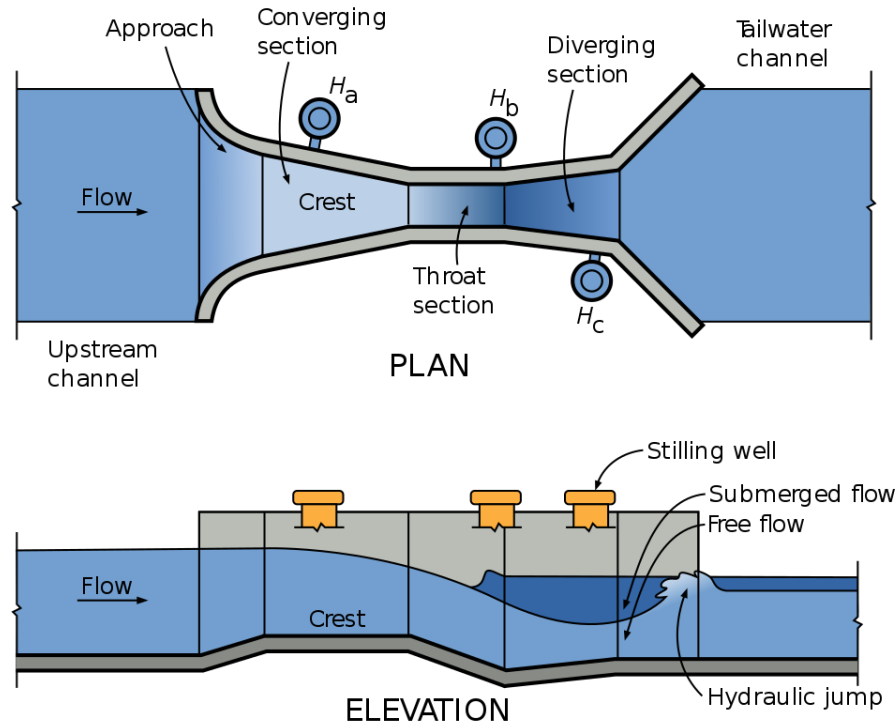


قناة بارشال - Parshall Flume

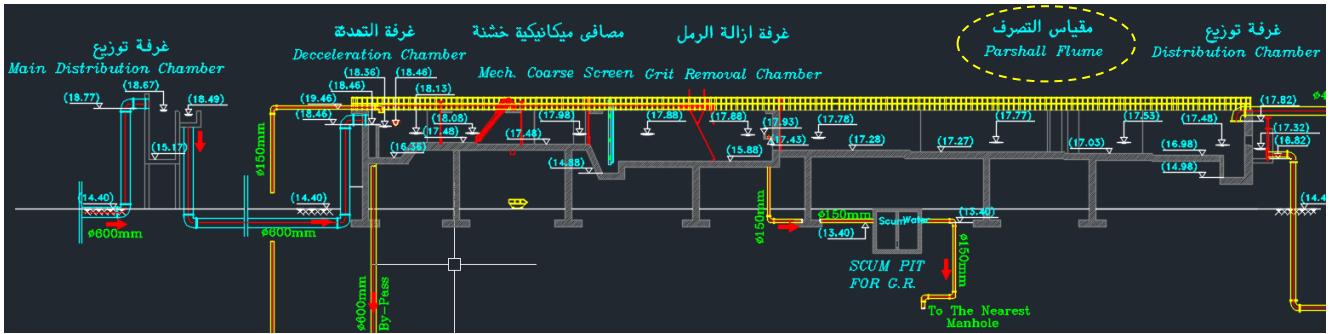
(الجزء الأول) - (Part 1)

- قناة بارشال هو جهاز قياس تدفق قناة مفتوحة تم تطويره لقياس تدفق المياه السطحية. قناة بارشال عبارة عن هيكل هيدروليكي ثابت. يتم استخدامه لقياس معدل التدفق الحجمي في العمليات الصناعية، السدود، وخطوط الصرف الصحي، والتدفقات المُدخلة / المُخرجة في محطات معالجة مياه الصرف. تم تسمية القنوات على اسم جون بارشال، الذي اخترعهم في أوائل الثلاثينيات.
- The Parshall flume is an open channel flow metering device that was developed to measure the flow of surface water. The Parshall flume is a fixed hydraulic structure. It is used to measure volumetric flow rate in industrial discharges, dam discharges municipal sewer lines, and influent / effluent flows in wastewater treatment plants. Flumes are named after John Parshall, who invented them in the early 1930s.
- قناة بارشال سهلة التركيب نسبياً، مما يجعلها خياراً شائعاً لقياس تدفقات المياه بمقدار فقد رفع منخفض، القدرة على التنظيف الذاتي، وبأقل قدر من الصيانة بمرور الوقت. بشكل عام، فهي أداة أساسية لأي منظمة أو منشأة تحتاج إلى قياس تدفق المياه في القنوات المفتوحة بشكل موثوق.
- Parshall flume is relatively easy to install, which makes it a popular choice for measuring water flows with low head loss, self-cleaning capability, and minimal maintenance over time. Overall, it is an essential tool for any organization or facility that needs reliably measure water flow in open channels.



❖ أجزاء قناة بارشال / Parshall Flume Sections

- ١- جزء المدخل / (Converging Section) - upstream section:
أرضية هذا الجزء مستوية السطح / level floor (crest) وتميل جدرانها إلى الداخل في اتجاه الجزء الأوسط (العنق).
- ٢- العنق - (Throat section):
تتوازي الجدران في هذا الجزء وتنحدر الأرضية / downward sloping floor من أعلى إلى أسفل في اتجاه الجزء الثالث.
- ٣- جزء المخرج / (Diverging Section) - Downstream section:
ترتفع أرضية هذا الجزء من أسفل إلى أعلى / upward sloping floor بحيث تصل إلى منسوب أقل قليلاً من منسوب المدخل وتنفرج جدرانها للخارج حيث يخرج الماء.



- وتتحدد سعة الجهاز بمدى عرض العنق والذي يتراوح من ١ بوصة إلى ٥٠ قدم (١ قدم = ١٢ بوصة)، ليعطي تصريف من ٠.٠٩ ل/ث حتى ٩٣.٠٤ م^٣/ث، ويقدر التصريف بقياس ارتفاع المياه في كل من H_a & H_b كما هو موضح بالشكل حيث تمثل H_a ارتفاع الماء عند دخوله قناة بارشال، وتمثل H_b ارتفاع الماء بالقرب من نهاية العنق.
 - The capacity of the device is determined by the throat width, which ranges from 1 inch to 50 feet (1 foot = 12 inches), to give a discharge from 0.09 L/s up to 93.04 m³/s, and the discharge is estimated by measuring the height of the water in each of H_a & H_b as it is shown in the figure where H_a is the height of the water as it enters the Parshall flume, and H_b is the height of the water near the end of the throat.
-
- تم تطوير قنوات بارشال بأحجام مختلفة (٢٢ مقاس)، وأبعادها موضحة في الشكل ٧,٩ والجدول ٧,٣. يجب توخي الحذر عند انشاء قناة بارشال والعمل وفقاً للأبعاد الهيكلية المعطاة لكل من الـ ٢٢ قناة، لأن أبعاد القنوات ليست مُنسبة لبعضها (ليست متناسبة طردياً مع مقاسها). حيث تلاحظ مثلاً أن طول العنق (L) وعمقه (N) يظلان ثابتين لسلسلة من القنوات بينما تتنوع الأبعاد الأخرى، حيث أن كل مقاس من الـ ٢٢ هو جهاز مختلف تماماً. على سبيل المثال، لا يمكن افتراض أن البعد في القناة ذات المقاس ١٢ قدم سيكون ثلاثة أضعاف البعد المقابل في القناة ذات المقاس ٤ قدام.
 - برجاء ملاحظة أن ١" = ١ بوصة، بينما ١' = ١ قدم. ١٢ قدم = ١٢ بوصة.
 - Parshall flumes were developed in various sizes, the dimensions of which are given in Figure 7.9 & Table 7.3. Care must be taken to construct the flumes exactly in accordance with the structural dimensions given for each of the 22 flumes, because the flumes are not hydraulic scale models of each other. Since throat length (L) and depth (N) remain constant for series of flumes while other dimensions are varied, each of the 22 flumes is an entirely different device. For example, it cannot be assumed that a dimension in the 12-ft flume will be three times the corresponding dimension in the 4-ft flume.
 - Please note that 1" = 1 inch (in), while 1' = 1 foot (ft). 1' = 12".
 - طبقاً لعرض العنق، يتم تقسيم قنوات بارشال إلى ثلاث مجموعات رئيسية، ليسهل تمييزها. وهذه المجموعات هي:
 - 'الصغيرة جداً' للقنوات ذات المقاسات ١, ٢, ٣ بوصة
 - 'الصغيرة' للقنوات ذات المقاسات من ٦ بوصة حتى ٨ قدم
 - 'الكبيرة' للقنوات ذات المقاسات من ١٠ قدم حتى ٥٠ قدم
 - On the basis of throat width, Parshall flumes have been somewhat arbitrarily classified into three main groups for the convenience of discussing them, selecting sizes, and determining discharges. These groups are:
 - 'very small' for 1 -, 2-, and 3-in flumes
 - 'small' for 6-in through 8-ft flumes
 - 'large' for 10-ft up to 50-ft flumes (USBR 1971).

Table 7.3 Parshall flume dimensions (millimetres)

	b_c	A	a	B	C	D	E	L	G	H	K	M	N	P	R	X	Y	Z
1"	25.4	363	242	356	93	167	229	76	203	206	19	—	29	—	—	8	13	3
2"	50.8	414	276	406	135	214	254	114	254	257	22	—	43	—	—	16	25	6
3"	76.2	467	311	457	178	259	457	152	305	309	25	—	57	—	—	25	38	13
6"	152.4	621	414	610	394	397	610	305	610	—	76	305	114	902	406	51	76	—
9"	228.6	879	587	864	381	575	762	305	457	—	76	305	114	1080	406	51	76	—
1'	304.8	1372	914	1343	610	845	914	610	914	—	76	381	229	1492	508	51	76	—
1'6"	457.2	1448	965	1419	762	1026	914	610	914	—	76	381	229	1676	508	51	76	—
2'	609.6	1524	1016	1495	914	1206	914	610	914	—	76	381	229	1854	508	51	76	—
3'	914.4	1676	1118	1645	1219	1572	914	610	914	—	76	381	229	2222	508	51	76	—
4'	1219.2	1829	1219	1794	1524	1937	914	610	914	—	76	457	229	2711	610	51	76	—
5'	1524.0	1981	1321	1943	1829	2302	914	610	914	—	76	457	229	3080	610	51	76	—
6'	1828.0	2134	1422	2092	2134	2667	914	610	914	—	76	457	229	3442	610	51	76	—
7'	2133.6	2286	1524	2242	2438	3032	914	610	914	—	76	457	229	3810	610	51	76	—
8'	2438.4	2438	1626	2391	2743	3397	914	610	914	—	76	457	229	4172	610	51	76	—
10'	3048	—	1829	4267	3658	4756	1219	914	1829	—	152	—	343	—	—	305	229	—
12'	3658	—	2032	4877	4470	5607	1524	914	2438	—	152	—	343	—	—	305	229	—
15'	4572	—	2337	7620	5588	7620	1829	1219	3048	—	229	—	457	—	—	305	229	—
20'	6096	—	2845	7620	7315	9144	2134	1829	3658	—	305	—	686	—	—	305	229	—
25'	7620	—	3353	7620	8941	10668	2134	1829	3962	—	305	—	686	—	—	305	229	—
30'	9144	—	3861	7925	10566	12313	2134	1829	4267	—	305	—	686	—	—	305	229	—
40'	12191	—	4877	8230	13818	15481	2134	1829	4877	—	305	—	686	—	—	305	229	—
50'	15240	—	5893	8230	17272	18529	2134	1829	6096	—	305	—	686	—	—	305	229	—

❖ Parshall Flume Sizes

➤ Very small flumes (1", 2", and 3")

The discharge capacity of the very small flumes ranges from 0.09 l/s to 32 l/s. The capacity of each flume overlaps that of the next size by about one-half the discharge range (see Table 7.4). The flumes must be carefully constructed. The exact dimensions of each flume are listed in Table 7.3. The maximum tolerance on the throat width b_c equals ± 0.0005 m.

The relatively deep and narrow throat section causes turbulence and makes the h_b gauge difficult to read in the very small flumes. Consequently, an h_c gauge, located near the downstream end of the diverging section of the flume is added. Under submerged flow conditions, this gauge may be read instead of the h_b gauge. The h_c readings are converted to h_b readings by using a graph, as will be explained in Section "Evaluation of discharge", and the converted h_b readings are then used to determine the discharge.

➤ Small flumes (6", 9", 1'6", 2' up to 8')

The discharge capacity of the small flumes ranges from 0.0015 m³/s to 3.95 m³/s. The capacity of each size of flume considerably overlaps that of the next size. The length of the side wall of the converging section, A, of the flumes with 1' up to 8' throat width is in meters:

$$A = b_c/2 + 1.219 \quad (7-3)$$

where b_c is the throat width in meters. The piezometer tap for the upstream head, h_a , is located in one of the converging walls a distance of $a = 2/3 A$ upstream from the end of the horizontal crest (see Figure 7.9). The location of the piezometer tap for the downstream head, h_b , is the same in all the 'small' flumes, being 51 mm ($X = 2$ inch) upstream from the low point in the sloping throat floor and 76 mm ($Y = 3$ inch) above it. The exact dimensions of each size of flume are listed in Table 7.3.

➤ **Large flumes (10' up to 50')**

The discharge capacity of the large flumes ranges from $0.16 \text{ m}^3/\text{s}$ to $93.04 \text{ m}^3/\text{s}$. The capacity of each size of flume considerably overlaps that of the next size. The axial length of the converging section is considerably longer than it is in the small flumes to obtain an adequately smooth flow pattern in the upstream part of the structure. The measuring station for the upstream head, h_a , however, is maintained at $a = b_c/3 + 0.813 \text{ m}$ upstream from the end of the horizontal crest. The location of the piezometer tap for the downstream head, h_b , is the same in all the 'large' flumes, being 305 mm ($X = 12 \text{ in}$) upstream from the floor at the downstream edge of the throat and 229 mm ($Y = 9 \text{ in}$) above it. The exact dimensions of each size of flume are listed in Table 7.3.

All flumes must be carefully constructed to the dimensions listed, and careful levelling is necessary in both longitudinal and transverse directions if the standard discharge table is to be used. **When gauge zeros are established, they should be set so that the h_a , h_b , and h_c gauges give the depth of water above the level crest - not the depths above pressure taps.**

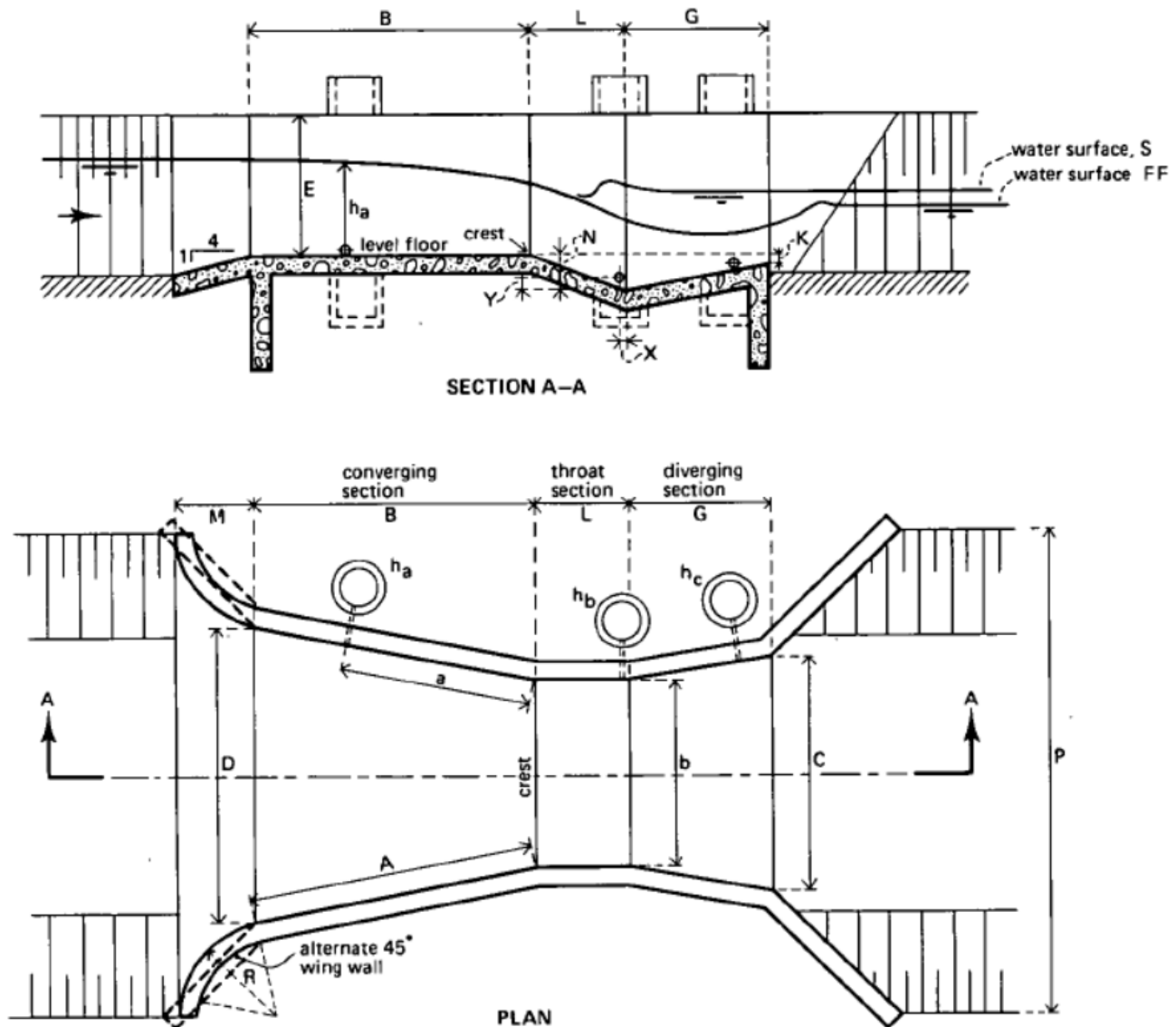


Figure 7.9 Parshall flume dimensions

- If the Parshall flume is never to be operated above the 0.60 submergence limit (h_b/h_a), there is no need to construct the portion downstream of the throat. The truncated Parshall flume (without diverging section) has the same modular flow characteristics as the standard flume. The truncated flume is sometimes referred to as the 'Montana flume'.

❖ Evaluation of discharge

The upstream head-discharge (h_a - Q) relationship of Parshall flume of various sizes, as calibrated empirically, is represented by an equation, having the form

$$Q = K h_a^u \quad (7-4)$$

where K denotes a dimensional factor, which is a function of the throat width. The power u varies between 1.522 and 1.60. Values of K and u for each size of flume are given in Table 7.4. In the listed equations Q is the modular discharge in m^3/s , and h_a is the upstream gauge reading in meters.

The flumes cover a range of discharges from 0.09 l/s to 93.04 m^3/s and have overlapping capacities to facilitate the selection of a suitable size. Each of the flumes listed in Table 7.4 is a standard device and has been calibrated for the range of discharges shown in the table. Detailed information on the modular discharge for each size- of flume as a function of h_a are presented in the Tables 7.5 to 7.11.

Table 7.4 Discharge characteristics of Parshall flumes

Throat width b_c in feet or inches	Discharge range in $m^3/s \times 10^{-3}$		Equation $Q = K h_a^u$ (Q in m^3/s)	Head range in metres		Modular limit h_b/h_a
	minimum	maximum		minimum	maximum	
1"	0.09	5.4	$0.0604 h_a^{1.55}$	0.015	0.21	0.50
2"	0.18	13.2	$0.1207 h_a^{1.55}$	0.015	0.24	0.50
3"	0.77	32.1	$0.1771 h_a^{1.55}$	0.03	0.33	0.50
6"	1.50	111	$0.3812 h_a^{1.58}$	0.03	0.45	0.60
9"	2.50	251	$0.5354 h_a^{1.53}$	0.03	0.61	0.60
1'	3.32	457	$0.6909 h_a^{1.522}$	0.03	0.76	0.70
1'6"	4.80	695	$1.056 h_a^{1.538}$	0.03	0.76	0.70
2'	12.1	937	$1.428 h_a^{1.550}$	0.046	0.76	0.70
3'	17.6	1427	$2.184 h_a^{1.566}$	0.046	0.76	0.70
4'	35.8	1923	$2.953 h_a^{1.578}$	0.06	0.76	0.70
5'	44.1	2424	$3.732 h_a^{1.587}$	0.06	0.76	0.70
6'	74.1	2929	$4.519 h_a^{1.595}$	0.076	0.76	0.70
7'	85.8	3438	$5.312 h_a^{1.601}$	0.076	0.76	0.70
8'	97.2	3949	$6.112 h_a^{1.607}$	0.076	0.76	0.70
in m^3/s						
10'	0.16	8.28	$7.463 h_a^{1.60}$	0.09	1.07	0.80
12'	0.19	14.68	$8.859 h_a^{1.60}$	0.09	1.37	0.80
15'	0.23	25.04	$10.96 h_a^{1.60}$	0.09	1.67	0.80
20'	0.31	37.97	$14.45 h_a^{1.60}$	0.09	1.83	0.80
25'	0.38	47.14	$17.94 h_a^{1.60}$	0.09	1.83	0.80
30'	0.46	56.33	$21.44 h_a^{1.60}$	0.09	1.83	0.80
40'	0.60	74.70	$28.43 h_a^{1.60}$	0.09	1.83	0.80
50'	0.75	93.04	$35.41 h_a^{1.60}$	0.09	1.83	0.80

Table 7.5 Free-flow discharge through 1" Parshall measuring flume in l/s computed from the formula

$$Q = 0.0604 h_a^{1.55}$$

[illegible]

Table 7.6 Free-flow discharge through 2" Parshall measuring flume in l/s computed from the formula

$$Q = 0.1207 h_a^{1.550}$$

[illegible]

Table 7.7 Free-flow discharge through 3" Parshall measuring flume in l/s computed from the formula
 $Q = 0.1771 h_a^{1.550}$

Upper-head h_a (m)	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
.03	0.77	0.81	0.85	0.90	0.94	0.98	1.02	1.07	1.11	1.16
.04	1.21	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65
.05	1.70	1.76	1.81	1.87	1.92	1.98	2.03	2.09	2.15	2.20
.06	2.26	2.32	2.38	2.44	2.50	2.56	2.62	2.68	2.75	2.81
.07	2.87	2.94	3.00	3.06	3.13	3.20	3.26	3.33	3.40	3.46
.08	3.53	3.60	3.67	3.74	3.81	3.88	3.95	4.02	4.09	4.17
.09	4.24	4.31	4.39	4.46	4.53	4.61	4.69	4.76	4.84	4.91
.10	4.99	5.07	5.15	5.23	5.30	5.38	5.46	5.54	5.62	5.70
.11	5.79	5.87	5.95	6.03	6.12	6.20	6.28	6.37	6.45	6.54
.12	6.62	6.71	6.79	6.88	6.97	7.05	7.14	7.23	7.32	7.41
.13	7.50	7.59	7.68	7.77	7.80	7.95	8.04	8.13	8.22	8.32
.14	8.41	8.50	8.60	8.69	8.78	8.88	8.97	9.07	9.16	9.26
.15	9.36	9.45	9.55	9.65	9.75	9.85	9.94	10.04	10.14	10.24
.16	10.34	10.44	10.54	10.64	10.75	10.85	10.95	11.05	11.15	11.26
.17	11.36	11.46	11.57	11.67	11.78	11.88	11.99	12.09	12.20	12.31
.18	12.41	12.52	12.63	12.74	12.84	12.95	13.06	13.17	13.28	13.39
.19	13.50	13.61	13.72	13.83	13.94	14.05	14.16	14.28	14.39	14.50
.20	14.62	14.73	14.84	14.96	15.07	15.19	15.30	15.42	15.53	15.65
.21	15.76	15.88	16.00	16.11	16.23	16.35	16.47	16.59	16.70	16.82
.22	16.94	17.06	17.18	17.30	17.42	17.54	17.66	17.79	17.91	18.03
.23	18.15	18.27	18.40	18.52	18.64	18.77	18.89	19.01	19.14	19.26
.24	19.39	19.51	19.64	19.77	19.89	20.02	20.15	20.27	20.40	20.53
.25	20.66	20.78	20.91	21.04	21.17	21.30	21.43	21.56	21.69	21.82
.26	21.95	22.08	22.21	22.34	22.48	22.61	22.74	22.87	23.01	23.14
.27	23.27	23.41	23.54	23.67	23.81	23.94	24.08	24.21	24.35	24.49
.28	24.62	24.76	24.89	25.03	25.17	25.31	25.44	25.58	25.72	25.86
.29	26.00	26.14	26.28	26.42	26.56	26.70	26.84	26.98	27.12	27.26
.30	27.40	27.54	27.68	27.83	27.97	28.11	28.25	28.40	28.54	28.68
.31	28.83	28.97	29.12	29.26	29.41	29.55	29.70	29.84	29.99	30.14
.32	30.28	30.43	30.58	30.72	30.87	31.02	31.17	31.32	31.46	31.61
.33	31.76	31.91	32.06							

Table 7.8 Free-flow discharge through 6" Parshall measuring flume in l/s computed from the formula
 $Q = 0.3812 h_a^{1.580}$

Upper-head h_a (m)	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
.03	1.5	1.6	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.3
.04	2.4	2.4	2.6	2.6	2.7	2.8	2.9	3.0	3.1	3.2
.05	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.4
.06	4.5	4.6	4.7	4.8	5.0	5.1	5.2	5.3	5.4	5.6
.07	5.7	5.8	6.0	6.1	6.2	6.4	6.5	6.6	6.8	6.9
.08	7.0	7.2	7.3	7.5	7.6	7.8	7.9	8.0	8.2	8.3
.09	8.5	8.6	8.8	8.9	9.1	9.2	9.4	9.6	9.7	9.9
.10	10.0	10.2	10.4	10.5	10.7	10.8	11.0	11.2	11.3	11.5
.11	11.7	11.8	12.0	12.2	12.3	12.5	12.7	12.8	13.0	13.2
.12	13.4	13.6	13.7	13.9	14.1	14.3	14.4	14.6	14.8	15.0
.13	15.2	15.4	15.6	15.7	15.9	16.1	16.3	16.5	16.7	16.9
.14	17.1	17.3	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8
.15	19.0	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.7	20.9
.16	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.8	23.0
.17	23.2	23.4	23.6	23.8	24.1	24.3	24.5	24.7	24.9	25.2
.18	25.4	25.6	25.8	26.0	26.3	26.5	26.7	27.0	27.2	27.4
.19	27.6	27.9	28.1	28.3	28.6	28.8	29.0	29.3	29.5	29.7
.20	30.0	30.2	30.4	30.7	30.9	31.2	31.4	31.6	31.9	32.1
.21	32.4	32.6	32.9	33.1	33.4	33.6	33.8	34.1	34.4	34.6
.22	34.8	35.1	35.4	35.6	35.8	36.1	36.4	36.6	36.9	37.1
.23	37.4	37.6	37.9	38.2	38.4	38.7	38.9	39.2	39.5	39.7
.24	40.0	40.2	40.5	40.8	41.0	41.3	41.6	41.8	42.1	42.4
.25	42.6	42.9	43.2	43.5	43.7	44.0	44.3	44.6	44.8	45.1
.26	45.4	45.6	45.9	46.2	46.5	46.8	47.0	47.3	47.6	47.9
.27	48.2	48.4	48.7	49.0	49.3	49.6	49.9	50.2	50.4	50.7
.28	51.0	51.3	51.6	51.9	52.2	52.5	52.8	53.0	53.3	53.6
.29	53.9	54.2	54.5	54.8	55.1	55.4	55.7	56.0	56.3	56.6
.30	56.9	57.2	57.5	57.8	58.1	58.4	58.7	59.0	59.3	59.6
.31	59.9	60.2	60.5	60.8	61.1	61.4	61.8	62.1	62.4	62.7
.32	62.0	63.3	63.6	63.9	64.2	64.6	64.9	65.2	65.5	65.8
.33	66.1	66.4	66.8	67.1	67.4	67.7	68.0	68.4	68.7	69.0
.34	69.3	69.6	70.0	70.3	70.6	70.9	71.3	71.6	71.9	72.2
.35	72.6	72.9	73.2	73.6	73.9	74.2	74.6	74.9	75.2	75.5
.36	75.9	76.2	76.5	76.9	77.2	77.6	77.9	78.2	78.6	78.9
.37	79.2	79.6	79.9	80.2	80.6	80.9	81.3	81.6	82.0	82.3
.38	82.6	83.0	83.3	83.7	84.0	84.4	84.7	85.1	85.4	85.8
.39	86.1	86.5	86.8	87.2	87.5	87.9	88.2	88.6	88.9	89.3
.40	89.6	90.0	90.3	90.7	91.0	91.4	91.8	92.1	92.5	92.8
.41	93.2	93.6	93.9	94.3	94.6	95.0	95.4	95.7	96.1	96.4
.42	96.8	97.2	97.5	97.9	98.3	98.6	99.0	99.4	99.7	100.1
.43	100.5	100.8	101.2	101.6	102.0	102.3	102.7	103.1	103.4	103.8
.44	104.2	104.6	104.9	105.3	105.7	106.1	106.4	106.8	107.2	107.6
.45	108.0	108.3	108.7	109.1	109.5	109.8	110.2	110.6		

$$Q = 0.5354 h_a^{1.530}$$

Upper-head h_a (m)	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
.03	2.5	2.6	2.8	2.9	3.0	3.2	3.3	3.4	3.6	3.7
.04	3.9	4.0	4.2	4.3	4.5	4.7	4.8	5.0	5.1	5.3
.05	5.5	5.6	5.8	6.0	6.2	6.3	6.5	6.7	6.9	7.0
.06	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0
.07	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0
.08	11.2	11.4	11.7	11.9	12.1	12.3	12.5	12.8	13.0	13.2
.09	13.4	13.7	13.9	14.1	14.4	14.6	14.8	15.1	15.3	15.6
.10	15.8	16.0	16.3	16.5	16.8	17.0	17.3	17.5	17.8	18.0
.11	18.3	18.5	18.8	19.0	19.3	19.6	19.8	20.1	20.4	20.6
.12	20.9	21.2	21.4	21.7	22.0	22.2	22.5	22.8	23.0	23.3
.13	23.6	23.9	24.2	24.4	24.7	25.0	25.3	25.6	25.9	26.2
.14	26.4	26.7	27.0	27.3	27.6	27.9	28.2	28.5	28.8	29.1
.15	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1
.16	32.4	32.7	33.0	33.4	33.7	34.0	34.3	34.6	35.0	35.3
.17	35.6	35.9	36.2	36.6	36.9	37.2	37.5	37.8	38.2	38.5
.18	38.8	39.2	39.5	39.8	40.2	40.5	40.8	41.2	41.5	41.8
.19	42.2	42.5	42.9	43.2	43.6	43.9	44.2	44.6	44.9	45.3
.20	45.6	46.0	46.3	46.7	47.0	47.4	47.7	48.1	48.4	48.8
.21	49.2	49.5	49.9	50.2	50.6	51.0	51.3	51.7	52.1	52.4
.22	52.8	53.2	53.5	53.9	54.3	54.6	55.0	55.4	55.8	56.1
.23	56.5	56.9	57.3	57.6	58.0	58.4	58.8	59.2	59.5	59.9
.24	60.3	60.7	61.1	61.5	61.9	62.2	62.6	63.0	63.4	63.8
.25	64.2	64.6	65.0	65.4	65.8	66.2	66.6	67.0	67.4	67.8
.26	68.2	68.6	69.0	69.4	69.8	70.2	70.6	71.0	71.4	71.8
.27	72.2	72.6	73.0	73.4	73.9	74.3	74.7	75.1	75.5	75.9
.28	76.4	76.8	77.2	77.6	78.0	78.4	78.9	79.3	79.7	80.1
.29	80.6	81.0	81.4	81.8	82.3	82.7	83.1	83.6	84.0	84.4
.30	84.8	85.3	85.7	86.2	86.6	87.0	87.5	87.9	88.3	88.8
.31	89.2	89.7	90.1	90.5	91.0	91.4	91.9	92.3	92.8	93.2
.32	93.7	94.1	94.6	95.0	95.5	95.9	96.4	96.8	97.3	97.7
.33	98.2	98.6	99.1	99.5	100.0	100.5	100.9	101.4	101.8	102.3
.34	102.8	103.2	103.7	104.2	104.6	105.1	105.6	106.0	106.5	107.0
.35	107.4	107.9	108.4	108.8	109.3	109.8	110.2	110.7	111.2	111.7
.36	112.2	112.6	113.1	113.6	114.1	114.6	115.0	115.5	116.0	116.5
.37	117.0	117.4	117.9	118.4	118.9	119.4	119.9	120.4	120.8	121.3
.38	121.8	122.3	122.8	123.3	123.8	124.3	124.8	125.3	125.8	126.3
.39	126.8	127.3	127.8	128.3	128.8	129.3	129.8	130.3	130.8	131.3
.40	131.8	132.3	132.8	133.3	133.8	134.3	134.8	135.3	135.8	136.3
.41	136.8	137.4	137.9	138.4	138.9	139.4	139.9	140.4	141.0	141.5
.42	142.0	142.5	143.0	143.5	144.1	144.6	145.1	145.6	146.2	146.7
.43	147.2	147.7	148.2	148.8	149.3	149.8	150.4	150.9	151.4	151.9
.44	152.5	153.0	153.5	154.1	154.6	155.1	155.6	156.2	156.7	157.3
.45	157.8	158.3	158.9	159.4	160.0	160.5	161.0	161.6	162.1	162.6
.46	163.2	163.7	164.3	164.8	165.4	165.9	166.5	167.0	167.6	168.1
.47	168.6	169.2	169.8	170.3	170.8	171.4	172.0	172.5	173.1	173.6
.48	174.2	174.7	175.3	175.8	176.4	177.0	177.5	178.1	178.6	179.2
.49	179.8	180.3	180.9	181.4	182.0	182.6	183.1	183.7	184.3	184.8
.50	185.4	186.0	186.5	187.1	187.7	188.2	188.8	189.4	190.0	190.5
.51	191.1	191.7	192.2	192.8	193.4	194.0	194.6	195.1	195.7	196.3
.52	196.9	197.4	198.0	198.6	199.2	199.8	200.4	200.9	201.5	202.1
.53	202.7	203.3	203.9	204.4	205.0	205.6	206.2	206.8	207.4	208.0
.54	208.6	209.2	209.8	210.3	210.9	211.5	212.1	212.7	213.3	213.9
.55	214.5	215.1	215.7	216.3	216.9	217.5	218.1	218.7	219.3	219.9
.56	220.5	221.1	221.7	222.3	222.9	223.5	224.1	224.7	225.3	225.9
.57	226.6	227.2	227.8	228.4	229.0	229.6	230.2	230.8	231.4	232.0
.58	232.7	233.3	233.9	234.5	235.1	235.7	236.4	237.0	237.6	238.2
.59	238.8	239.4	240.1	240.7	241.3	241.9	242.6	243.2	243.8	244.4
.60	245.0	245.7	246.3	246.0	247.6	248.2	248.8	249.4	250.1	250.7
.61	251.3									

Table 7.10 Free-flow discharge through Parshall measuring flumes 1-to-8 foot size in l/s computed from the formulae as shown in Table 7.4

Upper-head h_a (mm)	Discharge in l/s for flumes of various throat widths								
	1 feet	1.5 feet	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet
30	3.3	4.8							
32	3.7	5.3							
34	4.0	5.8							
36	4.4	6.4							
38	4.8	6.9							
40	5.2	7.5							
42	5.6	8.1							
44	6.0	8.7							
46	6.4	9.3	12.1	17.6					
48	6.8	9.9	12.9	18.8					
50	7.2	10.5	13.7	20.0					
52	7.7	11.2	14.6	21.3					
54	8.1	11.9	15.5	22.6					
56	8.6	12.5	16.4	23.9					
58	9.1	13.2	17.3	25.3					
60	9.5	14.0	18.2	26.7					
62	10.0	14.7	19.2	28.1	36.7	45.2			
64	10.5	15.4	20.2	29.5	38.6	47.6			
66	11.0	16.2	21.1	31.0	40.5	50.0			
68	11.6	16.9	22.1	32.4	42.5	52.4			
70	12.1	17.7	23.2	33.9	44.4	54.8			
72	12.6	18.5	24.2	35.5	46.5	57.4			
74	13.1	19.2	25.2	37.0	48.5	59.9			
76	13.7	20.1	26.3	38.6	50.6	62.5	74.1	85.8	97.2
78	14.2	20.9	27.4	40.2	52.7	65.1	77.3	89.4	101.3
80	14.8	21.7	28.5	41.8	54.9	67.8	80.4	93.1	105.6
82	15.4	22.0	29.6	43.5	57.0	70.5	83.7	96.9	109.8
84	15.9	23.4	30.7	45.2	59.3	73.2	87.0	100.7	114.2
86	16.5	24.3	31.9	46.8	61.5	76.0	90.3	104.6	118.6
88	17.1	25.1	33.0	48.6	63.8	78.9	93.6	108.5	123.0
90	17.7	26.0	34.2	50.3	66.1	81.7	97.1	112.5	127.5
92	18.3	26.9	35.4	52.1	68.4	84.6	100.5	116.5	132.1
94	18.9	27.8	36.6	53.8	70.8	87.6	104.0	120.6	136.8
96	19.5	28.7	37.8	55.6	73.2	90.5	107.6	124.7	141.5
98	20.1	29.7	39.0	57.5	75.6	93.5	111.2	128.9	146.2
100	20.8	30.6	40.2	59.3	78.0	96.6	114.8	133.1	151.1
102	21.4	31.5	41.5	61.2	80.5	99.7	118.5	137.4	156.0
104	22.0	32.5	42.8	63.1	83.0	102.8	122.2	141.8	160.9
106	22.7	33.5	44.0	65.0	85.6	106.0	126.0	146.1	165.9
108	23.4	34.4	45.4	66.9	88.1	109.1	129.8	150.6	171.0
110	24.0	35.4	46.6	68.9	90.7	112.4	133.7	155.1	176.1
112	24.7	36.4	48.0	70.8	93.3	115.6	137.6	159.6	181.2
114	25.4	37.4	49.3	72.8	96.0	118.9	141.5	164.2	186.5
116	26.0	38.4	50.7	74.8	98.6	122.2	145.5	168.8	191.8
118	26.7	39.5	52.0	76.9	101.3	125.6	149.5	173.5	197.1
120	27.4	40.5	53.4	78.9	104.0	129.0	153.6	178.2	202.5
122	28.1	41.5	54.8	81.0	106.8	132.4	157.7	183.0	208.0
124	28.8	42.6	56.2	83.1	109.6	135.9	161.8	187.9	213.5
126	29.5	43.6	57.6	85.2	112.4	139.4	166.0	192.7	219.0
128	30.2	44.7	59.0	87.3	115.2	142.9	170.2	197.6	224.6
130	31.0	45.8	60.4	89.5	118.0	146.5	174.5	202.6	230.3
132	31.7	46.9	61.9	91.6	120.9	150.1	178.8	207.6	236.0
134	32.4	48.0	63.4	93.8	123.8	153.7	183.1	212.7	241.8
136	33.2	49.1	64.8	96.0	126.8	157.4	187.5	217.8	247.6
138	33.9	50.2	66.3	98.2	129.7	161.0	191.9	223.0	253.5
140	34.7	51.3	67.8	100.5	132.7	164.8	196.4	228.1	259.4
142	35.4	52.5	69.3	102.7	135.7	168.5	200.9	233.4	265.4
144	36.2	53.6	70.8	105.0	138.7	172.3	205.4	238.7	271.4
146	37.0	54.8	72.4	107.3	141.8	176.1	210.0	244.0	277.5
148	37.7	55.9	73.9	109.6	144.9	180.0	214.6	249.4	283.7
150	38.5	57.1	75.4	112.0	148.0	183.8	219.2	254.8	289.8

Table 7.10 continued

Upper-head h_a (mm)	Discharge in l/s for flumes of various throat widths								
	1 feet	1.5 feet	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet
152	39.3	58.3	77.0	114.3	151.1	187.7	223.9	260.2	296.1
154	40.1	59.4	78.6	116.7	154.2	191.7	228.6	265.8	302.4
156	40.9	60.6	80.2	119.0	157.4	195.6	233.4	271.3	308.7
158	41.7	61.8	81.8	121.4	160.6	199.6	238.2	276.9	315.1
160	42.5	63.0	83.4	123.8	163.8	203.6	243.0	282.5	321.5
162	43.3	64.2	85.0	126.3	167.1	207.7	247.9	288.2	328.0
164	44.1	65.5	86.6	128.7	170.3	211.8	252.8	293.9	334.5
166	44.9	66.7	88.3	131.2	173.6	215.9	257.7	299.7	341.1
168	45.7	68.0	89.9	133.7	176.9	220.0	262.7	305.5	347.7
170	46.6	69.2	91.6	136.2	180.3	224.2	267.7	311.3	354.4
172	47.4	70.4	93.3	138.7	183.6	228.4	272.7	317.2	361.1
174	48.2	71.7	95.0	141.2	187.0	232.6	277.8	323.1	367.9
176	49.1	73.0	96.7	143.8	190.4	236.9	282.9	329.1	374.7
178	50.0	74.3	98.4	146.4	193.8	241.2	288.0	335.1	381.6
180	50.8	75.6	100.1	148.9	197.3	245.5	293.2	341.2	388.5
182	51.7	76.8	101.8	151.5	200.8	249.8	298.4	347.2	395.5
184	52.5	78.2	103.6	154.2	204.2	254.2	303.7	353.4	402.5
186	53.4	79.5	105.3	156.8	207.8	258.6	309.0	359.5	409.5
188	54.3	80.8	107.1	159.4	211.3	263.0	314.3	365.8	416.6
190	55.2	82.1	108.8	162.1	214.8	267.5	319.6	372.0	423.8
192	56.0	83.4	110.6	164.8	218.4	272.0	325.0	378.3	431.0
194	56.9	84.8	112.4	167.5	222.0	276.5	330.4	384.6	438.2
196	57.8	86.1	114.2	170.2	225.6	281.0	335.9	391.0	445.5
198	58.7	87.5	116.0	172.9	229.3	285.6	341.4	397.4	452.8
200	59.6	88.8	117.8	175.7	233.0	290.2	346.9	403.8	460.2
202	60.6	90.2	119.7	178.4	236.6	294.8	352.4	410.3	467.6
204	61.5	91.6	121.5	181.2	240.4	299.4	358.0	416.8	475.1
206	62.4	93.0	123.4	184.0	244.1	304.1	363.6	423.4	482.6
208	63.3	94.4	125.2	186.8	247.8	308.8	369.3	430.0	490.1
210	64.2	95.8	127.1	189.6	251.6	313.6	375.0	436.6	497.7
212	65.2	97.2	129.0	192.4	255.4	318.3	380.7	443.3	505.4
214	66.1	98.6	130.9	195.3	259.2	323.1	386.4	450.0	513.0
216	67.1	100.0	132.8	198.2	263.0	327.9	392.2	456.8	520.8
218	68.0	101.4	134.7	201.0	266.9	332.7	398.0	463.6	528.6
220	69.0	102.9	136.6	203.9	270.8	337.6	403.8	470.4	536.4
222	69.9	104.3	138.5	206.8	274.7	342.5	409.7	477.3	544.2
224	70.9	105.8	140.5	209.8	278.6	347.4	415.6	484.2	552.1
226	71.8	107.2	142.4	212.7	282.3	352.3	421.6	491.1	560.1
228	72.8	108.7	144.4	215.7	286.5	357.3	427.5	498.1	568.0
230	73.8	110.2	146.4	218.6	290.4	362.2	433.5	505.1	576.1
232	74.8	111.6	148.3	221.6	294.4	367.3	439.5	512.2	584.2
234	75.8	113.1	150.3	224.6	298.5	372.3	445.6	519.2	592.3
236	76.7	114.6	152.3	227.6	302.5	377.4	451.7	526.4	600.4
238	77.7	116.1	154.3	230.7	306.6	382.4	447.8	533.5	608.6
240	78.7	117.6	156.3	233.7	310.6	387.6	464.0	540.7	616.8
245	81.2	121.4	161.4	241.4	320.9	400.4	479.5	558.9	637.6
250	83.8	125.2	166.6	249.1	331.3	413.5	495.2	577.2	658.7
255	86.3	129.1	171.7	257.0	341.8	426.7	511.1	595.8	680.0
260	88.9	133.0	177.0	264.9	352.4	440.0	527.1	614.6	701.5
265	91.5	137.0	182.3	272.9	363.2	453.6	543.4	633.7	723.3
270	94.2	141.0	187.6	281.0	374.1	467.2	559.8	652.9	745.4
275	96.8	145.0	193.1	289.2	385.1	481.1	576.5	672.4	767.7
280	99.5	149.1	198.5	297.5	396.2	495.0	593.3	692.1	790.2
285	102.3	153.2	204.0	305.9	407.4	509.1	610.3	712.0	813.0
290	105.0	157.3	209.6	314.3	418.7	523.3	627.4	732.1	836.1
295	107.8	161.5	215.2	322.8	430.2	537.7	644.8	752.4	859.4
300	110.6	165.8	220.9	331.4	441.7	552.2	662.3	772.9	882.9

Table 7.10 continued

Upper-head h_a (mm)	Discharge in l/s for flumes of various throat widths								
	1 feet	1.5 feet	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet
305	113.4	170.0	226.7	340.2	453.4	566.9	680.0	793.6	906.7
310	116.2	174.3	232.4	348.9	465.2	581.7	697.8	814.6	930.7
315	119.1	178.7	238.3	357.8	477.1	596.7	715.9	835.7	954.9
320	122.0	183.1	244.2	366.7	489.1	611.8	734.1	857.0	979.4
325	124.9	187.5	250.1	375.7	501.2	627.0	752.5	878.6	1004
330	127.8	191.9	256.1	384.8	513.4	642.4	771.0	900.3	1029
335	130.8	196.4	262.2	394.0	525.8	657.9	789.8	922.3	1054
340	133.8	201.0	268.2	403.2	538.2	673.6	808.6	944.4	1080
345	136.8	205.5	274.4	412.6	550.7	689.4	827.7	966.7	1105
350	139.8	210.1	280.6	422.0	563.4	705.3	846.9	989.3	1131
355	142.8	214.7	286.8	431.3	576.1	721.4	866.3	1012	1157
360	145.9	219.4	293.1	441.0	589.0	737.6	885.8	1035	1183
365	149.0	224.1	299.4	450.6	602.0	753.9	905.5	1058	1210
370	152.1	228.8	305.8	460.3	615.0	770.3	925.4	1081	1237
375	155.3	233.6	312.2	470.1	628.2	786.9	945.4	1105	1264
380	158.4	238.4	318.7	480.0	641.4	803.6	965.6	1128	1291
385	161.6	243.3	325.2	489.9	654.8	820.5	985.9	1152	1318
390	164.8	248.2	331.8	499.9	668.3	837.4	1006	1176	1346
395	168.0	253.1	338.4	510.0	681.9	854.6	1027	1201	1374
400	171.3	258.0	345.1	520.1	695.5	871.8	1048	1225	1402
405	174.6	263.0	351.8	530.3	709.3	889.2	1069	1250	1430
410	177.9	268.0	358.5	540.6	723.2	906.6	1090	1274	1459
415	181.2	273.0	365.3	551.0	737.1	924.2	1111	1299	1487
420	184.5	278.1	372.2	561.4	751.2	942.0	1133	1325	1516
425	187.9	283.2	379.1	571.9	765.4	959.8	1154	1350	1545
430	191.2	288.4	386.0	582.5	779.6	977.8	1176	1375	1575
435	194.6	293.5	393.0	593.1	794.0	995.9	1198	1401	1604
440	198.0	298.7	400.0	603.8	808.4	1014	1220	1427	1634
445	201.5	304.0	407.1	614.6	823.0	1032	1242	1453	1664
450	204.9	309.2	414.2	625.4	837.6	1051	1264	1479	1694
455	208.4	314.6	421.4	636.4	852.3	1070	1287	1506	1724
460	211.9	319.9	428.6	647.3	867.2	1088	1310	1532	1755
465	215.4	325.2	435.8	658.4	882.1	1107	1332	1559	1786
470	219.0	330.6	443.1	669.5	897.1	1126	1355	1586	1817
475	222.5	336.1	450.4	680.7	912.2	1145	1378	1613	1848
480	226.1	341.5	457.8	692.0	927.4	1164	1402	1640	1879
485	229.7	347.0	465.2	703.3	942.7	1184	1425	1668	1911
490	233.3	352.5	472.6	714.7	958.1	1203	1448	1695	1942
495	236.9	358.1	480.1	726.1	973.5	1223	1472	1723	1974
500	240.6	363.6	487.7	737.6	989.1	1242	1496	1751	2006
505	244.2	369.2	495.3	749.2	1005	1262	1520	1779	2039
510	247.9	374.9	502.9	760.9	1020	1282	1544	1808	2071
515	251.6	380.6	510.5	772.6	1036	1302	1568	1836	2104
520	255.4	386.3	518.2	784.4	1052	1322	1592	1865	2137
525	259.1	392.0	526.0	796.2	1068	1342	1617	1893	2170
530	262.9	397.7	533.8	808.1	1084	1363	1642	1922	2203
535	266.7	403.5	541.6	820.1	1101	1383	1666	1951	2239
540	270.5	409.3	549.5	832.1	1117	1404	1691	1981	2271
545	274.3	415.2	557.4	844.2	1133	1424	1716	2010	2304
550	278.1	421.1	565.3	856.4	1150	1445	1741	2040	2339
555	282.0	427.0	573.3	868.6	1166	1466	1767	2070	2373
560	285.9	432.9	581.3	880.9	1183	1487	1792	2099	2407
565	289.8	438.8	589.4	893.2	1199	1508	1818	2130	2442
570	293.7	444.8	597.5	905.6	1216	1529	1844	2160	2477
575	297.6	450.8	605.6	918.1	1233	1551	1869	2190	2512
580	301.6	456.9	613.8	930.6	1250	1572	1895	2221	2547
585	305.5	463.0	622.0	943.2	1267	1594	1922	2252	2582
590	309.5	469.1	630.3	955.9	1284	1615	1948	2282	2618
595	313.5	475.2	638.6	968.6	1302	1637	1974	2313	2654
600	317.5	481.4	646.9	981.4	1319	1659	2001	2345	2690

Table 7.10 continued

Upper-head h_a (mm)	Discharge in l/s for flumes of various throat widths								
	1 feet	1.5 feet	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet
605	321.6	487.5	655.3	994.2	1336	1681	2027	2376	2726
610	325.6	493.7	663.7	1007	1354	1703	2054	2408	2762
615	329.7	500.0	672.2	1020	1371	1725	2081	2439	2798
620	333.8	506.2	680.7	1033	1389	1748	2108	2471	2835
625	337.9	512.5	689.2	1046	1407	1770	2135	2503	2872
630	342.0	518.9	697.8	1059	1424	1793	2163	2535	2909
635	346.1	525.2	706.4	1072	1442	1815	2190	2567	2946
640	350.3	531.6	715.0	1086	1460	1838	2218	2600	2983
645	354.5	538.0	723.7	1099	1478	1861	2245	2632	3021
650	358.6	544.4	732.4	1112	1496	1884	2273	2665	3059
655	362.9	550.9	741.1	1126	1515	1907	2301	2698	3097
660	367.1	557.3	749.9	1139	1533	1930	2529	2731	3135
665	371.3	563.8	758.8	1153	1551	1953	2357	2764	3173
670	375.6	570.4	767.6	1166	1570	1977	2386	2798	3211
675	379.8	576.9	776.5	1180	1588	2000	2414	2831	3250
680	384.1	583.5	785.4	1194	1607	2024	2443	2865	3289
685	388.4	590.1	794.4	1208	1625	2047	2472	2899	3328
690	392.8	596.8	803.4	1221	1644	2071	2500	2933	3367
695	397.1	603.4	812.5	1235	1663	2095	2529	2967	3406
700	401.5	610.1	821.5	1249	1682	2119	2558	3001	3446
705	405.8	616.8	839.7	1263	1701	2143	2588	3035	3485
710	410.2	623.6	839.8	1277	1720	2167	2617	3070	3525
715	414.6	630.4	849.0	1292	1739	2191	2646	3105	3565
720	419.1	637.2	858.2	1306	1758	2216	2676	3139	3605
725	423.5	644.0	867.5	1320	1778	2240	2706	3174	3645
730	428.0	650.8	876.8	1334	1797	2265	2736	3210	3686
735	432.4	657.7	886.1	1349	1817	2289	2765	3245	3727
740	436.9	664.6	895.4	1363	1836	2314	2796	3280	3767
745	441.4	671.5	904.8	1377	1856	2339	2826	3316	3808
750	445.9	678.4	914.3	1392	1875	2364	2856	3351	3850
755	450.4	685.4	923.7	1406	1895	2389	2886	3387	3891
760	455.0	692.4	933.2	1421	1915	2414	2917	3423	3932

Table 7.11 Free-flow discharge through Parshall measuring flumes 10 to 50 feet size in m³/s. Computed from the formulae as shown in Table 7.4

Upper-head h_a (mm)	Discharge per m ³ /s for flumes of various throat widths							
	10 feet	12 feet	15 feet	20 feet	25 feet	30 feet	40 feet	50 feet
90	0.158	0.188	0.233	0.307	0.381	0.455	0.603	0.751
95	0.173	0.205	0.254	0.334	0.415	0.496	0.658	0.819
100	0.187	0.223	0.275	0.363	0.451	0.539	0.714	0.889
105	0.203	0.241	0.298	0.392	0.487	0.582	0.772	0.962
110	0.218	0.259	0.321	0.423	0.525	0.627	0.832	1.04
115	0.234	0.278	0.344	0.454	0.564	0.674	0.893	1.11
120	0.251	0.298	0.369	0.486	0.603	0.721	0.956	1.19
125	0.268	0.318	0.393	0.519	0.644	0.770	1.02	1.27
130	0.285	0.339	0.419	0.552	0.686	0.819	1.09	1.35
135	0.303	0.360	0.445	0.587	0.728	0.870	1.15	1.44
140	0.321	0.381	0.472	0.622	0.772	0.923	1.22	1.52
145	0.340	0.403	0.499	0.658	0.817	0.976	1.29	1.61
150	0.359	0.426	0.527	0.694	0.862	1.03	1.37	1.70
155	0.378	0.449	0.555	0.732	0.909	1.09	1.44	1.79
160	0.398	0.472	0.584	0.770	0.956	1.14	1.51	1.89
165	0.418	0.496	0.613	0.809	1.00	1.20	1.59	1.98
170	0.438	0.520	0.643	0.848	1.05	1.26	1.67	2.08
175	0.459	0.545	0.674	0.889	1.10	1.32	1.75	2.18
180	0.480	0.570	0.705	0.930	1.15	1.38	1.83	2.28
185	0.502	0.595	0.737	0.971	1.21	1.44	1.91	2.38
190	0.524	0.621	0.769	1.01	1.26	1.50	1.99	2.48
195	0.546	0.648	0.801	1.06	1.31	1.57	2.08	2.59
200	0.568	0.675	0.835	1.10	1.37	1.63	2.16	2.70
205	0.591	0.702	0.868	1.14	1.42	1.70	2.25	2.80
210	0.614	0.739	0.902	1.19	1.48	1.77	2.34	2.92
215	0.638	0.757	0.937	1.24	1.53	1.83	2.43	3.03
220	0.662	0.786	0.972	1.28	1.59	1.90	2.52	3.14
225	0.686	0.814	1.01	1.33	1.65	1.97	2.61	3.26
230	0.711	0.844	1.04	1.38	1.71	2.04	2.71	3.37
235	0.736	0.873	1.08	1.42	1.77	2.11	2.80	3.49
240	0.761	0.903	1.12	1.47	1.83	2.19	2.90	3.61
245	0.786	0.933	1.15	1.52	1.89	2.26	3.00	3.73
250	0.812	0.964	1.19	1.57	1.95	2.33	3.09	3.85
255	0.838	0.995	1.23	1.62	2.02	2.41	3.19	3.98
260	0.865	1.03	1.27	1.67	2.08	2.48	3.29	4.10
265	0.891	1.06	1.31	1.73	2.14	2.56	3.40	4.23
270	0.919	1.09	1.35	1.78	2.21	2.64	3.50	4.36
275	0.946	1.12	1.39	1.83	2.27	2.72	3.60	4.49
280	0.974	1.16	1.43	1.89	2.34	2.80	3.71	4.62
285	1.002	1.19	1.47	1.94	2.41	2.88	3.82	4.75
290	1.030	1.22	1.51	1.99	2.48	2.96	3.92	4.89
295	1.058	1.26	1.55	2.05	2.54	3.04	4.03	5.02
300	1.087	1.29	1.60	2.11	2.61	3.12	4.14	5.16
305	1.116	1.33	1.64	2.16	2.68	3.21	4.25	5.30
310	1.146	1.36	1.68	2.22	2.75	3.29	4.36	5.44
315	1.175	1.40	1.73	2.28	2.83	3.38	4.48	5.58
320	1.205	1.43	1.77	2.33	2.90	3.46	4.59	5.72
325	1.236	1.47	1.81	2.39	2.97	3.55	4.71	5.86
330	1.266	1.50	1.86	2.45	3.04	3.64	4.82	6.01
335	1.297	1.54	1.90	2.51	3.12	3.73	4.94	6.15
340	1.328	1.58	1.95	2.57	3.19	3.82	5.06	6.30
345	1.360	1.61	2.00	2.63	3.27	3.91	5.18	6.45
350	1.391	1.65	2.04	2.69	3.34	4.00	5.30	6.60
355	1.423	1.69	2.09	2.76	3.42	4.09	5.42	6.75
360	1.455	1.73	2.14	2.82	3.50	4.18	5.54	6.91
365	1.488	1.77	2.19	2.88	3.58	4.27	5.67	7.06
370	1.521	1.81	2.23	2.94	3.66	4.37	5.79	7.22
375	1.554	1.84	2.28	3.01	3.73	4.46	5.92	7.37
380	1.587	1.88	2.33	3.07	3.81	4.56	6.05	7.53
385	1.621	1.92	2.38	3.14	3.90	4.66	6.17	7.69
390	1.65	1.96	2.43	3.20	3.98	4.75	6.30	7.85
395	1.69	2.00	2.48	3.27	4.06	4.85	6.43	8.01

Table 7.11 continued

Upper-head h_a (mm)	Discharge in m^3/s for flumes of various throat widths							
	10 feet	12 feet	15 feet	20 feet	25 feet	30 feet	40 feet	50 feet
400	1.72	2.04	2.53	3.34	4.14	4.95	6.56	8.17
405	1.76	2.09	2.58	3.40	4.22	5.05	6.69	8.34
410	1.79	2.13	2.63	3.47	4.31	5.15	6.83	8.50
415	1.83	2.17	2.68	3.54	4.39	5.25	6.96	8.67
420	1.86	2.21	2.74	3.61	4.48	5.35	7.10	8.84
425	1.90	2.25	2.79	3.68	4.56	5.45	7.23	9.01
430	1.93	2.30	2.84	3.74	4.65	5.56	7.37	9.18
435	1.97	2.34	2.89	3.81	4.74	5.66	7.51	9.35
440	2.01	2.38	2.95	3.89	4.82	5.76	7.64	9.52
445	2.04	2.43	3.00	3.96	4.91	5.87	7.78	9.69
450	2.08	2.47	3.05	4.03	5.00	5.98	7.92	9.87
455	2.12	2.51	3.11	4.10	5.09	6.08	8.06	10.0
460	2.15	2.56	3.16	4.17	5.18	6.19	8.21	10.2
465	2.19	2.60	3.22	4.24	5.27	6.30	8.35	10.4
470	2.23	2.65	3.27	4.32	5.36	6.41	8.49	10.6
475	2.27	2.69	3.33	4.39	5.45	6.52	8.64	10.8
480	2.31	2.74	3.39	4.47	5.54	6.63	8.79	10.9
485	2.34	2.78	3.44	4.54	5.64	6.74	8.93	11.1
490	2.38	2.83	3.50	4.62	5.73	6.85	9.08	11.3
495	2.42	2.88	3.56	4.69	5.82	6.96	9.23	11.5
500	2.46	2.92	3.62	4.77	5.92	7.07	9.38	11.7
505	2.50	2.97	3.67	4.84	6.01	7.19	9.53	11.9
510	2.54	3.02	3.73	4.92	6.11	7.30	9.68	12.1
515	2.58	3.06	3.79	5.00	6.20	7.42	9.83	12.2
520	2.62	3.11	3.85	5.08	6.30	7.53	9.99	12.4
525	2.66	3.16	3.91	5.15	6.40	7.65	10.1	12.6
530	2.70	3.21	3.97	5.23	6.50	7.76	10.3	12.8
535	2.74	3.26	4.03	5.31	6.59	7.88	10.5	13.6
540	2.78	3.31	4.09	5.39	6.69	8.00	10.6	13.0
550	2.87	3.40	4.21	5.55	6.89	8.24	10.9	13.6
560	2.95	3.50	4.33	5.71	7.09	8.48	11.2	14.0
570	3.04	3.60	4.46	5.88	7.30	8.72	11.6	14.4
580	3.12	3.71	4.58	6.04	7.50	8.97	11.9	14.8
590	3.21	3.81	4.71	6.21	7.71	9.22	12.2	15.2
600	3.30	3.91	4.84	6.38	7.92	9.47	12.6	15.6
610	3.38	4.02	4.97	6.55	8.13	9.72	12.9	16.1
620	3.47	4.12	5.10	6.73	8.35	9.98	13.2	16.5
630	3.56	4.23	5.23	6.90	8.57	10.2	13.6	16.9
640	3.65	4.34	5.37	7.08	8.78	10.5	13.9	17.3
650	3.75	4.45	5.50	7.25	9.00	10.8	14.3	17.8
660	3.84	4.56	5.64	7.43	9.23	11.0	14.6	18.2
670	3.93	4.67	5.77	7.61	9.45	11.3	15.0	18.7
680	4.03	4.78	5.91	7.80	9.68	11.6	15.3	19.1
690	4.12	4.89	6.05	7.98	9.91	11.8	15.7	19.6
700	4.22	5.01	6.19	8.17	10.1	12.1	16.1	20.0
710	4.31	5.12	6.34	8.35	10.4	12.4	16.4	20.5
720	4.41	5.24	6.48	8.54	10.6	12.7	16.8	20.9
730	4.51	5.35	6.62	8.73	10.8	13.0	17.2	21.4
740	4.61	5.47	6.77	8.93	11.1	13.2	17.6	21.9
750	4.71	5.59	6.92	9.12	11.3	13.5	17.9	22.3
760	4.81	5.71	7.06	9.31	11.6	13.8	18.3	22.8
770	4.91	5.83	7.21	9.51	11.8	14.1	18.7	23.3
780	5.01	5.95	7.36	9.71	12.1	14.4	19.1	23.8
790	5.12	6.08	7.52	9.91	12.3	14.7	19.5	24.3
800	5.22	6.20	7.67	10.1	12.6	15.0	19.9	24.8
810	5.33	6.32	7.82	10.3	12.8	15.3	20.3	25.3
820	5.43	6.45	7.98	10.5	13.1	15.6	20.7	25.8
830	5.54	6.58	8.13	10.7	13.3	15.9	21.1	26.3
840	5.65	6.70	8.29	10.9	13.6	16.2	21.5	26.8
850	5.75	6.83	8.45	11.1	13.8	16.5	21.9	27.3
860	5.86	6.96	8.61	11.4	14.1	16.8	22.3	27.8
870	5.97	7.09	8.77	11.6	14.4	17.2	22.8	28.3
880	6.08	7.22	8.93	11.8	14.6	17.5	23.2	28.9
890	6.19	7.35	9.10	12.0	14.9	17.8	23.6	29.4

Table 7.11 continued

Upper-head h_a (mm)	Discharge in m^3/s for flumes of various throat widths							
	10 feet	12 feet	15 feet	20 feet	25 feet	30 feet	40 feet	50 feet
900	6.31	7.48	9.26	12.2	15.2	18.1	24.0	29.9
910	6.42	7.62	9.42	12.4	15.4	18.4	24.4	30.5
920	6.53	7.75	9.59	12.6	15.7	18.8	24.9	31.0
930	6.64	7.89	9.76	12.9	16.0	19.1	25.3	31.5
940	6.76	8.02	9.93	13.1	16.2	19.4	25.8	32.1
950	6.87	8.16	10.1	13.3	16.5	19.8	26.2	32.6
960	6.99	8.30	10.3	13.5	16.8	20.1	26.6	33.2
970	7.11	8.44	10.4	13.8	17.1	20.4	27.1	33.7
980	7.23	8.58	10.6	14.0	17.4	20.8	27.5	34.3
990	7.34	8.72	10.8	14.2	17.7	21.1	28.0	34.8
1000	7.46	8.86	11.0	14.4	17.9	21.4	28.4	35.4
1010	7.58	9.00	11.1	14.7	18.2	21.8	28.9	36.0
1020	7.70	9.14	11.3	14.9	18.5	22.1	29.3	36.5
1030	7.82	9.29	11.5	15.1	18.8	22.5	29.8	37.1
1040	7.95	9.43	11.7	15.4	19.1	22.8	30.3	37.7
1050	8.07	9.58	11.8	15.6	19.4	23.2	30.7	38.3
1060	8.19	9.72	12.0	15.9	19.7	23.5	31.2	38.9
1070		9.87	12.2	16.1	20.0	23.9	31.7	39.5
1080		10.0	12.4	16.3	20.3	24.2	32.2	40.1
1090		10.2	12.6	16.6	20.6	24.6	32.6	40.6
1100		10.3	12.8	16.8	20.9	25.0	33.1	41.2
1110		10.5	13.0	17.1	21.2	25.3	33.6	41.8
1120		10.6	13.1	17.3	21.5	25.7	34.1	42.4
1130		10.8	13.3	17.6	21.8	26.1	34.6	43.1
1140		10.9	13.5	17.8	22.1	26.4	35.1	43.7
1150		11.1	13.7	18.1	22.4	26.8	35.6	44.3
1160		11.2	13.9	18.3	22.7	27.2	36.1	44.9
1170		11.4	14.1	18.6	23.1	27.6	36.5	45.5
1180		11.5	14.3	18.8	23.4	27.9	37.0	46.1
1190		11.7	14.5	19.1	23.7	28.3	37.6	46.8
1200		11.9	14.7	19.3	24.0	28.7	38.1	47.4
1210		12.0	14.9	19.6	24.3	29.1	38.6	48.0
1220		12.2	15.1	19.9	24.7	29.5	39.1	48.7
1230		12.3	15.3	20.1	25.0	29.9	39.6	49.3
1240		12.5	15.5	20.4	25.3	30.2	40.1	50.0
1250		12.7	15.7	20.7	25.6	30.6	40.6	50.6
1260		12.8	15.9	20.9	26.0	31.0	41.1	51.3
1270		13.0	16.1	21.2	26.3	31.4	41.7	51.9
1280		13.1	16.3	21.4	26.6	31.8	42.2	52.6
1290		13.3	16.5	21.7	27.0	32.2	42.7	53.2
1300		13.5	16.7	22.0	27.3	32.6	43.3	53.9
1310		13.6	16.9	22.3	27.6	33.0	43.8	54.5
1320		13.8	17.1	22.5	28.0	33.4	44.3	55.2
1330		14.0	17.3	22.8	28.3	33.8	44.9	55.9
1340		14.1	17.5	23.1	28.7	34.2	45.4	56.6
1350		14.3	17.9	23.4	29.0	34.7	46.0	57.2
1360		14.5	17.9	23.6	29.3	35.1	46.5	57.9
1370		14.7	18.1	23.9	29.7	35.5	47.0	58.6
1380			18.3	24.2	30.0	35.9	47.6	59.3
1390			18.6	24.5	30.4	36.3	48.2	60.0
1400			18.8	24.8	30.7	36.7	48.7	60.7
1410			19.0	25.0	31.1	37.2	49.3	61.4
1420			19.2	25.3	31.4	37.6	49.8	62.1
1430			19.4	25.6	31.8	38.0	50.4	62.8
1440			19.6	25.9	32.2	38.4	51.0	63.5
1450			19.9	26.2	32.5	38.9	51.5	64.2
1460			20.1	26.5	32.9	39.3	52.1	64.9
1470			20.3	26.8	33.2	39.7	52.7	65.7
1480			20.5	27.1	33.6	40.1	53.2	66.3
1490			20.7	27.4	34.0	40.6	53.8	67.0
1500			21.0	27.6	34.3	41.0	54.4	67.7
1510			21.2	27.9	34.7	41.5	55.0	68.5
1420			21.4	28.2	35.1	41.9	55.6	69.2
1530			21.6	28.5	35.4	42.3	56.1	69.9

Table 7.11 continued

Upper-head h_a (mm)	Discharge in m^3/s for flumes of various throat widths							
	10 feet	12 feet	15 feet	20 feet	25 feet	30 feet	40 feet	50 feet
1540			21.9	28.8	35.8	42.8	56.7	70.7
1550			22.1	29.1	36.2	43.2	57.3	71.4
1560			22.3	29.4	36.5	43.7	57.9	72.1
1570			22.6	29.7	36.9	44.1	58.5	72.9
1580			22.8	30.0	37.3	44.6	59.1	73.6
1590			23.0	30.3	37.7	45.0	59.7	74.4
1600			23.2	30.7	38.1	45.5	60.3	75.1
1610			23.5	31.0	38.4	45.9	60.9	75.9
1620			23.7	31.3	38.8	46.4	61.5	76.6
1630			24.0	31.6	39.2	46.9	62.1	77.4
1640			24.2	31.9	39.6	47.3	62.7	78.1
1650			24.4	32.2	40.0	47.8	63.4	78.9
1660			24.7	32.5	40.4	48.2	64.0	79.7
1670			24.9	32.8	40.8	48.7	64.6	80.4
1680				33.1	41.1	49.2	65.2	81.2
1690				33.5	41.5	49.6	65.8	82.0
1700				33.8	41.9	50.1	66.5	82.8
1710				34.1	42.3	50.6	67.1	83.5
1720				34.4	42.7	51.1	67.7	84.3
1730				34.7	43.1	51.5	68.3	85.1
1740				35.1	43.5	52.0	69.0	85.9
1750				35.4	43.9	52.5	69.6	86.7
1760				35.7	44.3	53.0	70.2	87.5
1770				36.0	44.7	53.5	70.9	88.3
1780				36.4	45.1	53.9	71.5	89.1
1790				36.7	45.5	54.4	72.2	89.9
1800				37.0	45.9	54.9	72.8	90.7
1810				37.3	46.4	55.4	73.5	91.5
1820				37.7	46.8	55.9	74.1	92.3

- In some tables; Table 7.5 for 1" throat width Parshall flume, Table 7.6 for 2" throat width Parshall flume, Table 7.7 for 3" throat width Parshall flume, and Table 7.8 for 6" throat width Parshall flume and Table 7.9 for 9" throat width Parshall flume, there is a header row of Head h_a in addition to the traditional header column as follows:

Head h_a (m)	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
-------------------	------	------	------	------	------	------	------	------	------	------

This gives more accuracy by specifying the third decimal value after "." (hundredths). Ex: if you specify 0.15 from the header column and .007 from the header row that means that $h_a = 0.157$.

❖ Submerged flow

When the ratio of gauge reading h_b to h_a (h_b/h_a) exceeds (**greater than**) the limits of 0.50 for 1- to 3-in flumes, 0.60 for 6-, and 9-in flumes, 0.70 for 1- to 8-ft flumes and 0.80 for 10- to 50-ft flumes, the modular flume discharge is reduced due to submergence. This ratio (h_b/h_a) is used to indicate the degree to which downstream conditions limit free flow out of the flume. As Parshall Flumes increase in size, their resistance to the effects of downstream submergence increases.

1-3 inch Parshall 50%

6 inch Parshall 60%

1-8 foot Parshall 70%

10-50 foot Parshall 80%

The non-modular discharge of Parshall flumes equals

$$Q_s = Q - Q_E \quad (7-5)$$

where Q equals the modular discharge (Tables 7.5 to 7.11) and Q_E is the reduction on the modular discharge due to submergence.

The diagrams in Figures 7.10 to 7.16 give the corrections, Q_E , for submergence for Parshall flumes of various sizes. The correction for the 1-ft flume is made applicable to the 1.5-ft up to 8-ft flumes by multiplying the correction Q_E for the 1-ft flume by the factor given below for the particular size of the flume in use.

Size of flume		correction factor
b_c in ft	b_c in m	
1	0.3048	1.0
1.5	0.4572	1.4
2	0.6096	1.8
3	0.9144	2.4
4	1.2191	3.1
5	1.5240	3.7
6	1.8288	4.3
7	2.1336	4.9
8	2.4384	5.4

Similarly, the correction for the 10-ft flumes is made applicable to the larger flumes by multiplying the correction for the 10-ft flume by the factor given below for the particular flume in use.

Size of flume		correction factor
b_c in ft	b_c in m	
10	3.048	1.0
12	3.658	1.2
15	4.572	1.5
20	6.096	2.0
25	7.620	2.5
30	9.144	3.0
40	12.192	4.0
50	15.240	5.0

UPSTREAM HEAD
 h_a in metres

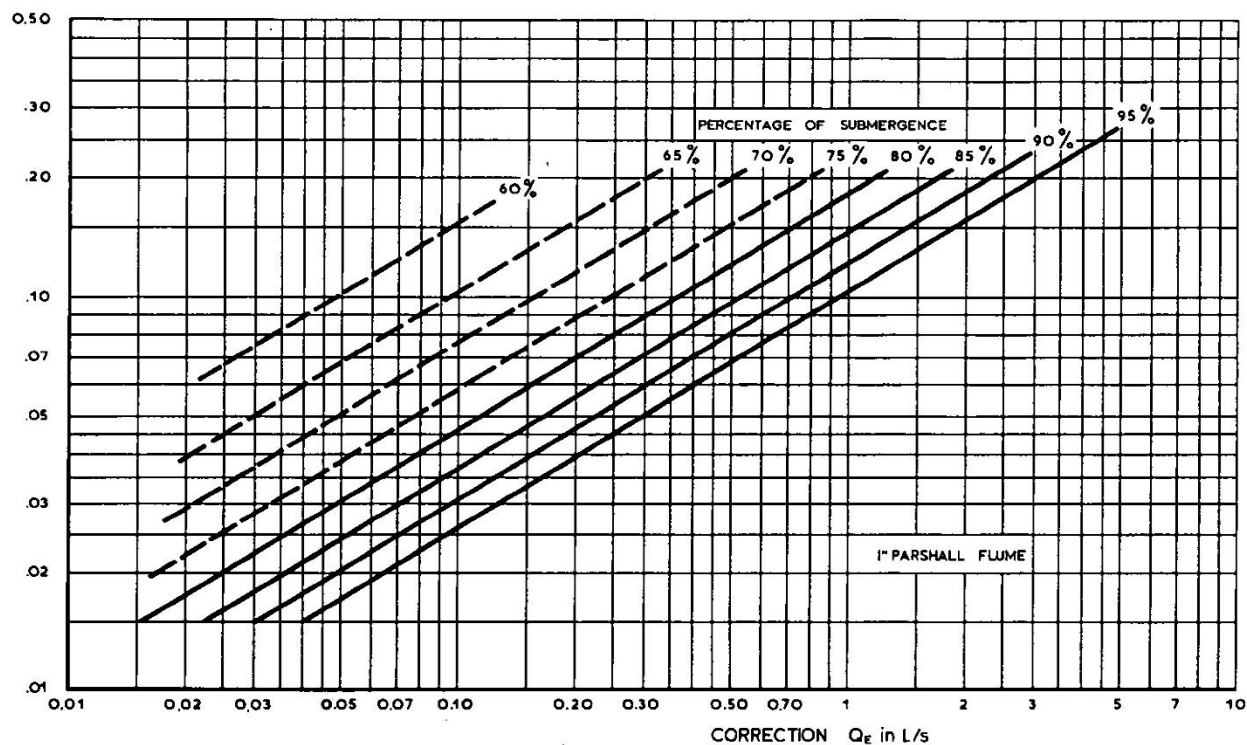


Figure 7.10 Discharge correction for submerged flow; 1" Parshall flume

UPSTREAM HEAD
 h_a in metres

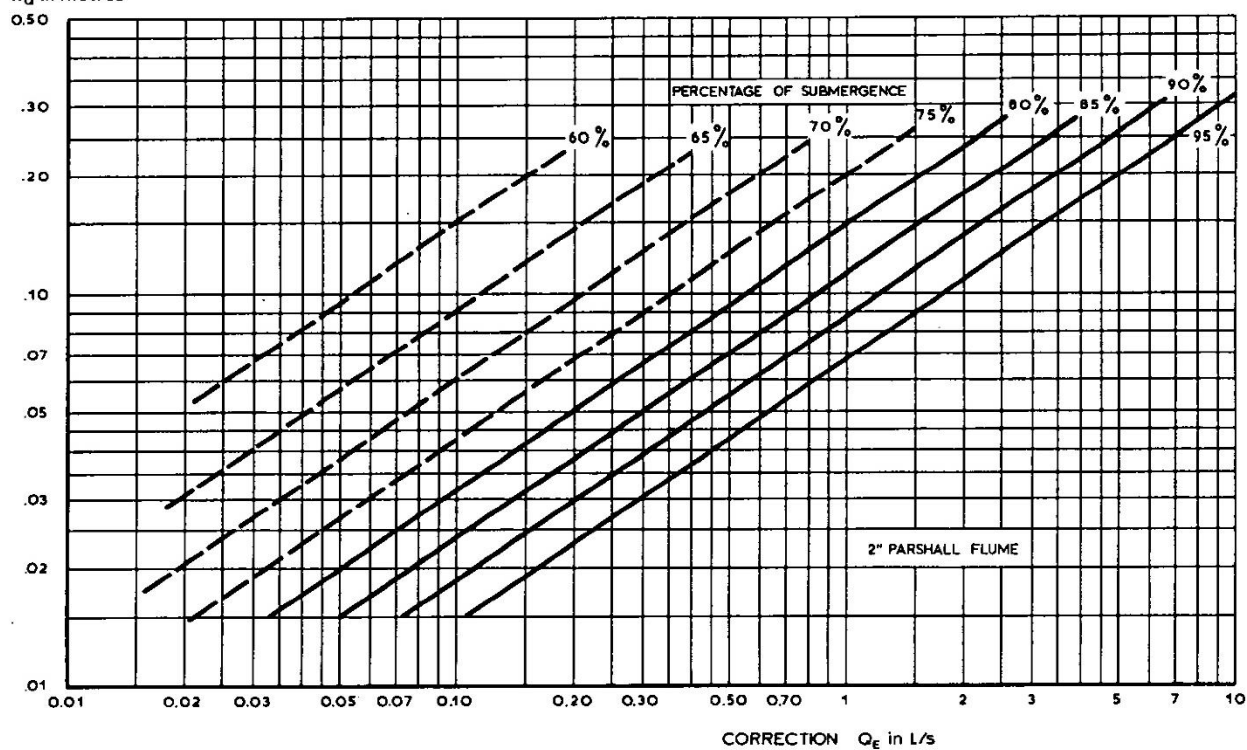


Figure 7.11 Discharge correction for submerged flow; 2" Parshall flume

UPSTREAM HEAD
 h_u in metres

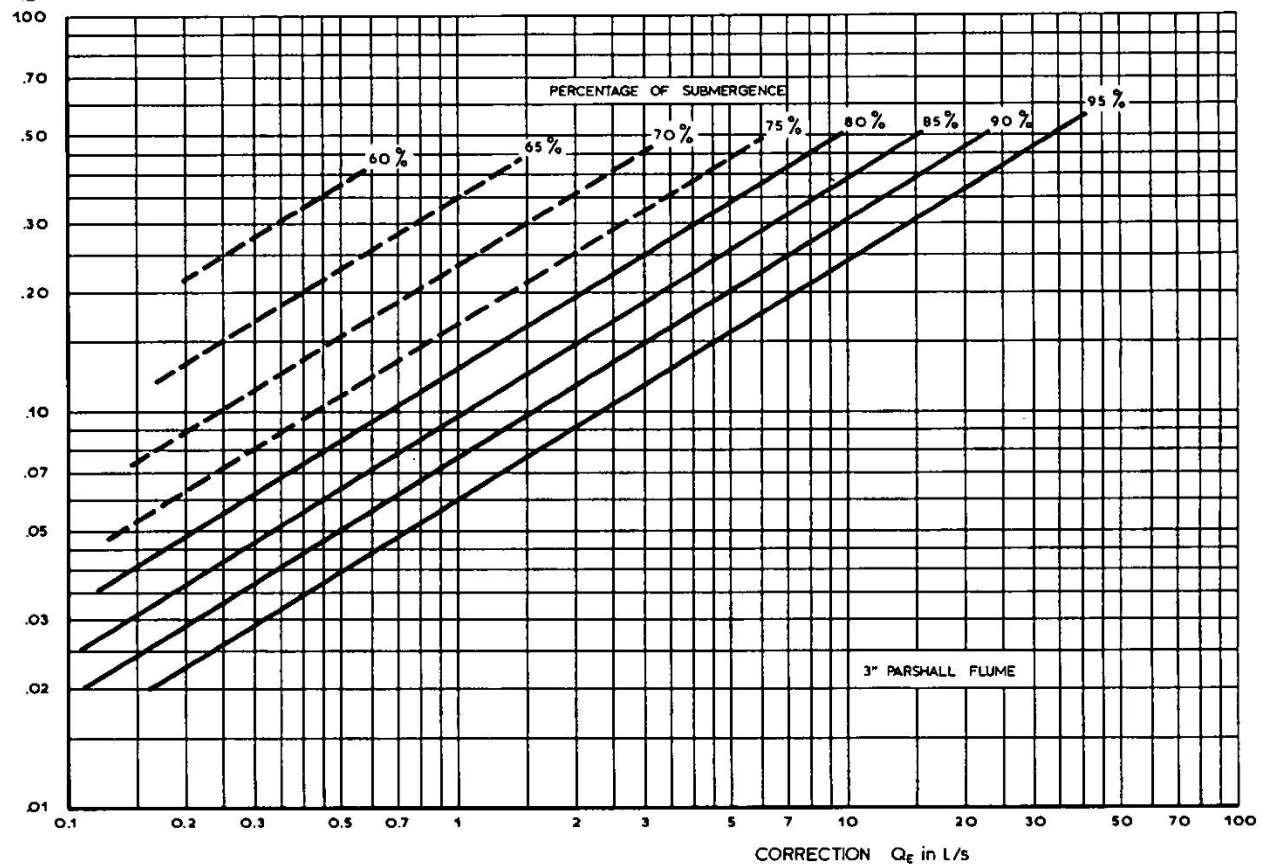


Figure 7.12 Discharge correction for submerged flow; 3" Parshall flume

UPSTREAM HEAD
 h_u in metres

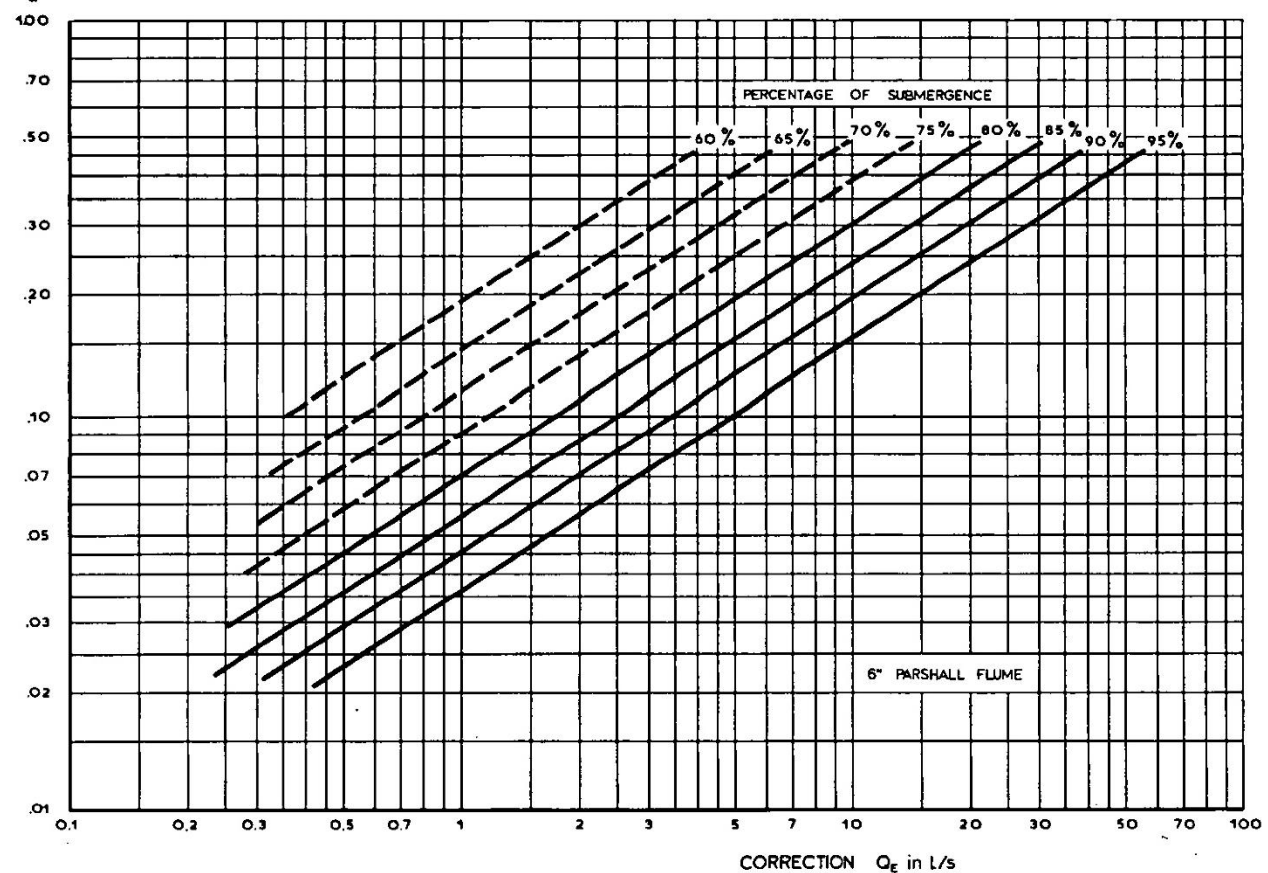


Figure 7.13 Discharge correction for submerged flow; 6" Parshall flume

UPSTREAM HEAD
 h_a in metres

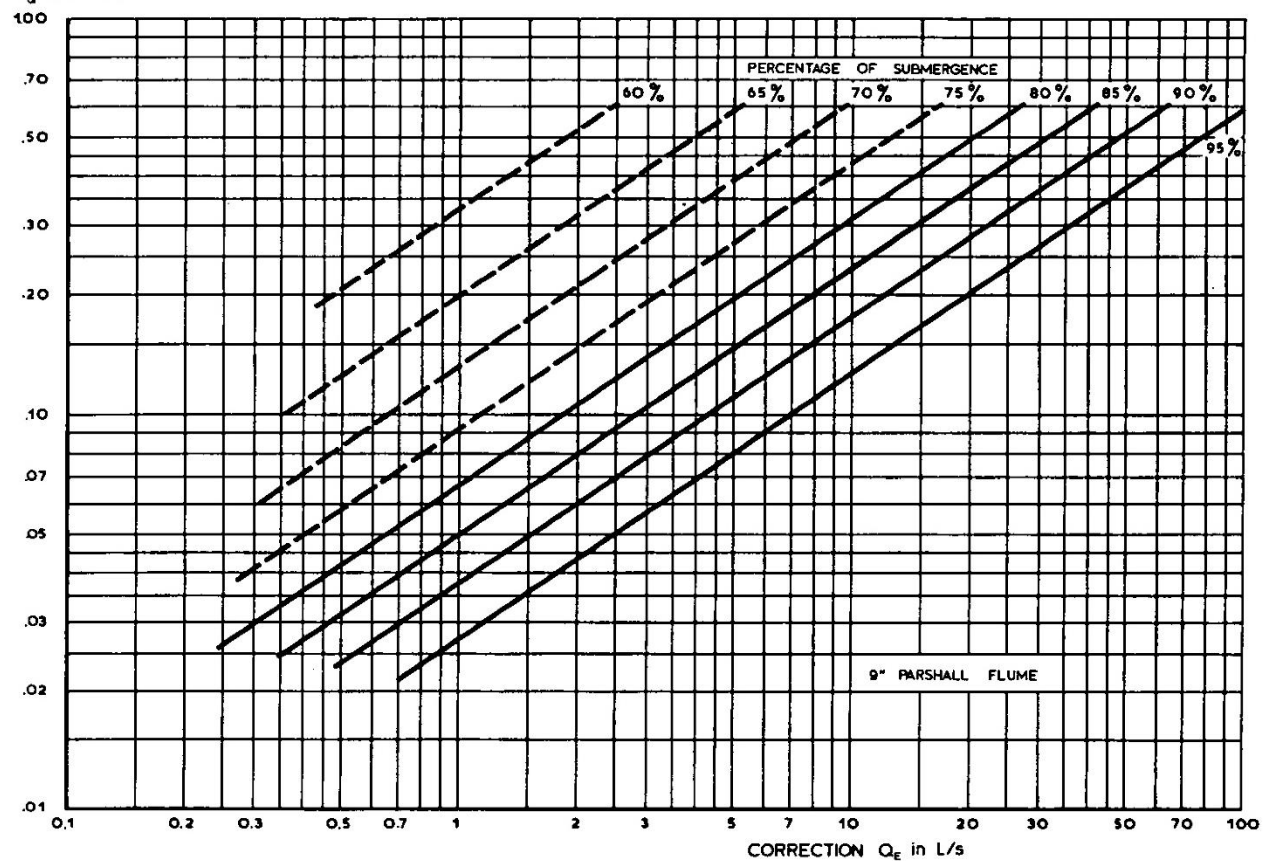


Figure 7.14 Discharge correction for submerged flow; 9" Parshall flume

UPSTREAM HEAD
 h_a in metres

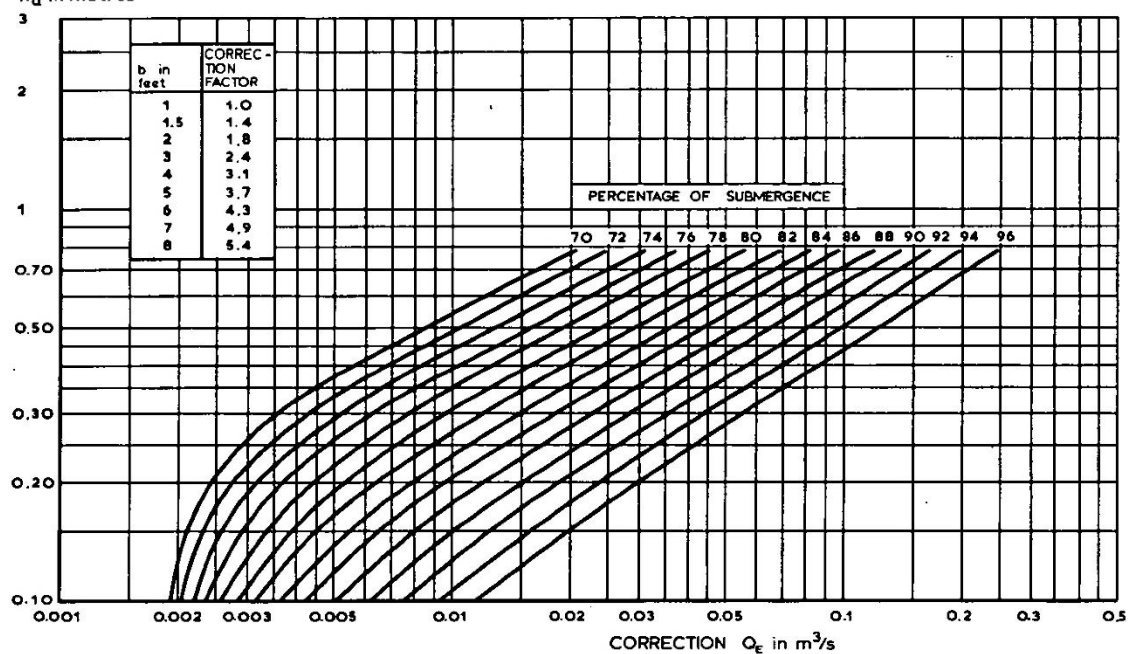


Figure 7.15 Discharge correction for submerged flow; 1' Parshall flume, correction Q_e (m^3/s)

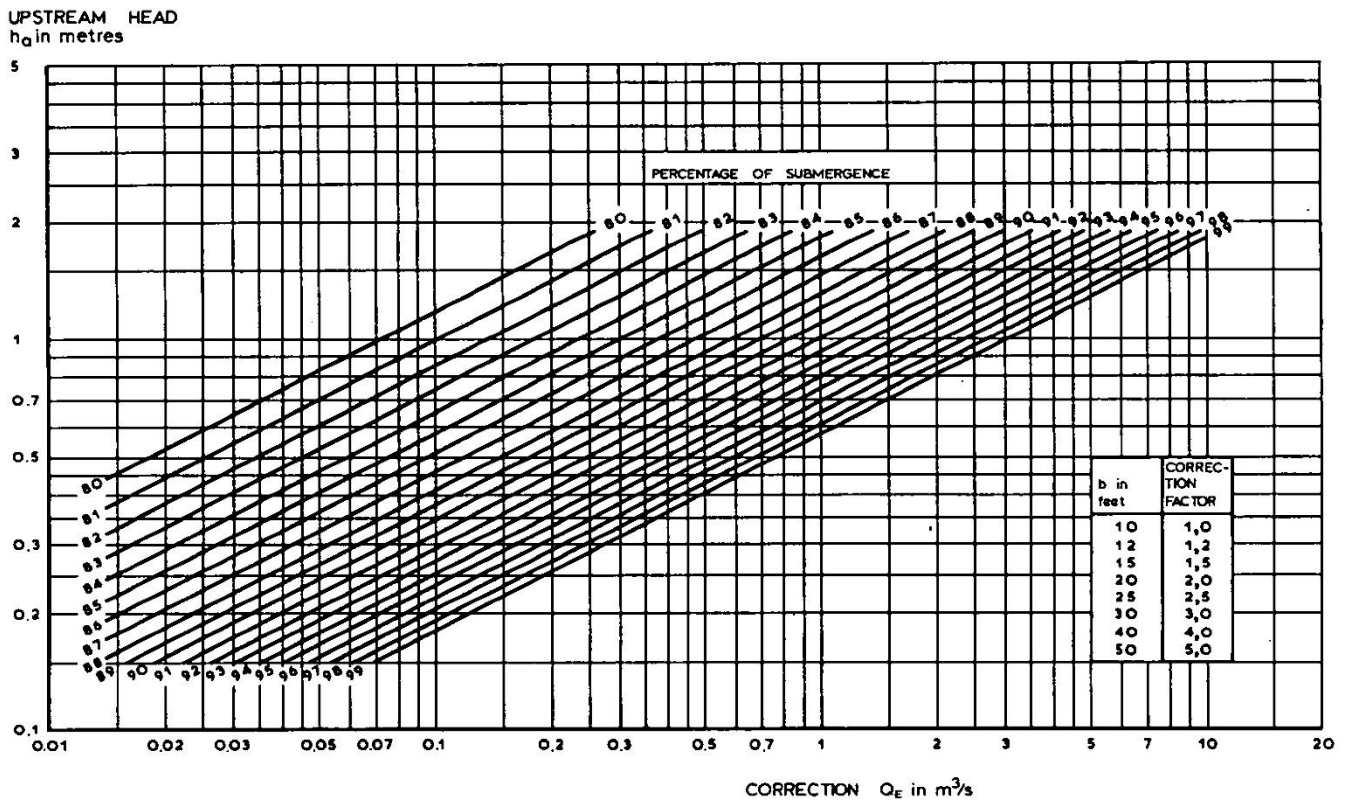


Figure 7.16 Diagram for determining correction to be subtracted from free-discharge flow to obtain submerged flow discharge through 10' Parshall flumes

If the size and elevation of the flume cannot be selected to permit modular-flow operation, the submergence ratio h_b/h_a should be kept below the practical limit of 0.90, since the flume ceases to be a measuring device if submergence exceeds this limit. It is recommended to use a long-throated flume instead of a non-modular Parshall flume.

As mentioned, turbulence in the relatively deep and narrow throat of the 'very small' flumes makes the h_b gauge difficult to read. If an h_c gauge is used under submerged flow conditions, the h_c readings should be converted to h_b readings with the aid of Figure 7.17, and the converted h_b values are then used to determine the submerged discharge with the aid of Figures 7.10 to 7.14.

❖ Accuracy of discharge measurement

The error in the modular discharge read from the Tables 7.5 to 7.11 is expected to be about 3%. Under submerged flow conditions the error in the discharge becomes greater, until at 90% submergence the flume ceases to be a measuring device. The method by which this discharge error is to be combined with errors in h_a , h_b , and the flume dimensions are shown in Annex 2 (link to Annex 2 from [here](#)).

❖ Loss of head through the flume

The size and elevation of the crest of the flume depend on the available loss of head through the flume Δh ($\approx \Delta H$). Since for the Parshall flume h_a and h_b are measured at rather arbitrary locations, the loss of head through the flume Δh is not equal to the difference between h_a and h_b but has a greater value (Figure 7.18). The head loss Δh can be determined from the diagrams in Figures 7.19 and 7.20 for small and large flumes. For very small flumes no data on Δh is available.

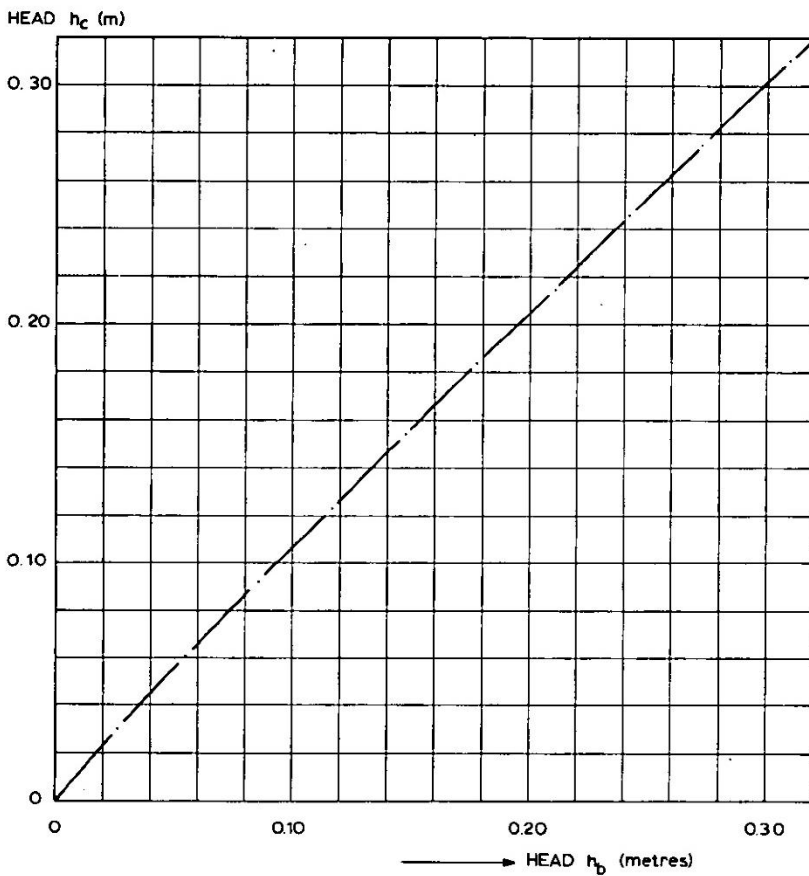


Figure 7.17 Relationship of h_c and h_b gauges for 1", 2" and 3" Parshall flumes for submergences greater than 50 percent (after Parshall 1953)

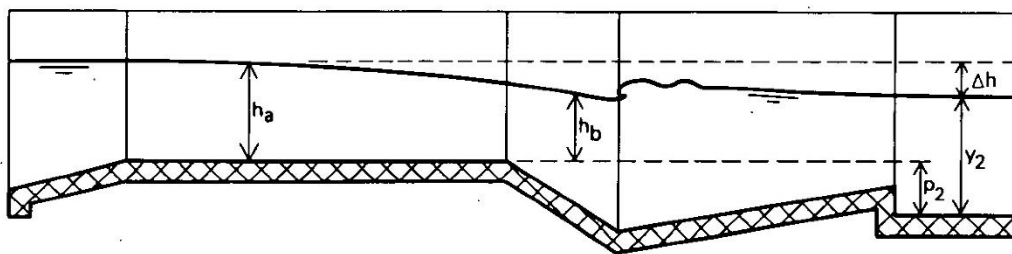


Figure 7.18 Section of Parshall flume

❖ Limits of application

The limits of application of the Parshall measuring flumes essential for reasonable accuracy are:

- Each type of flume should be constructed exactly to the dimensions listed in Table 7.3;
- The flume should be carefully levelled in both longitudinal and transverse directions;
- The practical range of heads h_a , for each type of flume as listed in Table 7.4 is recommended as a limit on h_a ;
- The submergence ratio h_b/h_a should not exceed 0.90.

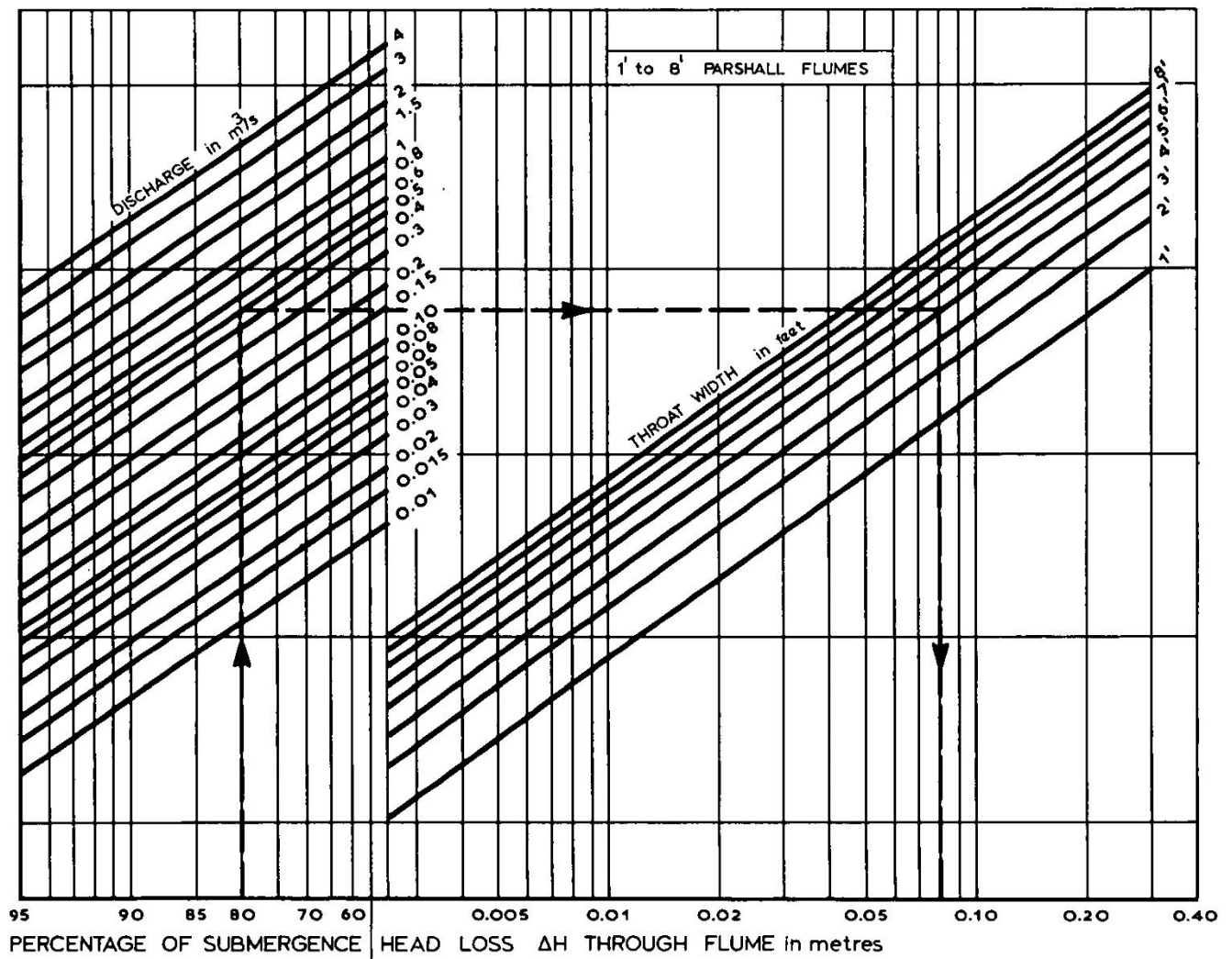


Figure 7.19 Head-loss through Parshall flumes. 1' up to 8' Parshall flumes

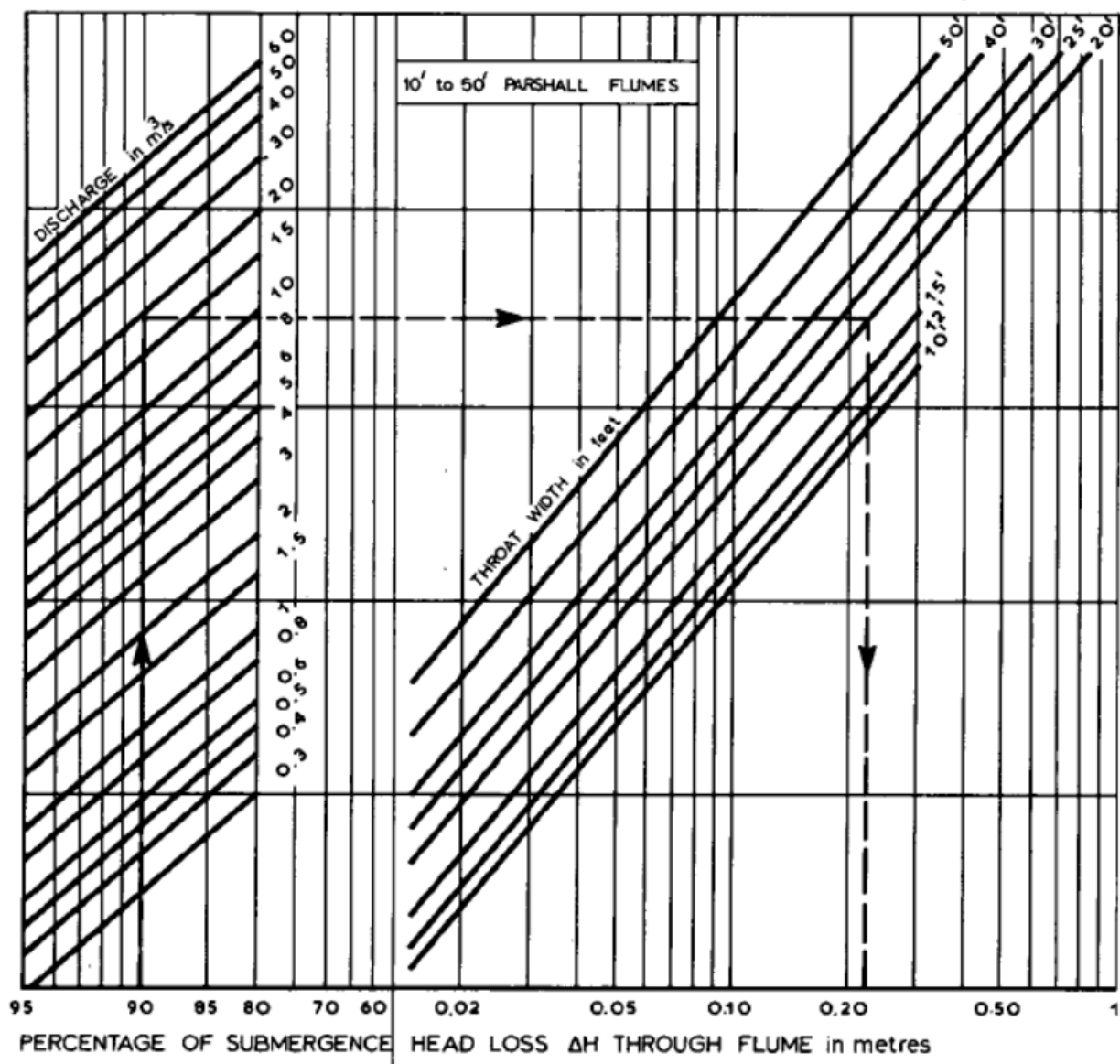


Figure 7.20 Head-loss through Parshall flumes (10-50 feet wide)

حاسبة قناة بارشال (التدفق الحر)

Parshall flume (Free-Flow Discharge) - Calculator

Parshall flume (Free-Flow Discharge) - Calculator

Please input the following values:

Throat width (b_c) [inch/feet]
 Head (h_a) [m]

Outputs:

Used Equation $0.6909 h_a^{1.522}$

Free-Flow Discharge (Q) 0.0384969 [m³/s] = 38.49693 l/s

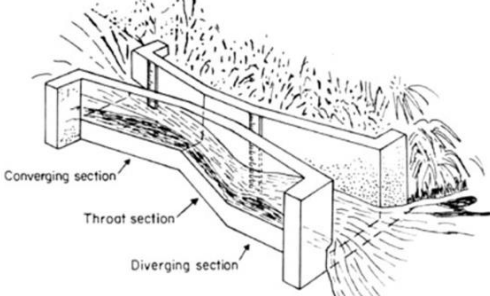


Table 7.4 Discharge characteristics of Parshall flumes

Throat width b_c in feet or inches	Discharge range in m ³ /s $\times 10^{-3}$		Equation $Q = K h_a^u$ (Q in m ³ /s)	Head range in metres		Modular limit h_b/h_a
	minimum	maximum		minimum	maximum	
1"	0.09	5.4	$0.0604 h_a^{1.55}$	0.015	0.21	0.50
2"	0.18	13.2	$0.1207 h_a^{1.55}$	0.015	0.24	0.50
3"	0.77	32.1	$0.1771 h_a^{1.55}$	0.03	0.33	0.50
6"	1.50	111	$0.3812 h_a^{1.58}$	0.03	0.45	0.60
9"	2.50	251	$0.5354 h_a^{1.53}$	0.03	0.61	0.60
1'	3.32	457	$0.6909 h_a^{1.522}$	0.03	0.76	0.70
1'6"	4.80	695	$1.056 h_a^{1.538}$	0.03	0.76	0.70
2'	12.1	937	$1.428 h_a^{1.550}$	0.046	0.76	0.70
3'	17.6	1427	$2.184 h_a^{1.566}$	0.046	0.76	0.70
4'	35.8	1923	$2.953 h_a^{1.578}$	0.06	0.76	0.70
5'	44.1	2424	$3.732 h_a^{1.587}$	0.06	0.76	0.70
6'	74.1	2929	$4.519 h_a^{1.595}$	0.076	0.76	0.70
7'	85.8	3438	$5.312 h_a^{1.601}$	0.076	0.76	0.70
8'	97.2	3949	$6.112 h_a^{1.607}$	0.076	0.76	0.70
in m ³ /s						
10'	0.16	8.28	$7.463 h_a^{1.60}$	0.09	1.07	0.80
12'	0.19	14.68	$8.859 h_a^{1.60}$	0.09	1.37	0.80
15'	0.23	25.04	$10.96 h_a^{1.60}$	0.09	1.67	0.80
20'	0.31	37.97	$14.45 h_a^{1.60}$	0.09	1.83	0.80
25'	0.38	47.14	$17.94 h_a^{1.60}$	0.09	1.83	0.80
30'	0.46	56.33	$21.44 h_a^{1.60}$	0.09	1.83	0.80
40'	0.60	74.70	$28.43 h_a^{1.60}$	0.09	1.83	0.80
50'	0.75	93.04	$35.41 h_a^{1.60}$	0.09	1.83	0.80

❖ مميزات الآلة الحاسبة:

- ✓ لا تحتاج إلى اتصال بالإنترنت للحصول على النتائج.
- ✓ يمكنك من الحصول على نتائج بصورة أسرع من الجدول.
- ✓ تحل محل كل الجدول.
- ✓ تعمل على تجنب إجهاد العين وأخطاء القراءة من الجداول.
- ✓ تعطي نتائج أكثر دقة من الجداول.
- ✓ تظهر رسالة تنبيه إذا كانت المدخلات خارج النطاق ولا تظهر نتائج في هذه الحالة.

▪ رابط التحميل من [هنا](#). (أنصح بتحميل الملف وعدم استخدامه على الإنترنت ليعمل بصورة سليمة).

❖ Calculator features:

- ✓ Offline, doesn't need internet connection to get results.
 - ✓ Get results faster than table.
 - ✓ Substitute carrying-over all table.
 - ✓ Avoid eyestrain and misreading from tables.
 - ✓ Gives more accurate results than tables.
 - ✓ Show message if inputs are out of range and show no results in this case.
- Download link from [here](#). (using downloaded file is recommended, not online, in order to work properly).

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" اللهم صلِّ وسلم وبارك على سيدنا وحبيبنا ونبينا محمد صلى الله عليه وسلم تسليماً كثيراً "

▪ يمكنكم متابعة أحدث ما أنشره وما تم نشره من مواضيع من [هنا](#)، أو عن طريق مسح رمز الاستجابة السريع التالي.

