University of Minnesota
St. Anthony Falls Hydraulic Laboratory

Project Report 279

# PARSHALL FLUME CALIBRATIONS
# APPROACH STUDIES
# 12-INCH THROAT

by

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Prepared for

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## PREFACE

The Metro Waste Control Commission (MWCC) of St. Paul has installed Parshall flumes in sewer manholes at various locations to monitor the discharges. The Parshall flume is an accurate measuring device for open channel flow when installed as specified in the standard manuals. This calls for ideal approach conditions, which may not always be possible in manhole installations. The MWCC proposed to investigate the accuracy of Parshall flumes in these installations. A literature search revealed very little definitive information on the effect of adverse approach flow conditions on the accuracy of discharge measurements. A study of Parshall flume calibrations for various approach geometries was initiated. A commercially available reinforced plastic flume with a 12-inch throat was used. This report summarizes the studies.

# I. INTRODUCTION

Parshall flumes have been used extensively for many years to measure flow discharges in canals and natural channels. Standard commercial models in various sizes are readily available. The Metro Waste Control Commission (MWCC) has installed about 150 Parshall Flumes of various sizes in sewer manholes to monitor the discharge rates at various locations. The Parshall Flume and other types have been used back as far as the early 1900's and standard installation dimensions have been developed and outlined in various sources. The flumes are installed, head measurements made, and the discharges determined from standard tables or graphs of head versus discharge. If installed according to standard specifications, discharges can be measured with confidence. When Parshall flumes are installed in manhole locations, the approach conditions may or may not be ideal. A literature search conducted by the St. Anthony Falls Hydraulic Laboratory* has revealed very little definitive information on the effect of adverse approach flow conditions on the accuracy of discharge measurements. Recommendations were made to conduct calibration studies on a flume or flumes typically used by MWCC and to test various approach geometries which simulated the approach flow conditions in the typical manhole installations. The MWCC authorized the St. Anthony Falls Hydraulic Laboratory to conduct these studies. This report is a summary of the studies.

The MWCC conducted a survey of the flume sizes installed and the sizes of the approach pipes. Flume sizes varied from 3 inches up to 48 inches. The number in use of each were 12 for the 3–inch, 19 for the 6–inch, 17 for the 9–inch, 19 for the 12–inch, and 6 for the 18–inch. Larger sizes were mostly single installations. It was decided that the ideal size to test would be a flume with a 12–inch throat width because it was one of the most numerous in use and it could be conveniently installed in the Laboratory main test channel. The flume was provided by MWCC. Initially, a trapezoidal channel was installed upstream of the flume to represent a standard approach condition and provide a base for comparison of geometry variations. The MWCC survey showed that the inlet pipes to the flumes varied from a 21–inch to 60–inch diameter. The second series of tests was conducted with the lower half of a 60–inch pipe replacing the trapezoidal channel. Another series was conducted with a 36–inch diameter as the inlet pipe. Various wing wall geometries, invert elevations, offsets, flume tilt, and flume slopes were investigated with these inlets.

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*Dahlin, Warren Q. and Joseph M. Wetzel, "Measuring of Waste Water Flow by Flumes Installed in Manholes," St. Anthony Falls Hydraulic Laboratory, University of Minnesota, External Memorandum No. M–198, July, 1986.

## II. CONCLUSIONS

1. The calibration curve for the Type A series, which simulated a standard installation, had slightly less slope that the standard calibration curve. At the higher flows the data points were very close to the standard curve and at the lower end plotted slightly to the left. The calibration curve for Type A2 was $Q = 3.8886\ H_a^{1.5736}$, as compared to $Q = 4\ H_a^{1.522}$ for the standard curve. Deviation of the measured discharge from the standard varied from about 1.2 percent at the higher flows to 10–15 percent of the lower flows. Although the turbulence level varied for the 3 wing wall geometries, the plots of data points showed very little difference.

2. In the Type B series, which had the 5–foot diameter inlet pipe, the calibration curves obtained were similar to those from the trapezoidal channel when the invert of the inlet pipe was below or level with the invert of the flume. Various wing wall geometries, box lengths, and widths did not effect the calibration curves appreciably. When the invert of the inlet pipe was raised 6 inches above the invert of the flume, some variations were observed. More turbulence was observed in the inlet box and flume, particularly for the middle range of flows. In this range, data points plotted to the right of the calibration curve of best fits.

3. With the 3–foot diameter inlet pipe installed and in line with the Parshall flume, the flow pattern in the box was fairly smooth and moderately turbulent. The rating curves obtained were similar to those obtained with the standard installation and the 5–ft diameter inlet. Offsetting the inlet pipe by 9 inches and 18 inches resulted in rating curves with a somewhat steeper slope than when the inlet pipe was in line and was closer to the standard curve. The measured water surface profiles showed considerable variations with the inlet pipe offset by 18 inches.

4. In the extreme case with a 2–ft side channel, the observed flow patterns were very poor, with large variations in the water surface profiles and high turbulence. The rating curves for $H_a$, $H_{a1}$, and $H_{a2}$ showed large differences between them. Offsetting the inlet pipe does cause variations in the rating curves; the more the offset the greater the variations.

5. In the calibration tests with the flume tilted in the lateral direction, the water surface profiles were essentially level. The calibration curves are slightly steeper with the flume tilted, as compared to the curves when the flume is level and close to the slope of the standard curve.

6. In the calibration tests with the flume sloped down or up in the longitudinal direction, the water surface profiles were essentially level. The resulting curves have a slightly steeper slope than the curves with the flume level and are close to the standard curve and the curves when the flume was tilted in the lateral direction.

## III. STANDARD DESIGN WITH TRAPEZOIDAL INLET CHANNEL, TYPES A, A1, AND A2

### A. LAYOUT OF TEST FACILITY

The Parshall flume used in the testing program was provided by the MWCC and is a Fischer Porter Type 10F1940. It is a one–piece reinforced–plastic Parshall flume with a 1–ft throat. The Parshall flume was installed in the Laboratory's main test channel, which is 9 ft wide, 6 ft deep, and about 250 ft long. The layout is shown on Chart 1 and in Photos 1 through 3. A 2–ft supply line and control valve was provided for the higher discharges and a 6–inch supply line and control valve for the lower flows. For the submergence tests, a temporary adjustable weir was installed in the channel downstream of the flume. The discharge from the flume is conveyed through the Laboratory's waste channel to the weighing tanks shown in Photo 4, where the discharge is determined. The weighing tanks facility consists of two identical tanks each capable of holding 40,000 lbs of water and suspended on beam balances. The scales are marked in 10 lb increments. By accumulating a sufficient weight of water, and using a minimum run time of 5 minutes, the discharges can be measured with a total accuracy of 0.25 percent. Diversion from tank to tank and the opening and closing of the bottom design valves is pneumatically controlled (Photo 4). The dimensions of the flume are given on Chart 2. Initially, the flume was provided with stilling wells and point gages on the right side only for the measurement of head, $H_a$ and $H_b$, as shown on Chart 2. A 32–ft long trapezoidal channel was installed upstream of the flume to simulate standard approach conditions called for in various manuals (Figures 1 and 2, and Photo 1). Also tested were three wing wall geometries: Type A with no wing walls, Type A1 with a 45–degree wing wall, and Type A2 with a curved wing wall (Chart 2). The width of the throat section was measured at various locations shown on Chart 3. The dimensions given are variations from the 12–inch nominal throat width in inches.

### B. FREE FLOW CALIBRATIONS

The flume was first calibrated for the free flow condition: that is, the tailwater was not controlled as shown in Photos 5 through 7 for the Type A flume. The flume is measuring a near capacity flow of 16.6 cfs with an $H_a$ of 2.54 ft. Type A1, which has the 45 degree wing walls, is shown in Photo 8, and Type A2, which has the curved wing walls, in Photo 9, both with the same discharge of 16.6 cfs. A series of runs at various discharges were made for each wing wall configuration. The results are plotted on Chart 4. The Type A data with no wing walls is plotted as circles, Type A1 with the 45–degree wing wall as squares, and Type A2 with the curved wing walls as triangles. No significant differences in the data plots between the three wing wall configurations are evident. From the measured heads ($H_a$) and the measured discharges (Q), the calibration curve of best fit was determined for each type. The Type A2 equation $Q = 3.8886\ H_a^{1.5736}$ is plotted on Chart 4. For comparison, the standard equation for a 12–inch flume, $Q = 4\ W\ H_a^{1.522W^{0.026}}$, as given in various manuals, is also plotted on Chart 4. With a 12–inch throat width, W, this equation reduces to $Q = 4\ H_a^{1.522}$. The comparison shows good agreement at the higher discharges. For the lower discharges, the data for Types A, A1, and A2 plot slightly to the left of the standard curve; that is, for a particular $H_a$, the corresponding discharge is less. All of the data measured in the various runs are tabulated in the Appendix. Column 1 gives the measured head ($H_a$) and column 2 the measured discharge (Q). From these data, the calibration curve of best fit was determined and the discharge computed for the measured $H_a$ values (column 3). The deviation of measured Q from the best fit curve Q is presented in column 4. Column 5 presents the discharges computed from the standard equation for the measured heads $H_a$. Column 6 presents the deviation of measured Q from the standard calibration curve Q. For Type A, for example, the deviation of measured Q from the best fit curve Q varies from –2.29 to 4.03 percent. The deviation of the measured Q from the standard calibration curve Q varies from –11.08 to 2.63 percent.

To determine if adverse approach conditions could cause significant variations in the head $H_a$ readings, a series of brief explanatory tests were made with a 17–inch wide board placed at various locations in the approach, as shown in Charts 5 through 7. The flume appears to smooth out disturbances quite effectively, as indicated by the percent variation for the various configurations. The greatest variations were caused in runs 7 and 10, when the board was placed on either side of the flume and immediately upstream. The resulting variations were –17.4 and –11.2 percent. With the board placed at various locations further upstream, the flume was quite effective in smoothing out the disturbances.

## C. SUBMERGENCE CALIBRATIONS

Some limited observations were made on the Type A Parshall flume with submergence conditions. Using the downstream weir, the tailwater was raised in stages with a constant Q and the effect on the head $H_a$ and $H_b$ readings observed. The $H_b$ location is at the downstream end of the throat section, as shown on Chart 2 and is in a very turbulent location when the hydraulic jump is approaching. Considerable fluctuations occurred in the $H_b$ stilling well and the readings were difficult to make. The results were inconclusive and it would take considerable testing time to run conclusive tests. In consultations with the sponsor, MWCC, it was decided to discontinue the submergence tests. The flumes are used infrequently for submergence measurements in the field, and for this limited program the decision was made to concentrate on free flow conditions.

## IV. FIVE–FOOT DIAMETER INLET CHANNEL TYPES B THROUGH B35

### A. TYPES B THROUGH B5

In the Type B series of geometries, the approach conditions were varied to simulate approach conditions present in the MWCC system. The bottom half of a 5–ft diameter inlet tunnel, 20–ft long, was fabricated of sheet metal and installed upstream of the flume, replacing the trapezoidal channel. A rectangular inlet box connected the tunnel to the flume, as shown on Chart 8 and in Photo 10. Box lengths of 4 ft (Types B, B1, and B2) and 2 ft (Types B3, B4, and B5) were tested. Each box length was tested with the three wing wall configurations similar to the Type A series; that is, no wing walls, 45–degree wing walls, and curved wing walls. The various combinations are shown on Chart 8 and Type B2 is shown in Photo 10. The calibrations and curves of best fit are plotted on Chart 9 for B, B1, and B2, and Chart 10 for B3, B4, and B5. The supporting information is tabulated in the Appendix.

The results are similar to those observed for the Type A series. At higher discharges, the data points agree with the standard discharge curve, and at lower discharges, the points are slightly to the left of the standard curve.

### B. TYPES B6 THROUGH B11

In Types B through B5, the inlet box was 6 ft wide. In Types B6 through B11, the inlet box width was reduced to 5 ft, the same diameter as the inlet tunnel, as shown on Chart 11. Again box lengths of 4 ft and 2 ft were tested, each with the 3 wing wall geometries, as specified on Chart 11. Photo 11 shows an overall view of the flume inlet box and inlet tunnel, and Photo 12 a close–up view of the inlet box and flume during the calibration tests. The flow conditions through the test set–up appear fairly calm, with minimum turbulence for these low flow conditions. At higher flows, the turbulence level is increased. The results are presented on Chart 12 for B6 through B8, and Chart 13 for B9 through B11, and supporting information in the Appendix. The rating curves are similar to previous curves presented in the B series.

### C. TYPES B12 THROUGH B17

The geometries of Types B12 through B17 (Chart 14) are similar to Types B through B5 (Chart 8) except that the invert of the inlet tunnel and box have been raised so they are level with the flume invert. The same box lengths of 4 ft and 2 ft and wing wall geometries were tested. The data points and best fit curve are presented on Chart 15 for Types B12 through B14 (4–ft box) and on Chart 16 for Types B15 through B17 (2–ft box). When compared with Charts 9 and 10, in which the invert of the inlet tunnel and box was lower by 3.75 inches, only small differences at the lower end may be noticed and slight differences in the equations of best fit. The supporting information is tabulated in the Appendix.

## D. TYPES B18 THROUGH B23

Types B18 through B23 have the inlet tunnel and box inlet level with the invert of the flume similar to Types B12 through B17, but in this series, the inlet box has been reduced in width from 6 ft to 5 ft (Photo 13). The same procedure as before was followed in calibrating Types B18 through B23, and the results are presented on Charts 18 and 19 and in the Appendix. Again, only minor differences are noticeable at the lower flows.

## E. TYPES B24 THROUGH B29

The calibration curves for the types with the inverts of the inlet tunnel, box, and flume at the same elevation were similar to calibration curves of the types with the invert of the inlet tunnel and box 3.75 inches lower than the flume invert. Therefore, it was decided to raise the invert of the 5–ft diameter tunnel 6 inches above the flume invert and lower the box invert back down 3.75 inches, as shown on Chart 20. Other than that, the same box lengths of 4 ft and 2 ft, and wing wall geometries were tested as designated on Chart 20. The results are presented on Charts 21 and 22 and in the Appendix. Visual observations show more turbulence in the box and flume due to the water dropping down into the box, but this does not appear to influence the rating curves appreciably.

## F. TYPES B30 THROUGH B35

Types B30 through B35 are similar to preceding Types B24 through B29, except the inlet box width has been reduced from 6 ft to 5 ft, the same width as the inlet pipe diameter (Chart 23). Box lengths of 4 ft an 2 ft and the 3 wing wall geometries were again tested. Photos 14 through 16 show Type B30 in operation at 3 flow levels. In Photo 14, the discharge is about 2.5 cfs and the disturbance caused by the inflow dropping into the box and the build up of the water surface on the right side where the $H_a$ is measured can be noted. In Photo 15, the discharge is about 4.2 cfs and shows increased turbulence in the box and build up along the right side of the flume. Increasing the flow, as in Photo 16, with a flow of 7.4 cfs, the drop into the box has less overall effect, the surface turbulence and wall build up is not as severe. The result of the calibrations are presented on Chart 24 for Types B30 through B32, and Chart 25 for Types B33 through B35. The supporting data are tabulated in the Appendix. The most noticeable variations occur for low flows in Types B30 through B32, as shown on Chart 24, where the lower end of the rating curve is shifted more to the right. The rating curve plotted is based on the equation $Q = 3.9974\ H_a^{1.5367}$ for Type B32.

# V. THREE–FOOT DIAMETER INLET PIPE TYPES C THROUGH C5, C7 THROUGH C13

## A. TYPES C THROUGH C2

In Types C through C2, the inlet was revised to a 3–ft diameter pipe and a 2–ft long by 3–ft wide box as shown on Chart 26. The invert of the pipe and box are 3.75 inches below the invert of the flume. The box was 2.75 inches wider than the flume, so small fillets were placed in the corners, as shown on Chart 26. These fillets were so small that no significant differences could be observed in the model or data. A rounded inlet was placed at the pipe inlet, as shown in Photo 17, to provide good entrance conditions. The Type C configuration is shown in operation in Photos 17 through 20; for low flows in Photos 17 and 18 and for the maximum flow of about 17.0 cfs in Photos 19 and 20. The flow entering the flume for all discharges is fairly smooth, with minimum turbulence. The results are presented on Chart 27 and in the Appendix, and are similar to results obtained in the Type B series.

## B. TYPES C3 THROUGH C5

The geometries of Types C3 through C5 are similar to Types C through C2, with the 3–ft diameter inlet pipe offset by 9 inches, as shown on Chart 28. This offset necessitates the wing wall geometries again on the left side of the flume. Since the flow entering the flume will be unsymmetrical, another stilling well and point gage was installed on the opposite side from $H_a$, or the left side of the flume, as shown on Chart 28 and labeled $H_{a1}$. Also a rail was placed across the flume between $H_a$ and $H_{a1}$ so that a traverse could be made with a point gage $H_{a2}$ to record the water surface profiles. Photos 21 and 22 show the Type C3 flume in operation with a discharge of about 17.0 cfs. The disturbance caused by the offset inflow can be seen in Photo 22. Type C4 is shown in Photo 23 with the 45 degree wing wall and in Photo 24 with the curved wing wall, both with about 17.0 cfs flow. During the Type C series tests, the head readings were recorded at $H_a$, $H_{a1}$, water surface traverse ($H_{a2}$), and the discharge measured in the weighing tanks. The results are presented on Chart 29 for Type C3, Chart 30 for Type C4, and Chart 31 for Type C5. On these charts, the $H_a$ reading is plotted as circles, $H_{a1}$ as squares, and the centerline reading of the $H_{a2}$ traverse as triangles. In most test runs, the 3 different heads plot about the same, except in the discharge range from about 1 to 5 cfs. In that range, the head readings differ somewhat and the data points plot to the right of the calibration curves of best fit. This is evident in all 3 types, particularly for Type C5 on Chart 31. Chart 32 shows a plot of the water surface profiles for Type C5 measured across the flume ($H_{a2}$). The water surface was measured at 2–inch increments across the flume, resulting in the profiles shown. The corresponding $H_a$ and $H_{a1}$

readings are marked along each vertical side as indicated. The profiles vary somewhat, but nothing really unusual is evident. The supporting information is listed in the Appendix.

## C. TYPES C7 THROUGH C9

Types C7 through C9 are similar to Type C3 through C5; except the 3–ft diameter inlet pipe has now been offset by 18 inches, as shown on Chart 33. These types were tested in a similar manner; that is, the 3 wing wall geometries and the various head readings and discharges determined. Photos 25 through 27 show the flume in operation with Types C7, C8, and C9, respectively. The water surface is quite uneven and turbulent, considerably more so than any previous geometries tested. The calibration results are presented in Charts 34 through 37 and in the Appendix. The plots of data points show noticeable variations in the head readings for all three types and in the middle range of discharges the points plot to the right of the curve of best fit. The water surface profiles on Chart 37 show considerable variations, particularly at the middle and high discharges.

## D. TYPES C10 AND C11

Another factor that could influence the accuracy of measurements of Parshall flumes is the lateral tilting of the flume which would be possible if the flume is not carefully installed in the field. Two tilt levels were investigated, 0.5 inches, as shown on Chart 38 (Type C10) and 1.0 inches as shown on Chart 40 and in Photos 28 and 29 (Type C11). These measurements were made at the throat section, as shown in section B–B on the Charts. For these tests, the 3–ft diameter inlet pipe was aligned with the longitudinal axis of the flume and the invert was 3.75 inches below the flume invert. For setting the $H_a$, $H_{a1}$, and $H_{a2}$ point gages, the reference elevation chosen was at the center of the upstream end of the throat (Charts 38 and 40). The data points and calibration curves are presented on Charts 39 (0.5–inch tilt) and 41 (1.0–inch tilt). The calibration curves are slightly steeper than for Types C through C2, which has the flume level, and closer to the slope of the standard curve. For Type C11, the equation is $Q = 3.9649\ H_a^{1.5605}$ compared to $Q = 3.8793\ H_a^{1.5925}$ for Type C2. The water surface profiles are essentially level, as shown on Chart 42, where only the 5 highest test profiles are shown.

## E. TYPES C12 AND C13

Another possibility in flume installations is that the flume could be sloped down or up in the longitudinal direction. The flume could be sloped down, as Type C12 (Chart 43) or up, as Type C13 (Chart 45). The results are presented on Chart 44 for Type C12 and Chart 46 for Type C13, with the supporting information in the Appendix. The resulting curves have a slightly steeper slope than the curves with the flume level.

# VI. TWO FOOT SIDE CHANNEL – TYPE C6

The geometry of Type C6 is an extreme case, where the inflow is introduced through a 2–ft channel on the extreme left side, as shown on Chart 47. Photos 30 and 31 show the flume being calibrated with a discharge of about 15.0 cfs. The photos show that this geometry has very poor approach conditions. Photo 32 shows a lower discharge of about 4.7 cfs and also a lower turbulence level. The results are presented on Charts 48 and 49. On Chart 48, the $H_a$, $H_{a1}$, and $H_{a2}$ values vary enough so that a calibration curve of best fit was drawn for each. In determining the equation for $H_{a2}$, the centerline values of the traverses were used. The equations vary from $Q = 4.1173\ H_a^{1.520}$ for $H_a$, which is close to the standard equation given in manuals, to $Q = 6.4227\ H_{a1}^{1.5669}$ for $H_{a1}$, with $H_{a2}$ in between. The water surface profiles plotted on Chart 49 show large variations and are much higher on the $H_a$ side of the flume. These tests prove that adverse approach conditions can cause considerable variations in the head readings from which the discharge is determined.

# PHOTOS

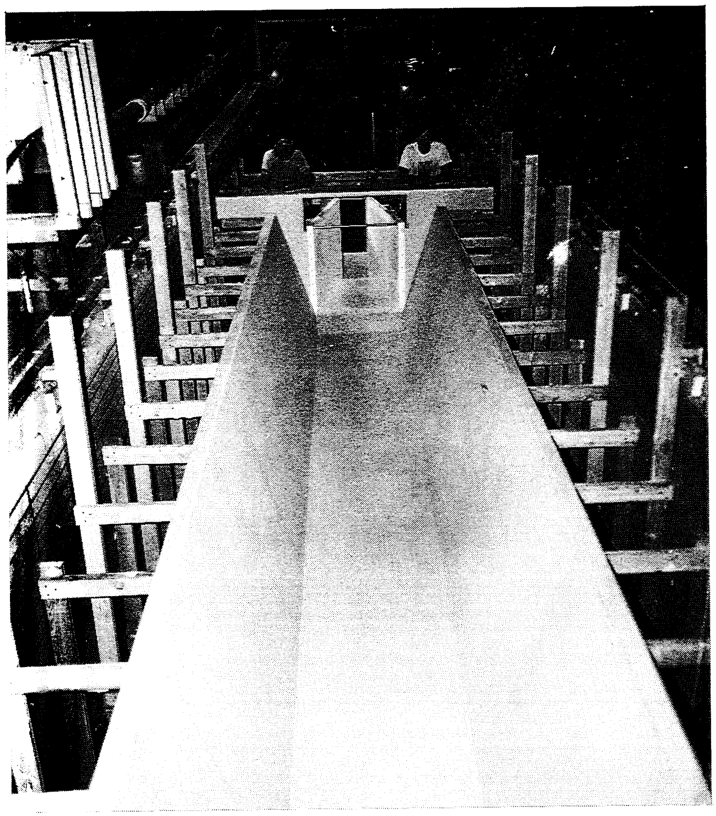


Photo 1 – Type A. The 12–inch Parshall flume installed in the main test channel.

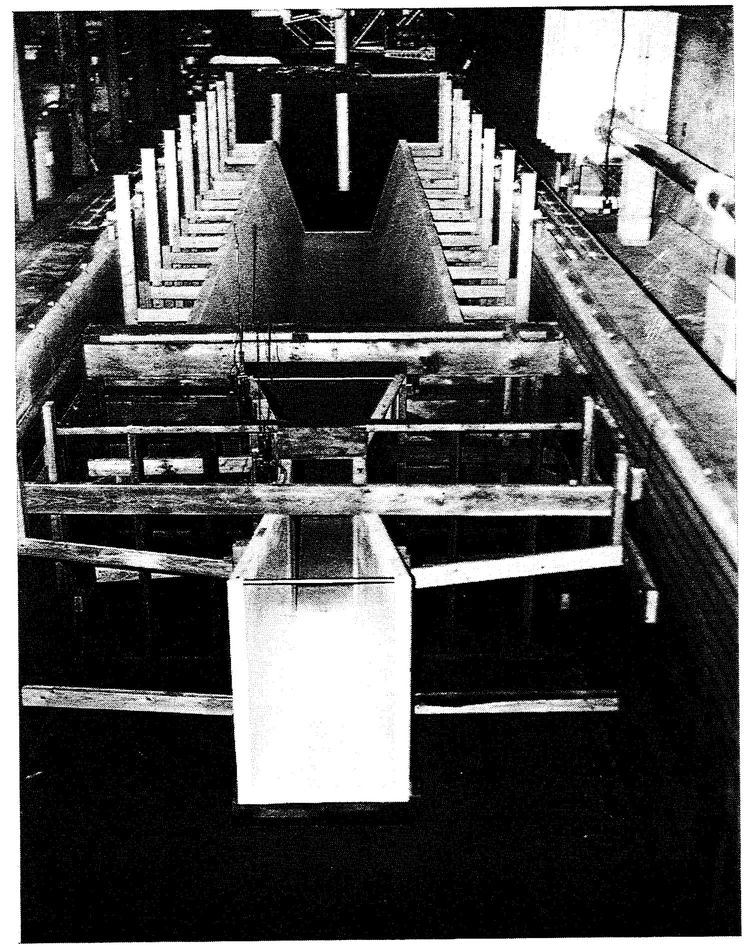


Photo 2 – Type A. The 12–inch Parshall flume installed in the main test channel.

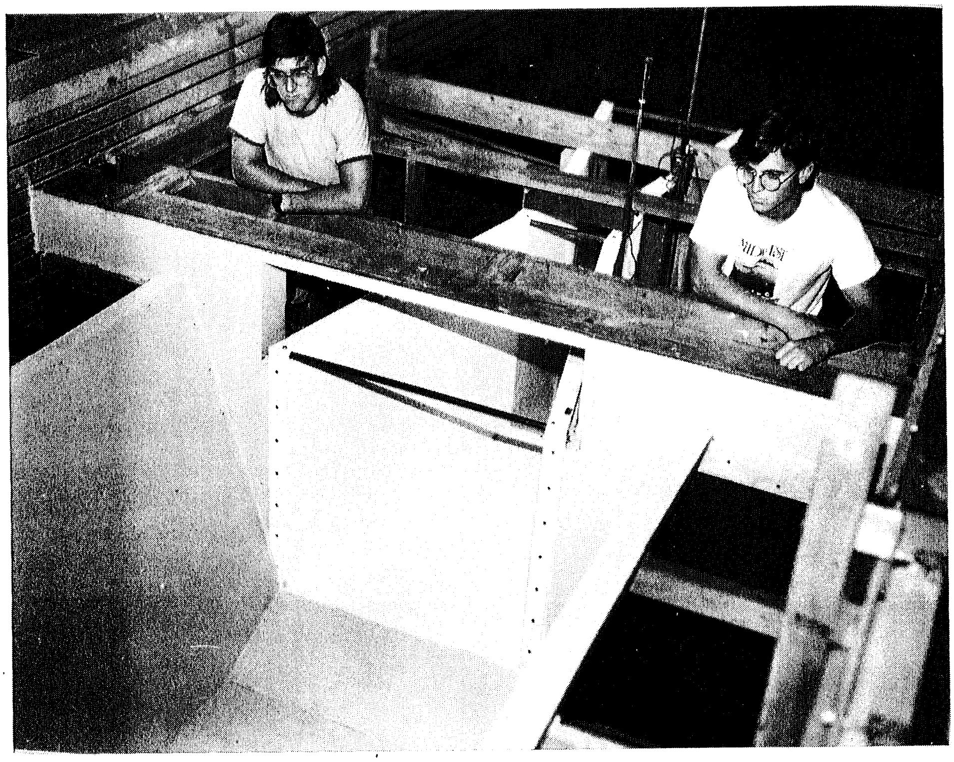


Photo 3 – Type A. The 12–inch Parshall flume ready for testing.

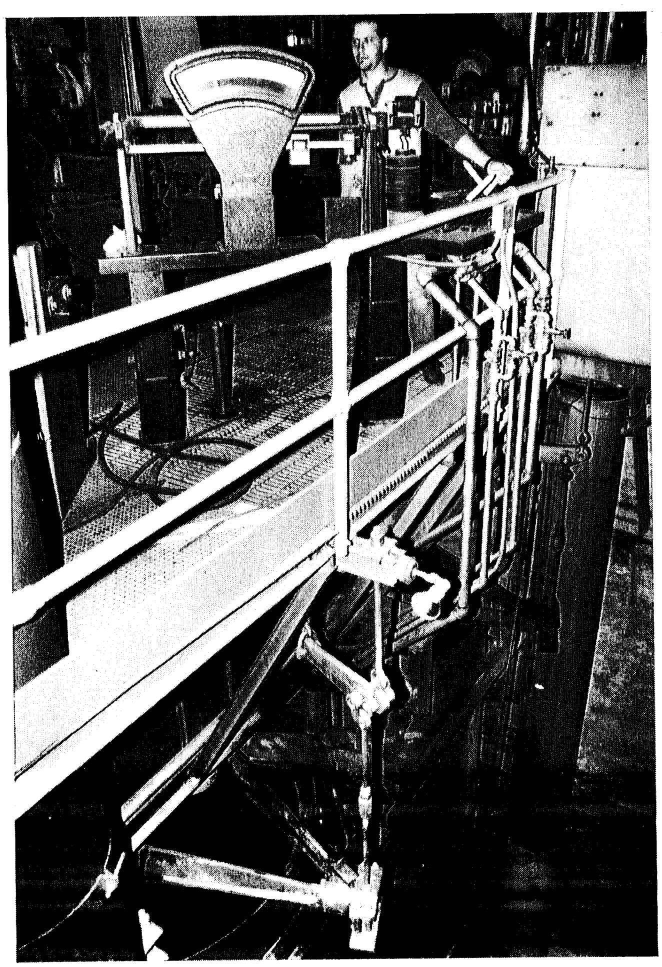


Photo 4 – The Laboratory weighing tanks.

Photo 5 – Type A. Q = 16.6 cfs, $H_a$ = 2.54 ft.

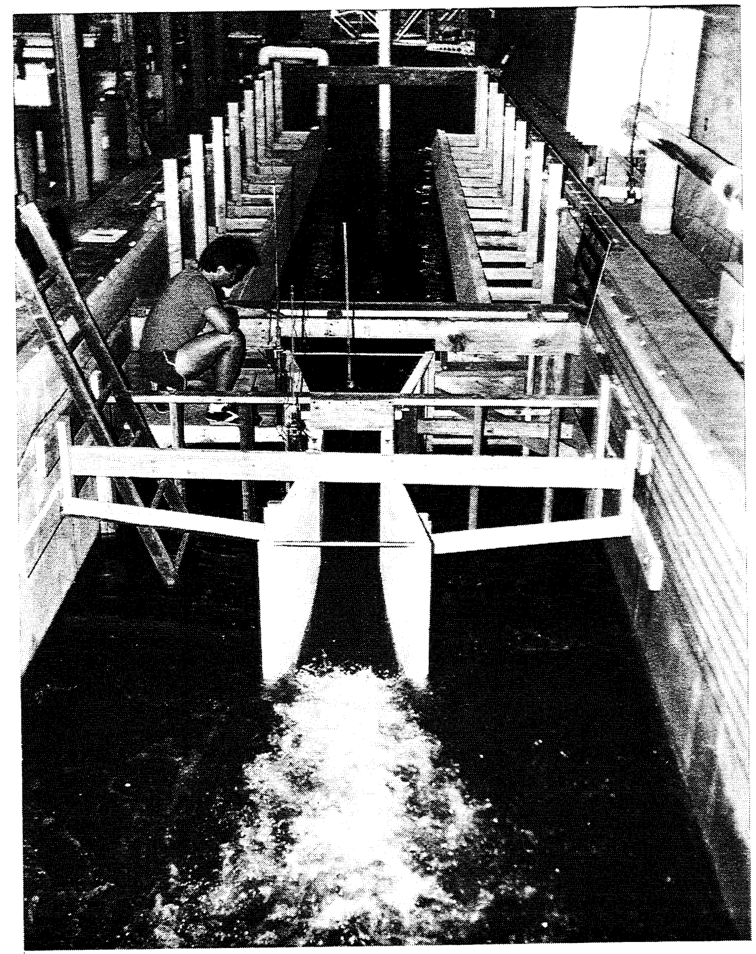


Photo 6 – Type A. Q = 16.6 cfs, $H_a$ = 2.54 ft.

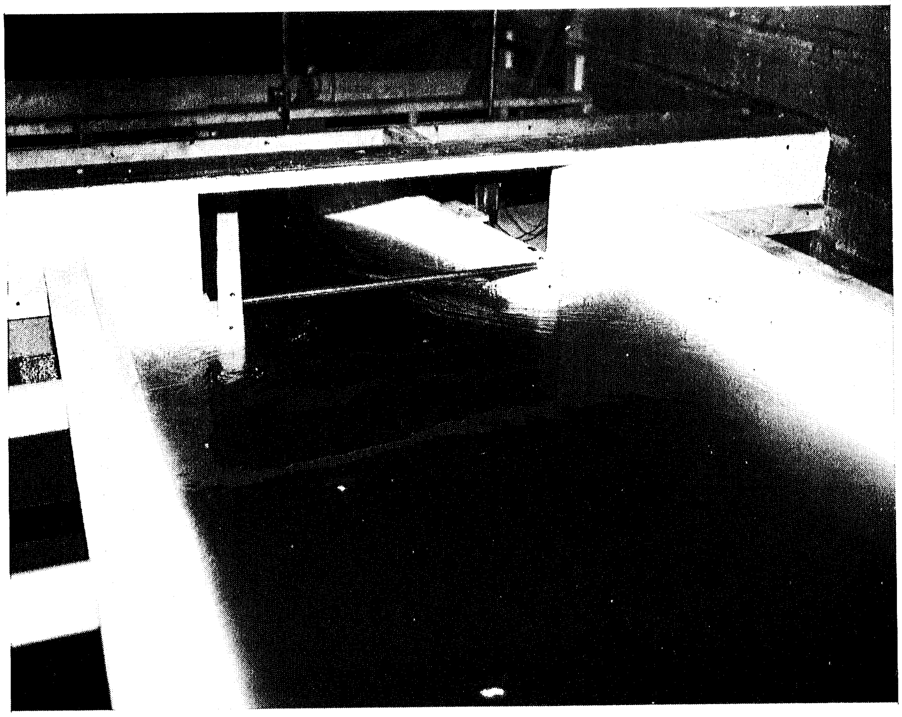


Photo 7 – Type A. Q = 16.6 cfs, $H_a$ = 2.54 ft.

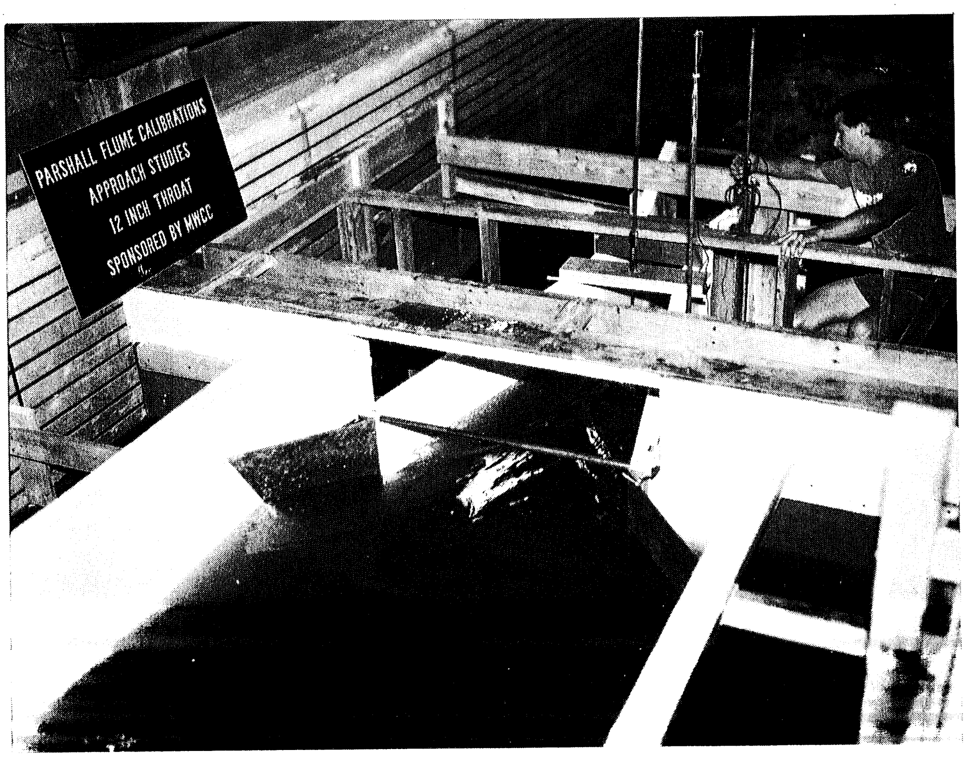



Photo 8 – Type A1. Q = 16.6 cfs, $H_a$ = 2.54 ft.

Photo 9 – Type A2. $Q = 16.6$ cfs, $H_a = 2.54$ ft.

Photo 10 – Type B2. The 5–ft diameter inlet channel.

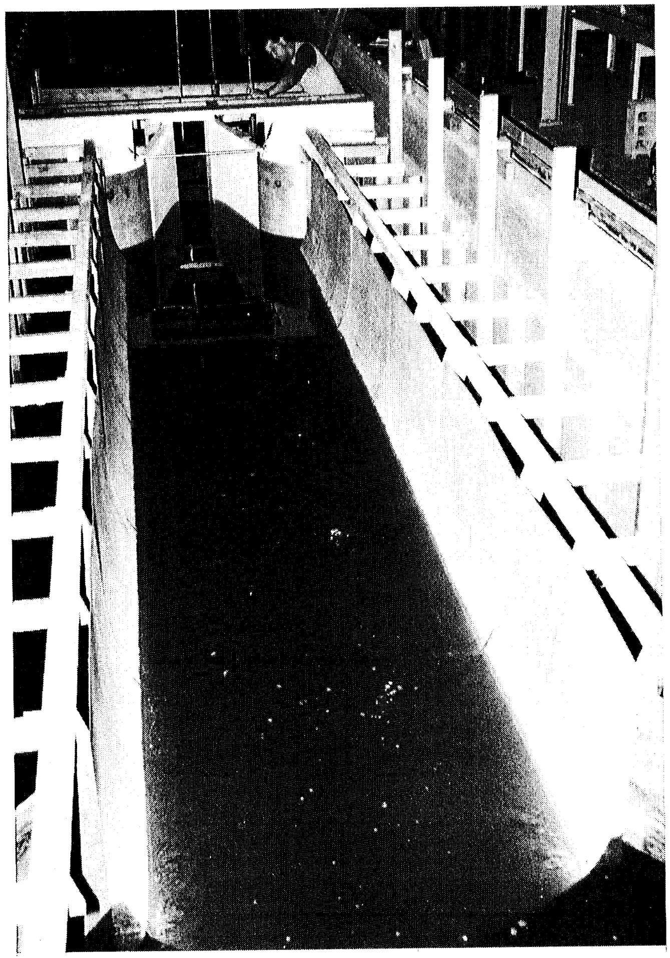


Photo 11 – Type B11. Q = 3.39 cfs, $H_a$ = 0.91 ft.

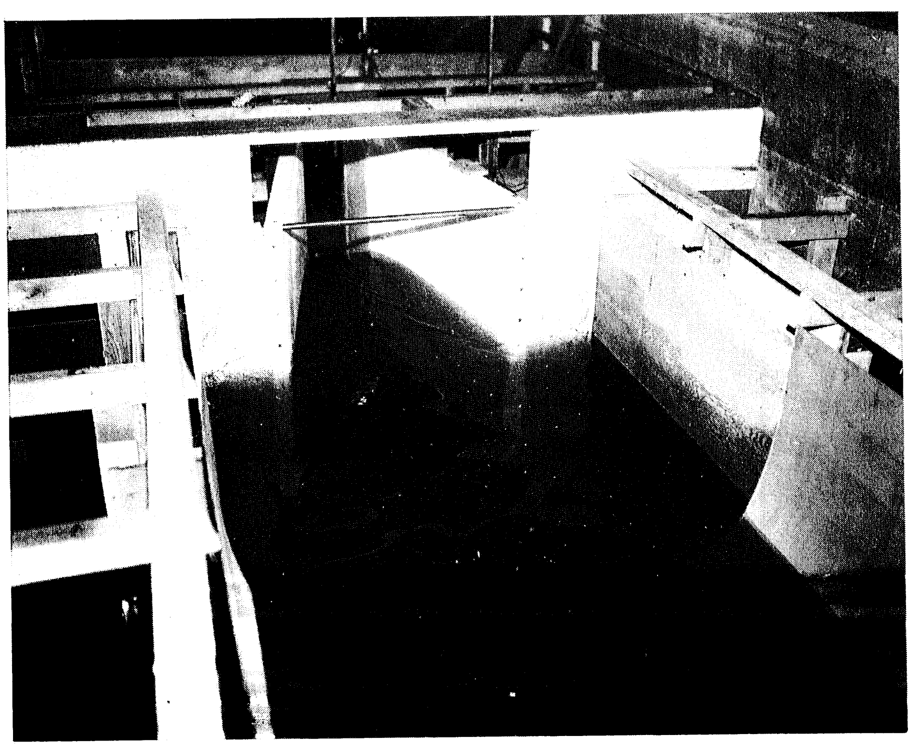


Photo 12 – Type B6. Q = 5.34 cfs, $H_a$ = 1.20 ft.

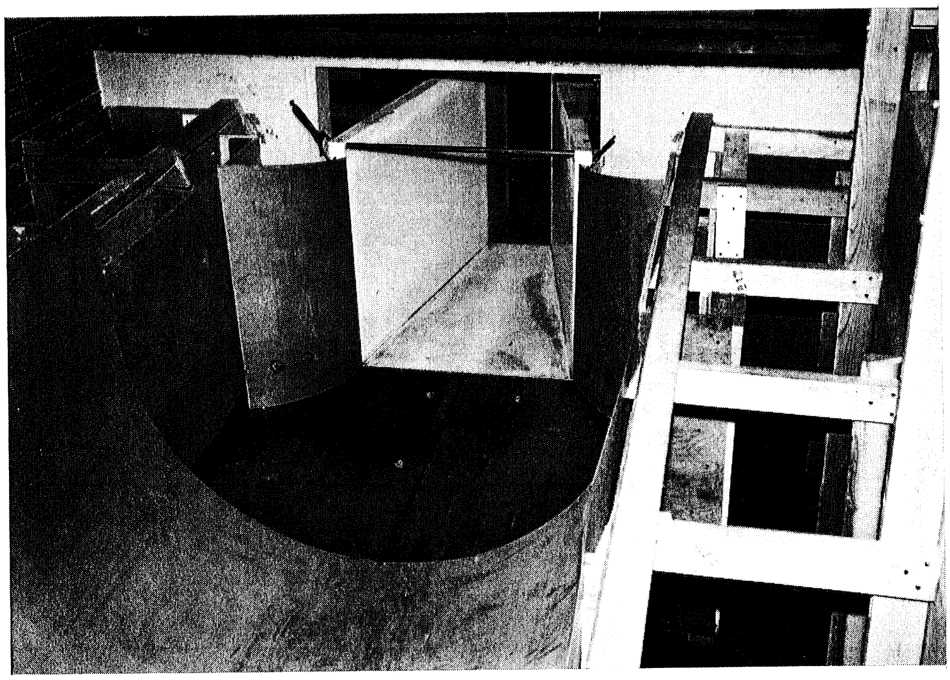


Photo 13 – Type B20. Inverts of approach channel, box, and Parshall flume at the same elevation.

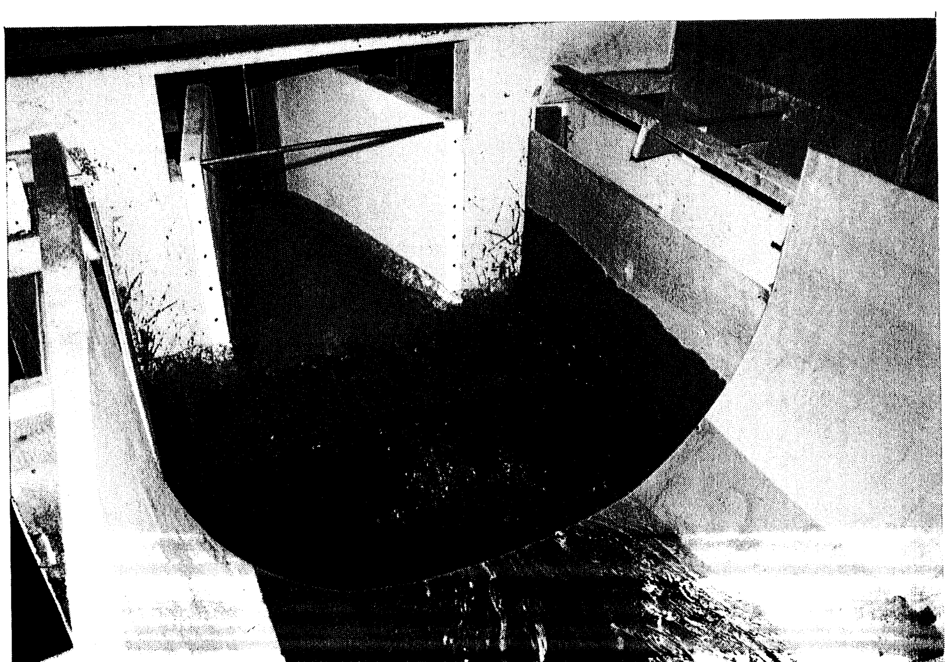


Photo 14 – Type B30. Q ≅ 2.5 cfs, $H_a$ ≅ 0.74 ft.

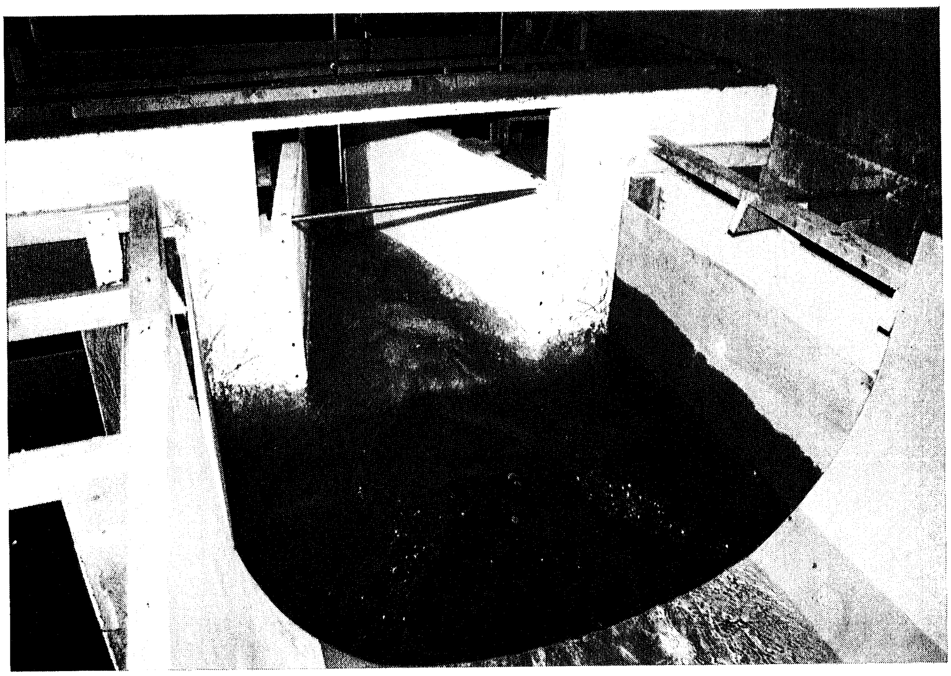


Photo 15 – Type B30. Q $\cong$ 4.2 cfs, $H_a \cong$ 1.04 ft.

Photo 16 – Type B30. Q $\cong$ 7.4 cfs, $H_a \cong$ 1.50 ft.

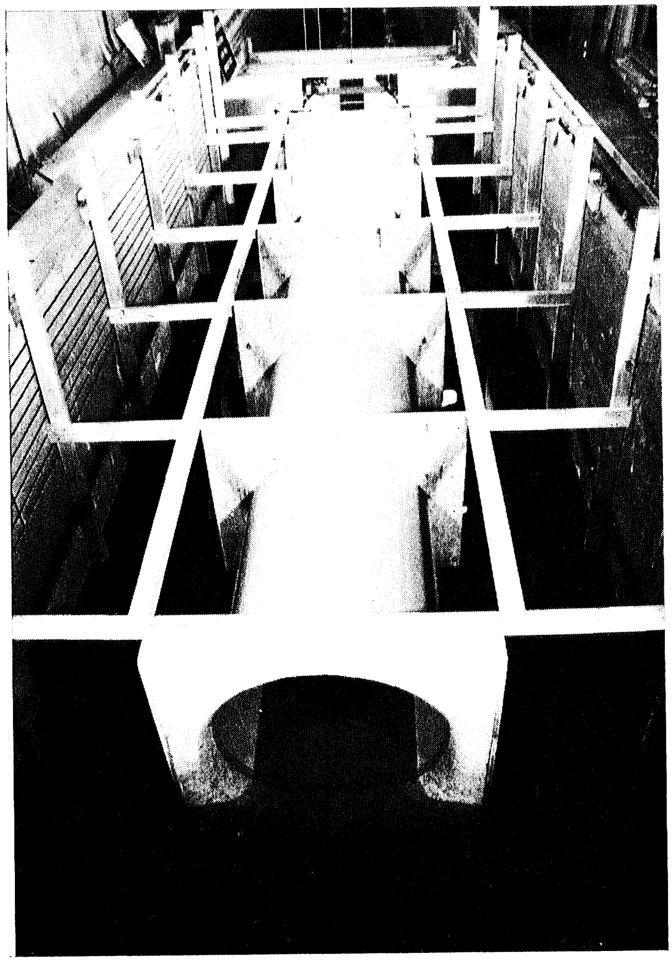


Photo 17 – Type C. Q $\cong$ 0.5 cfs, $H_a \cong$ 0.28 ft.

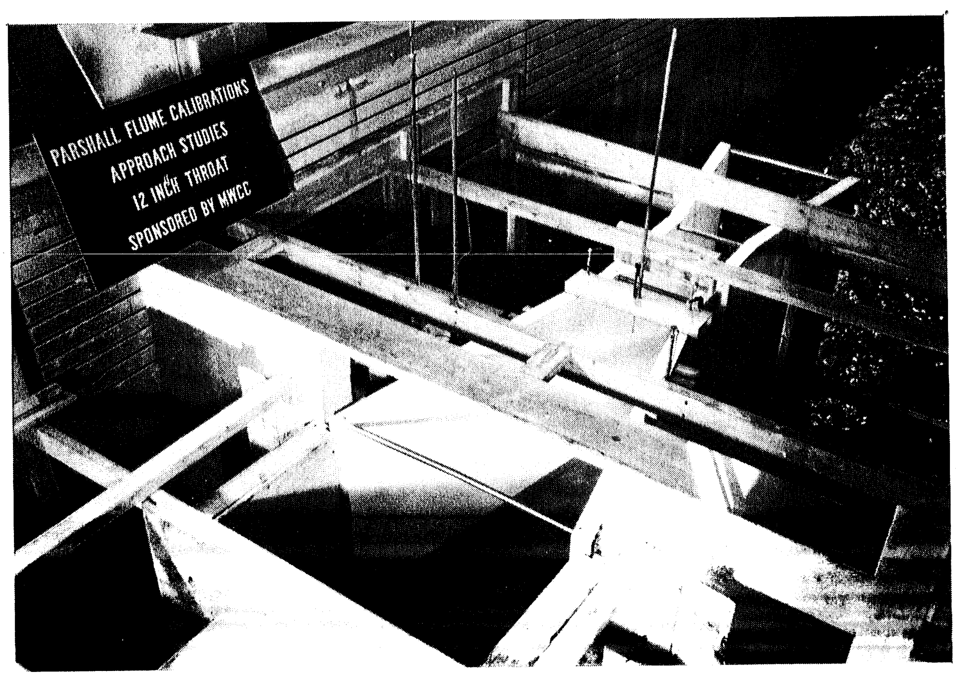



Photo 18 – Type C. Q $\cong$ 0.5 cfs, $H_a \cong$ 0.28 ft.

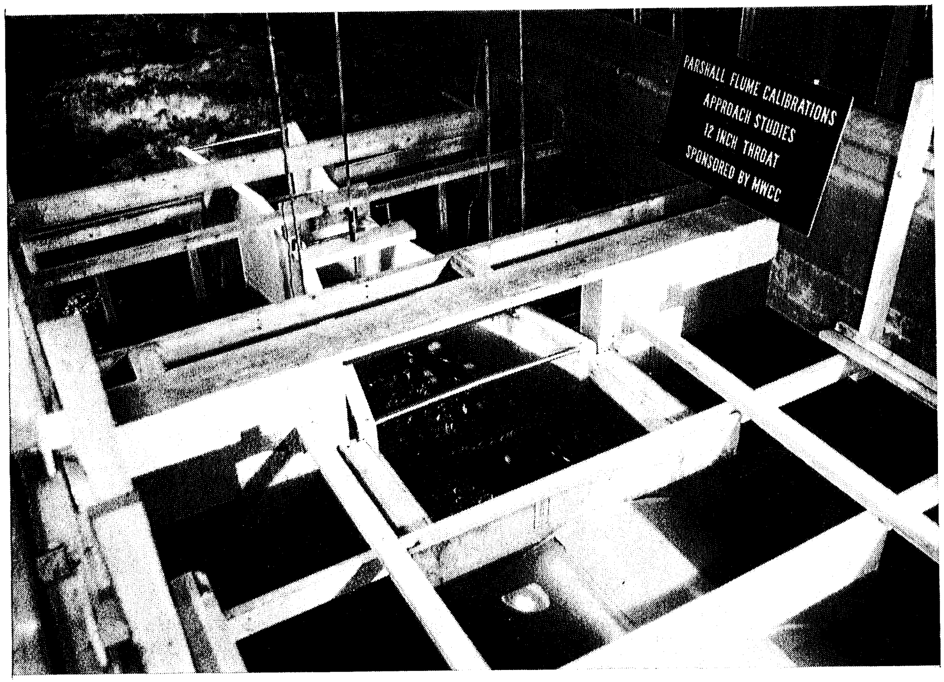



Photo 19 – Type C. $Q \cong 17.0$ cfs, $H_a \cong 2.50$ ft.

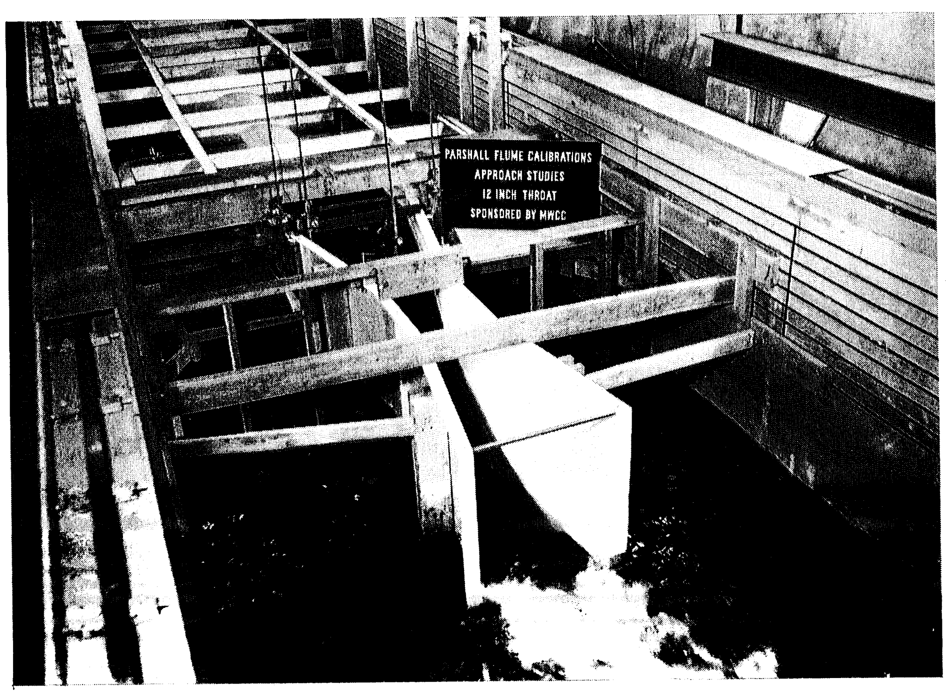



Photo 20 – Type C. $Q \cong 17.0$ cfs, $H_a \cong 2.50$ ft.

Photo 21 – Type C3. Q $\cong$ 17.0 cfs, $H_a$ $\cong$ 2.60 ft.

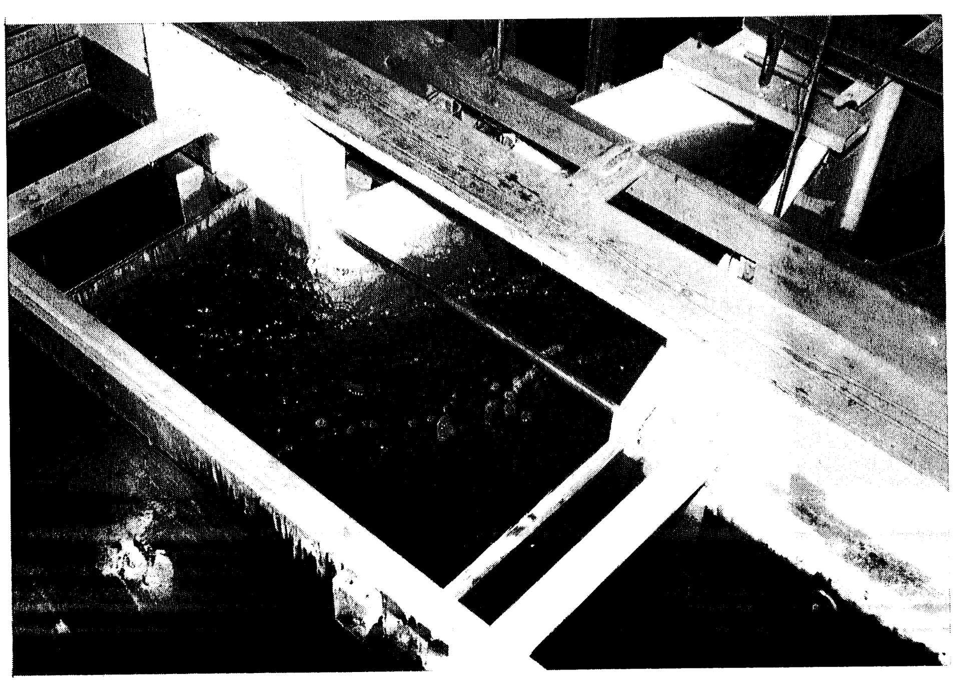


Photo 22 – Type C3. Q $\cong$ 17.0 cfs, $H_a$ $\cong$ 2.60 ft.

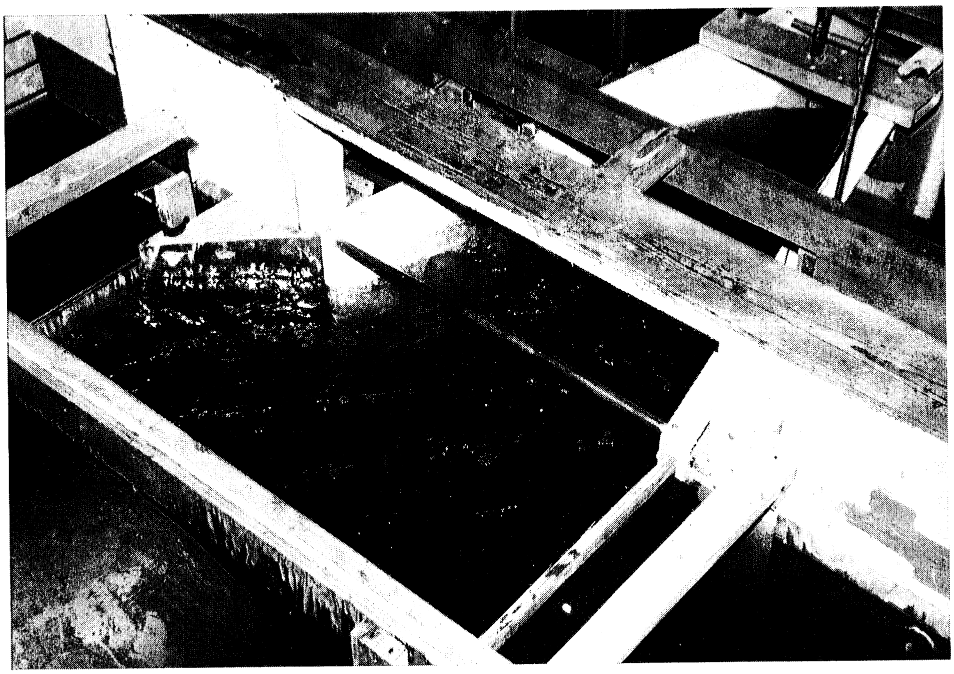


Photo 23 – Type C4. $Q \cong 17.0$ cfs, $H_a \cong 2.60$ ft.

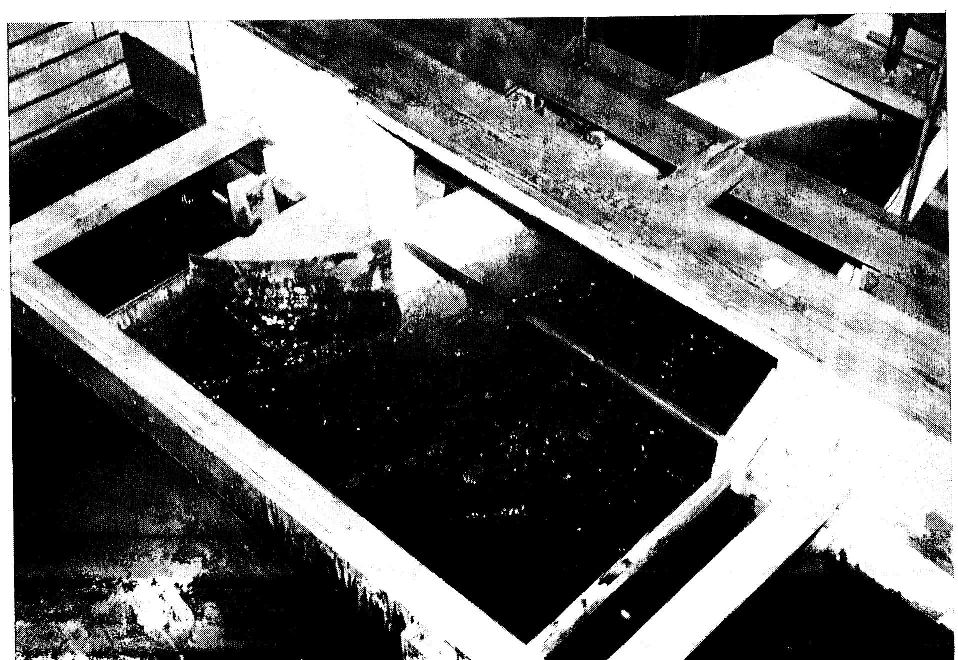


Photo 24 – Type C5. $Q \cong 17.0$ cfs, $H_a \cong 2.60$ ft.

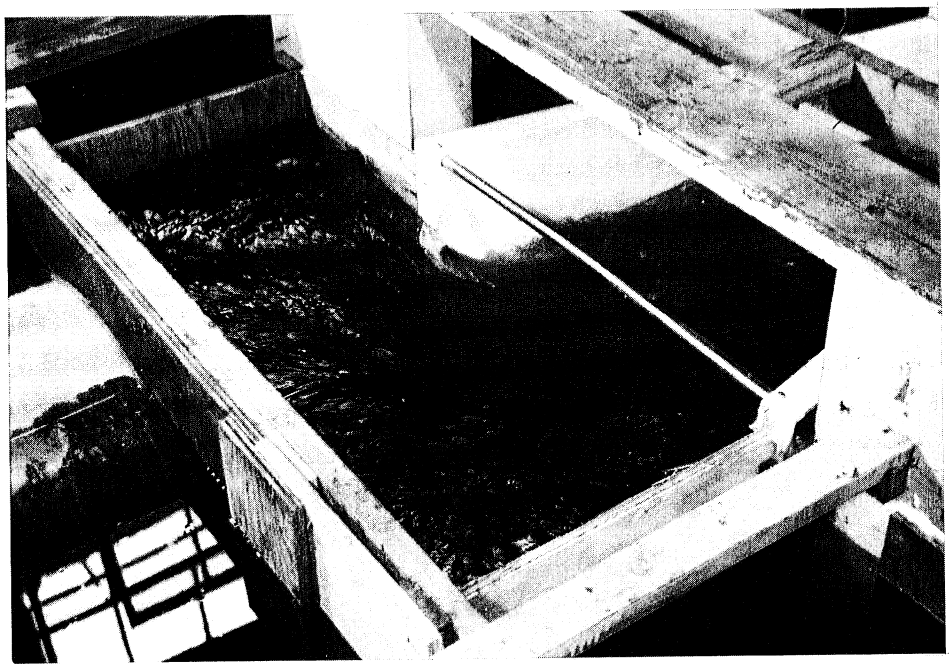


Photo 25 – Type C7. $Q \cong 13.0$ cfs, $H_a \cong 2.20$ ft.

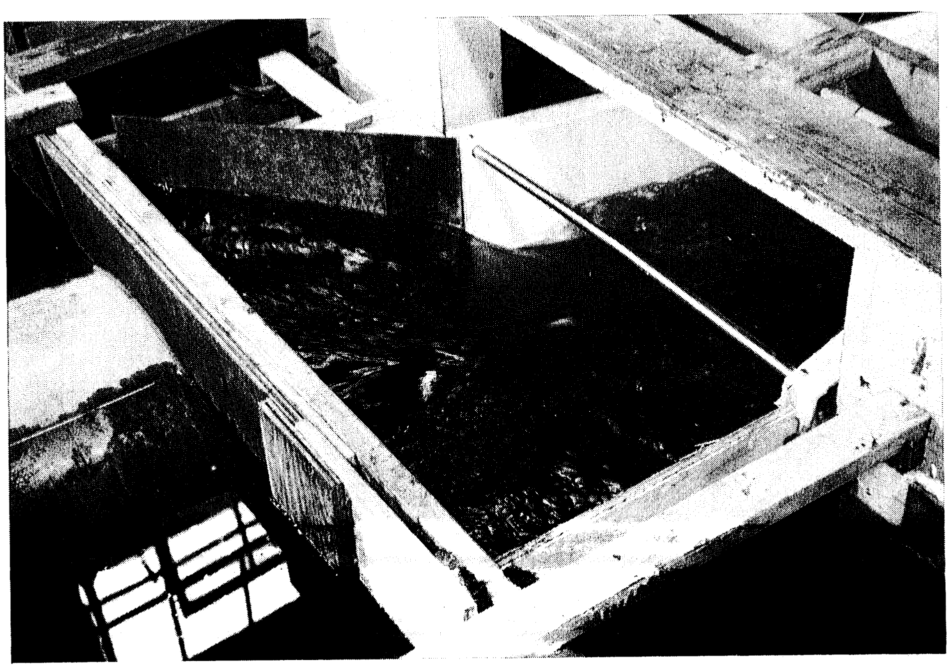


Photo 26 – Type C8. $Q \cong 13.0$ cfs, $H_a \cong 2.20$ ft.

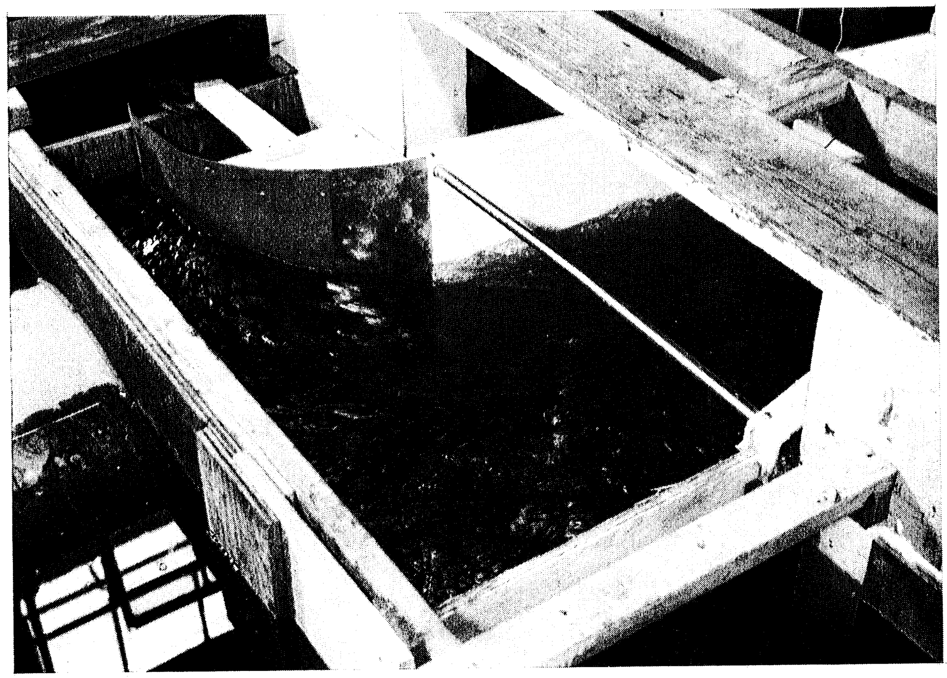


Photo 27 – Type C9. $Q \cong 13.0$ cfs, $H_a \cong 2.20$ ft.

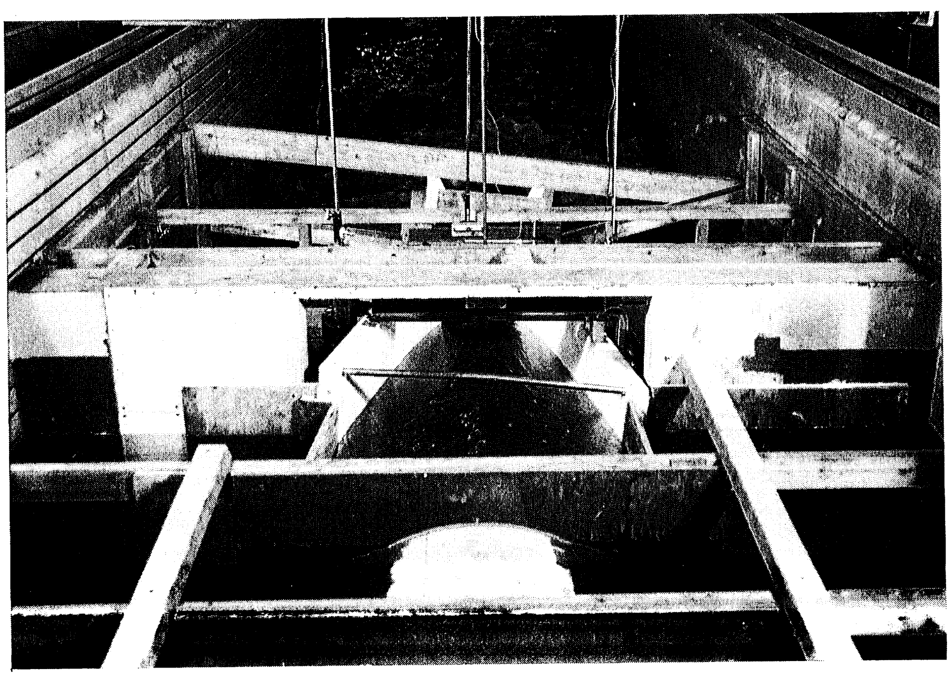


Photo 28 – Type C11. $Q \cong 16.5$ cfs, $H_a \cong 2.50$ ft.

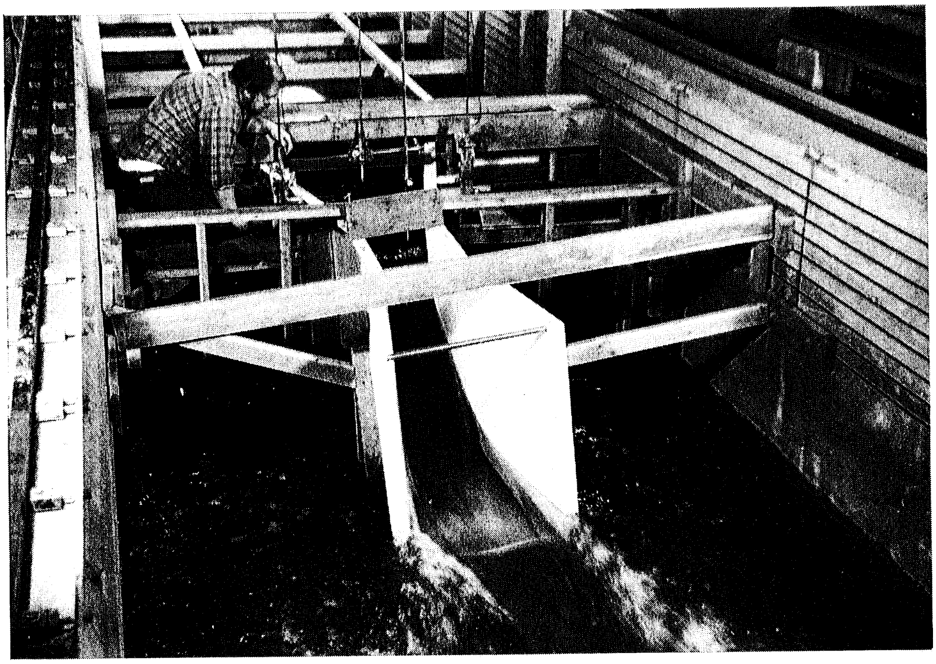


Photo 29 – Type C11. Q ≅ 16.5 cfs, $H_a$ ≅ 2.50 ft.

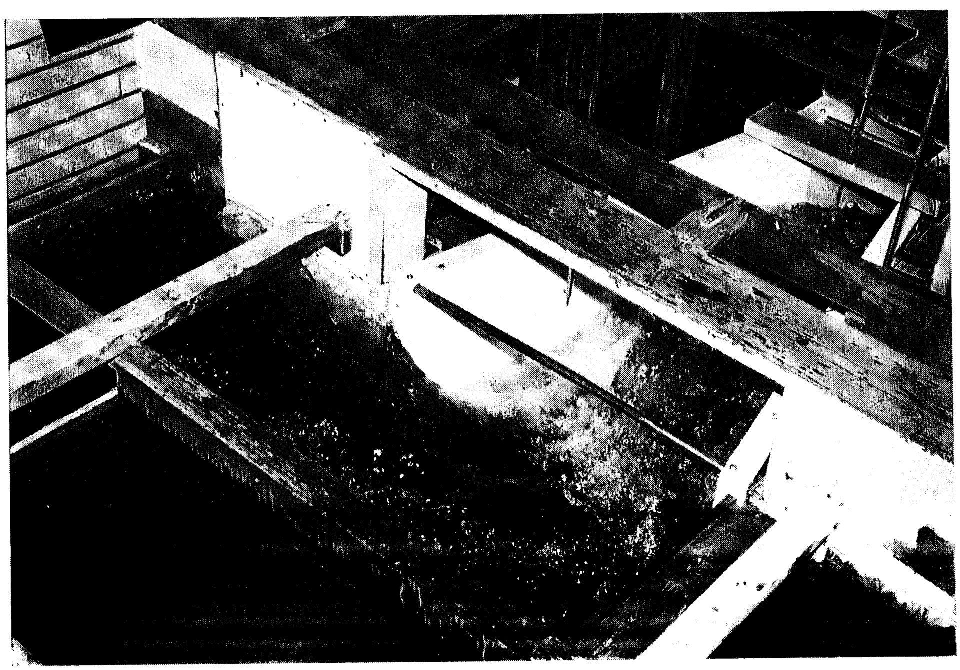


Photo 30 – Type C6. Q ≅ 15.0 cfs, $H_a$ ≅ 2.30 ft.

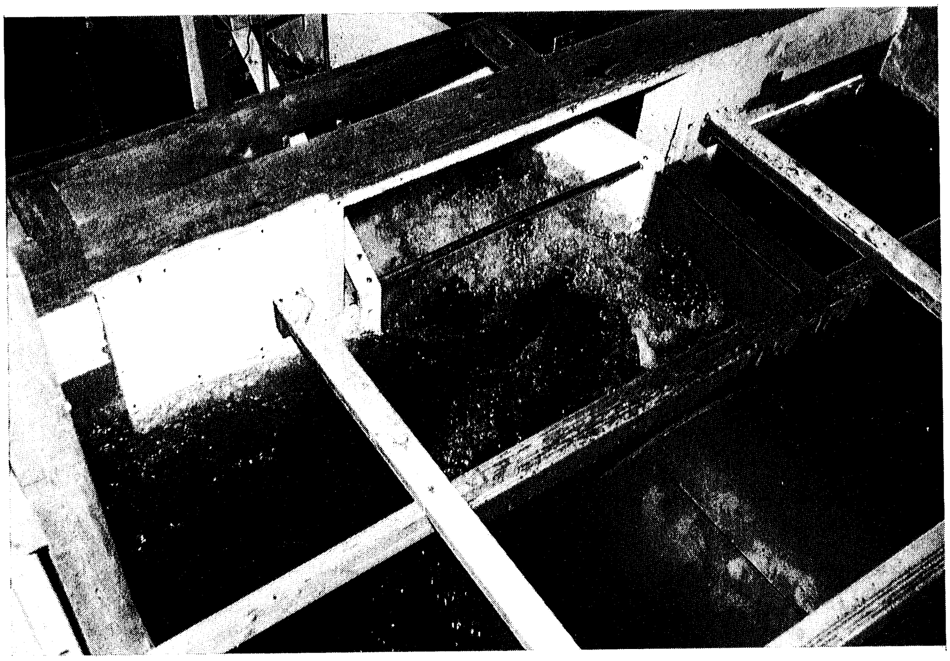


Photo 31 – Type C6. Q $\cong$ 15.0 cfs, $H_a \cong$ 2.30 ft.

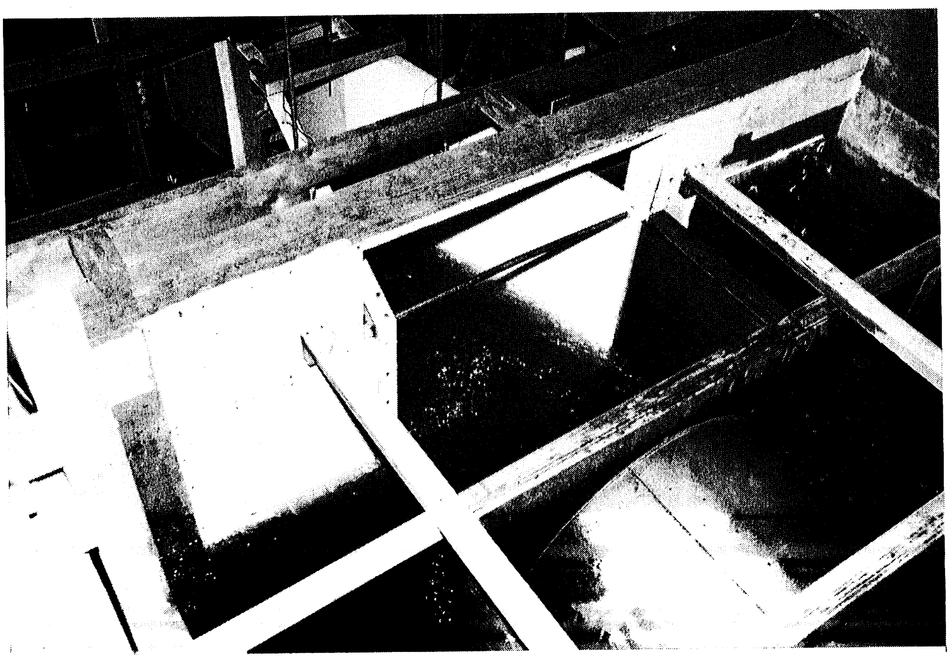
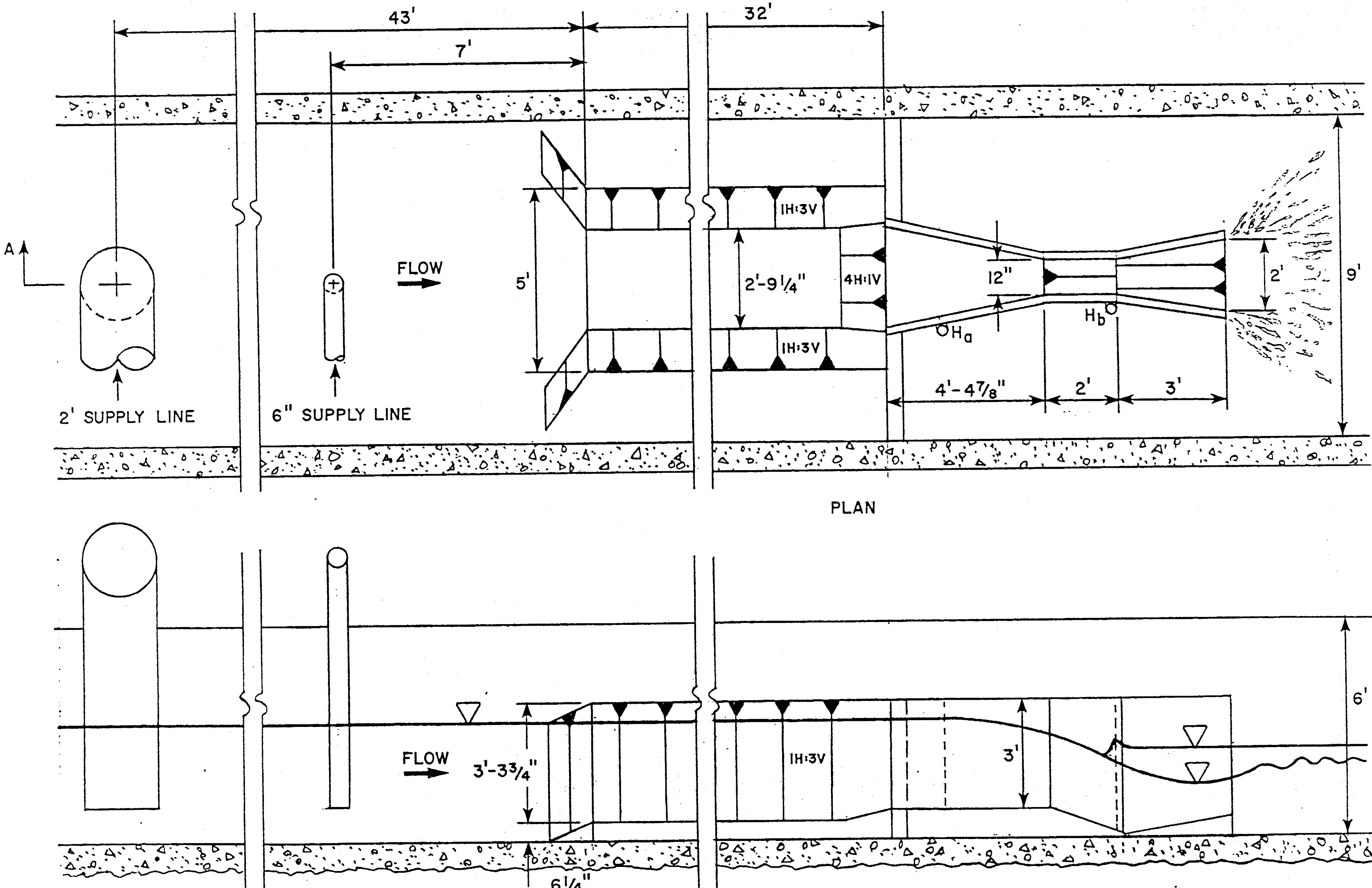


Photo 32 – Type C6. Q $\cong$ 4.7 cfs, $H_a \cong$ 1.10

# CHARTS




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
LAYOUT OF TEST FACILITY-TYPE A

CHART 1

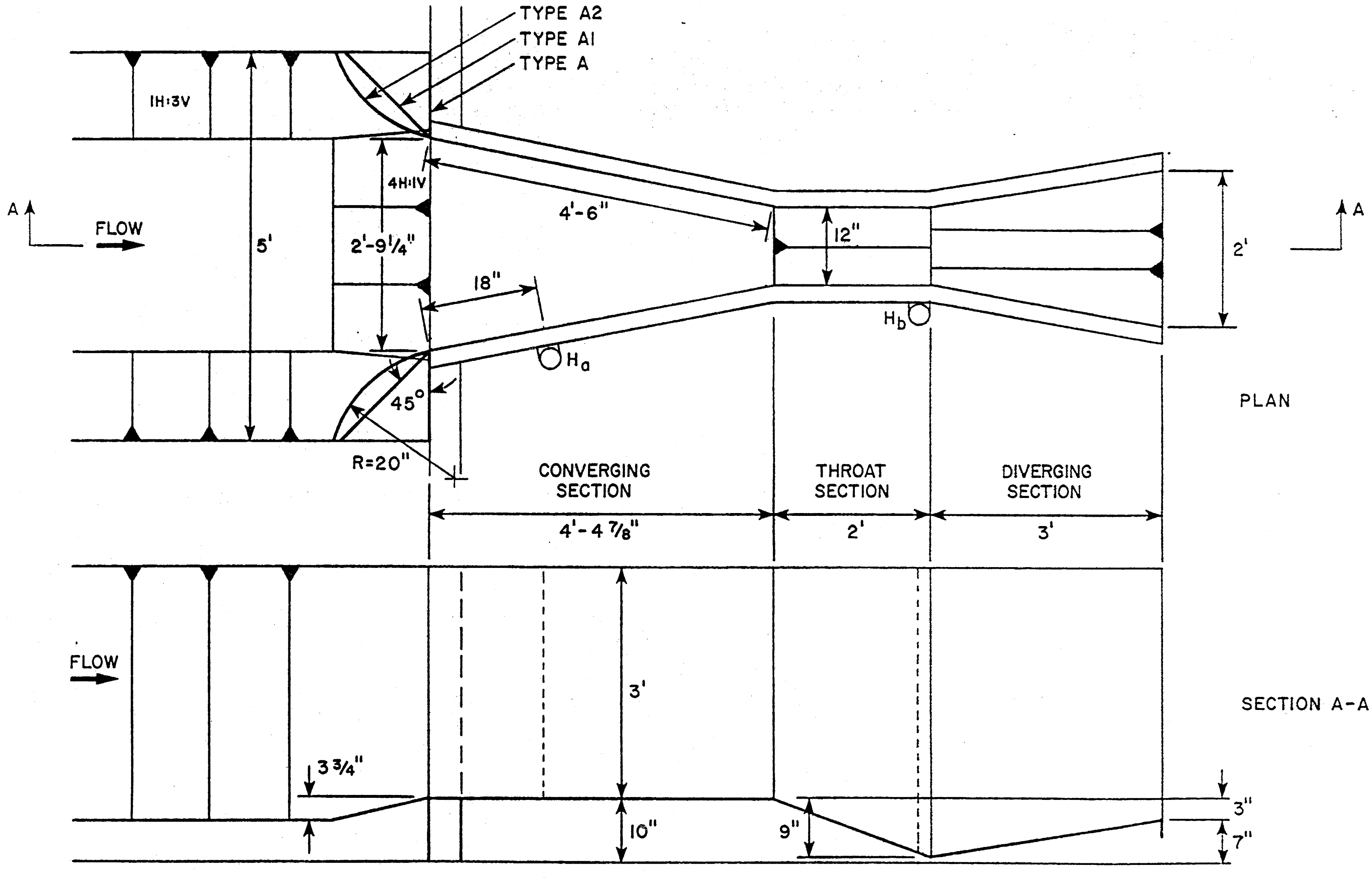
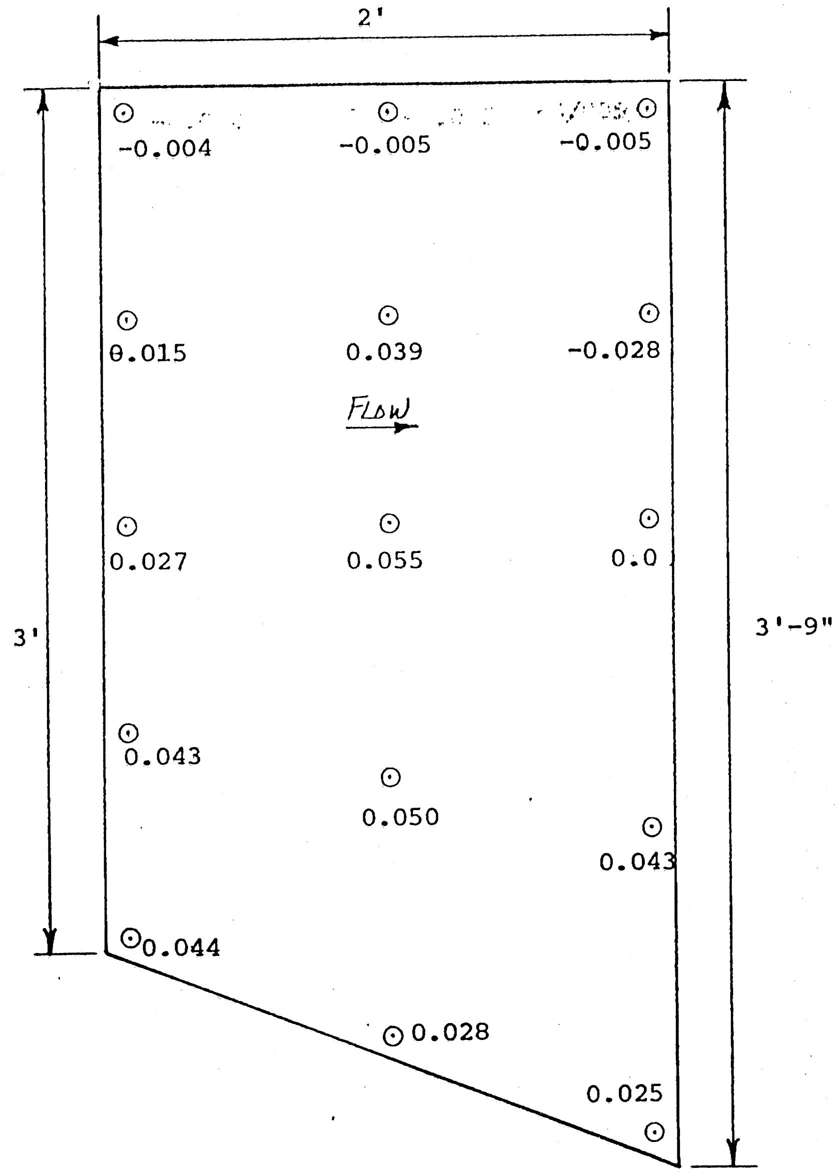



CHART 2

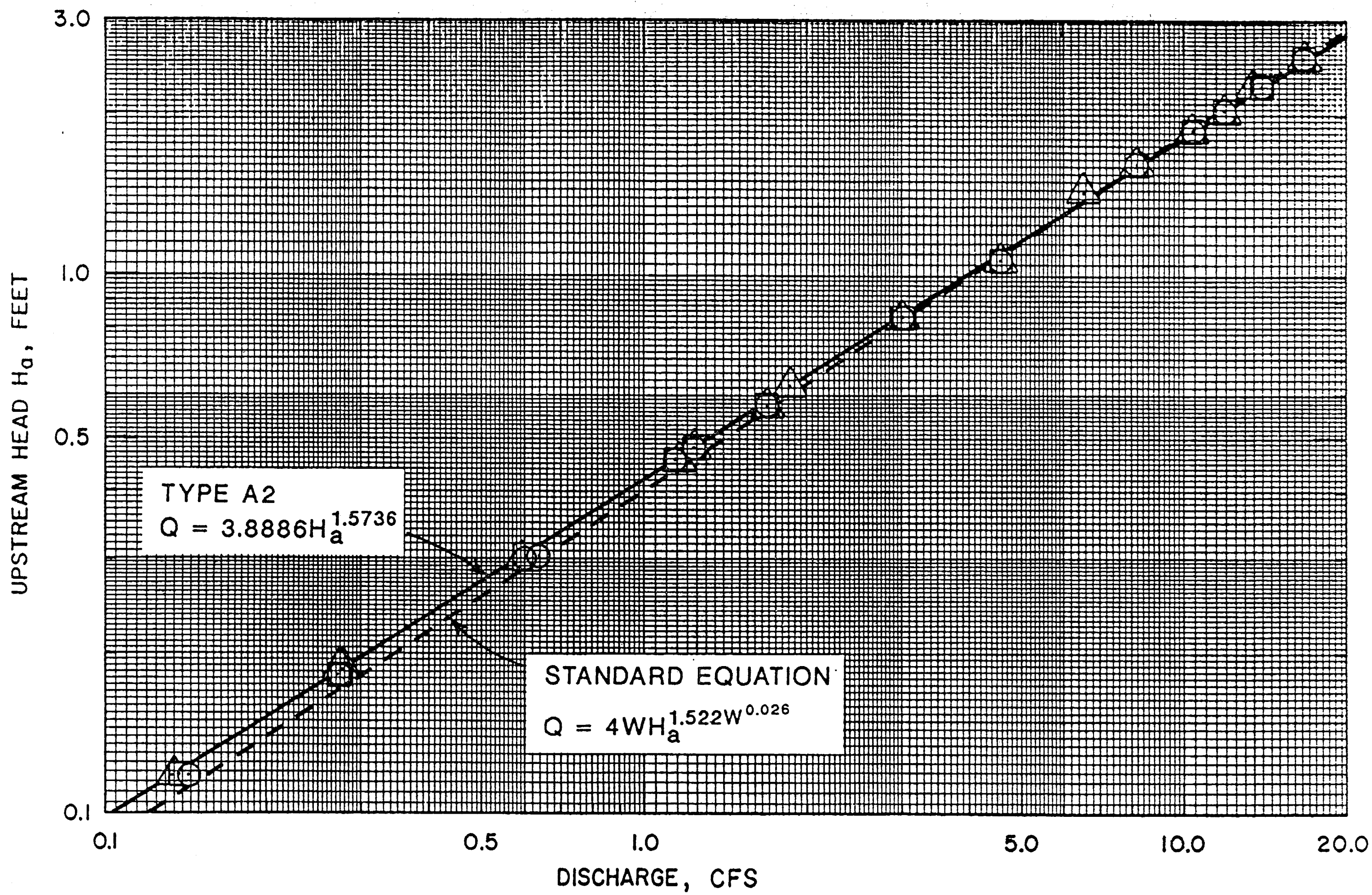
PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES A, A1, A2




Parshall Flume
Throat Section
Dimensions given are
variations from the
12-inch nominal throat
width in inches.

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12-inch throat
Type A
Variations in Throat Width

CHART 3




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE A : NO WING WALLS
⊡ TYPE A1 : 45° WING WALLS
△ TYPE A2 : CURVED WING WALLS

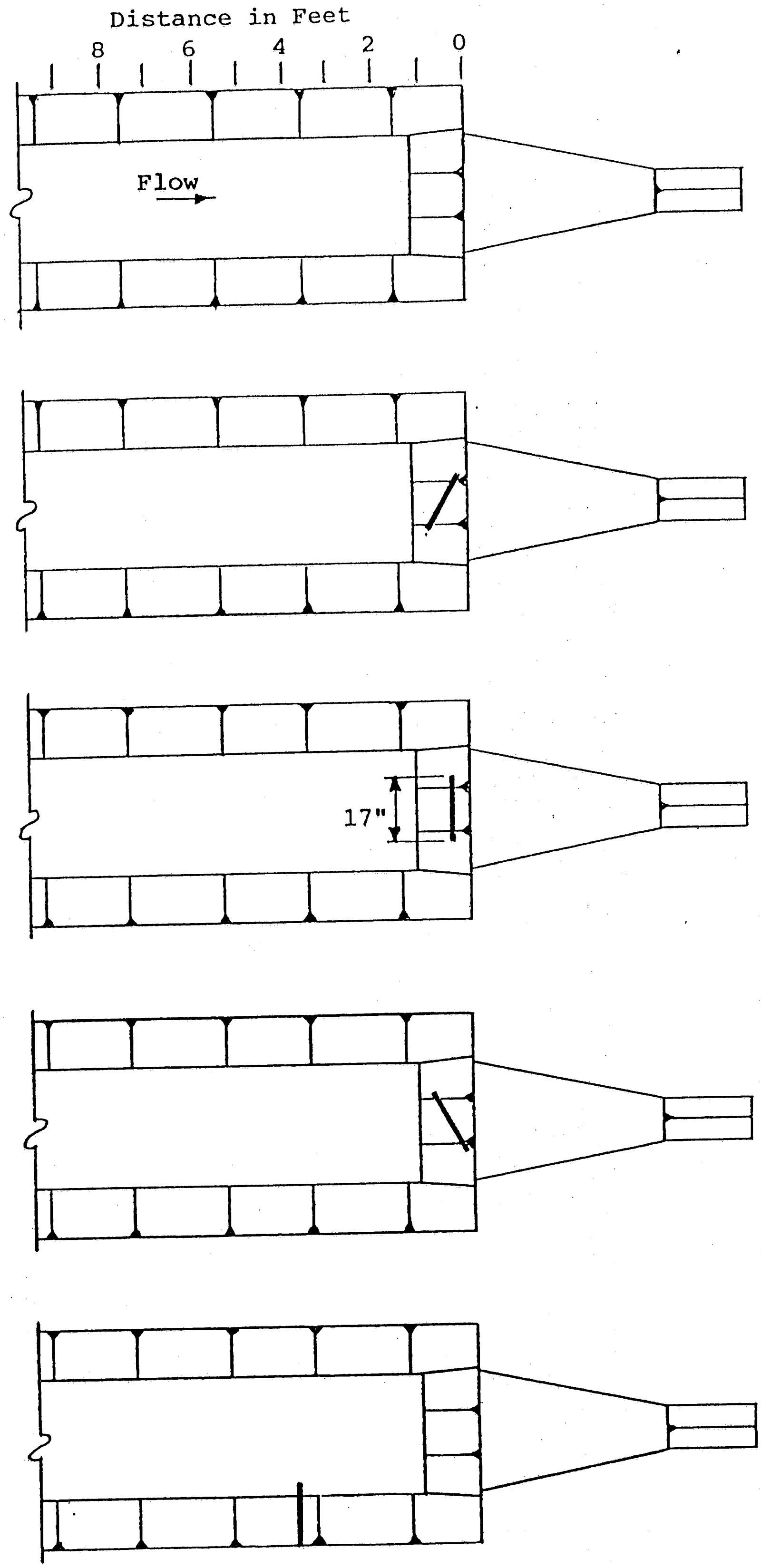
CHART 4

| Run Number | $H_a$ feet | Q* cfs | Percent Variation |
|---|---|---|---|
| 1** | 1.531 | 7.613 | 0 |
| 2 | 1.519 | 7.519 | -1.2 |
| 3 | 1.511 | 7.457 | -2.0 |
| 4 | 1.511 | 7.457 | -2.0 |
| 5 | 1.536 | 7.652 | +0.5 |

*Computed from:

$Q = 3.9013\ H_a^{1.5696}$

**Base flow for comparison.




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12-inch Throat
Type A Variations
Approach Disturbances

CHART 5

| Run Number | $H_a$ feet | $Q^*$ cfs | Percent Variation |
|---|---|---|---|
| 6 | 1.496 | 7.341 | -3.6 |
| 7 | 1.356 | 6.292 | -17.4 |
| 8 | 1.491 | 7.303 | -4.1 |
| 9 | 1.486 | 7.265 | -4.6 |
| 10 | 1.419 | 6.757 | -11.2 |

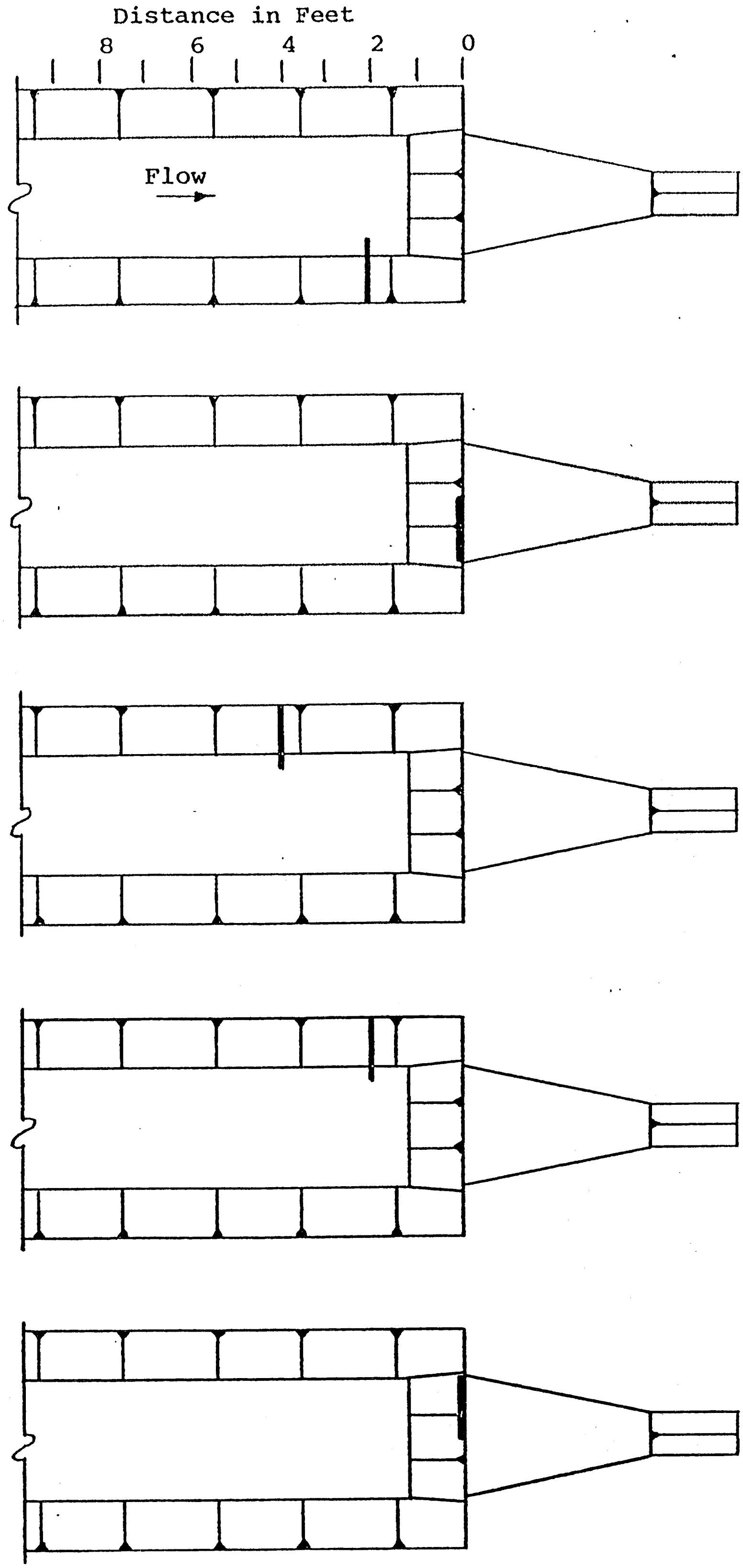



CHART 6

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12-inch Throat
Type A Variations
Approach Disturbances

| Run Number | $H_a$ feet | Q* cfs | Percent Variation |
|---|---|---|---|
| 11 | 1.521 | 7.535 | -1.0 |
| 12 | 1.531 | 7.613 | 0 |
| 13 | 1.531 | 7.613 | 0 |
| 14 | 1.496 | 7.341 | -3.6 |
| 15 | 1.516 | 7.496 | -1.5 |

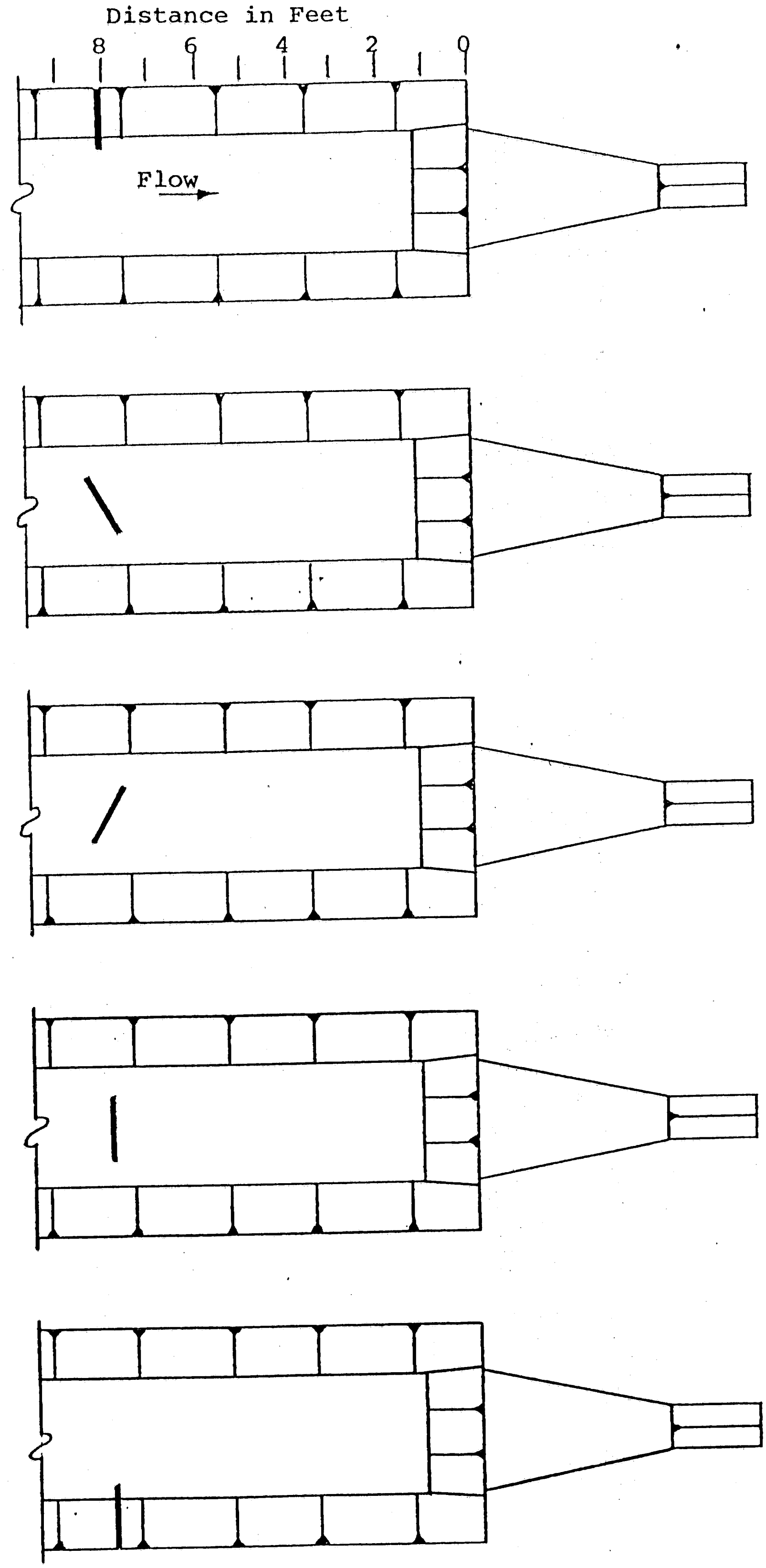



CHART 7

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12-inch Throat
Type A Variations
Approach Disturbances

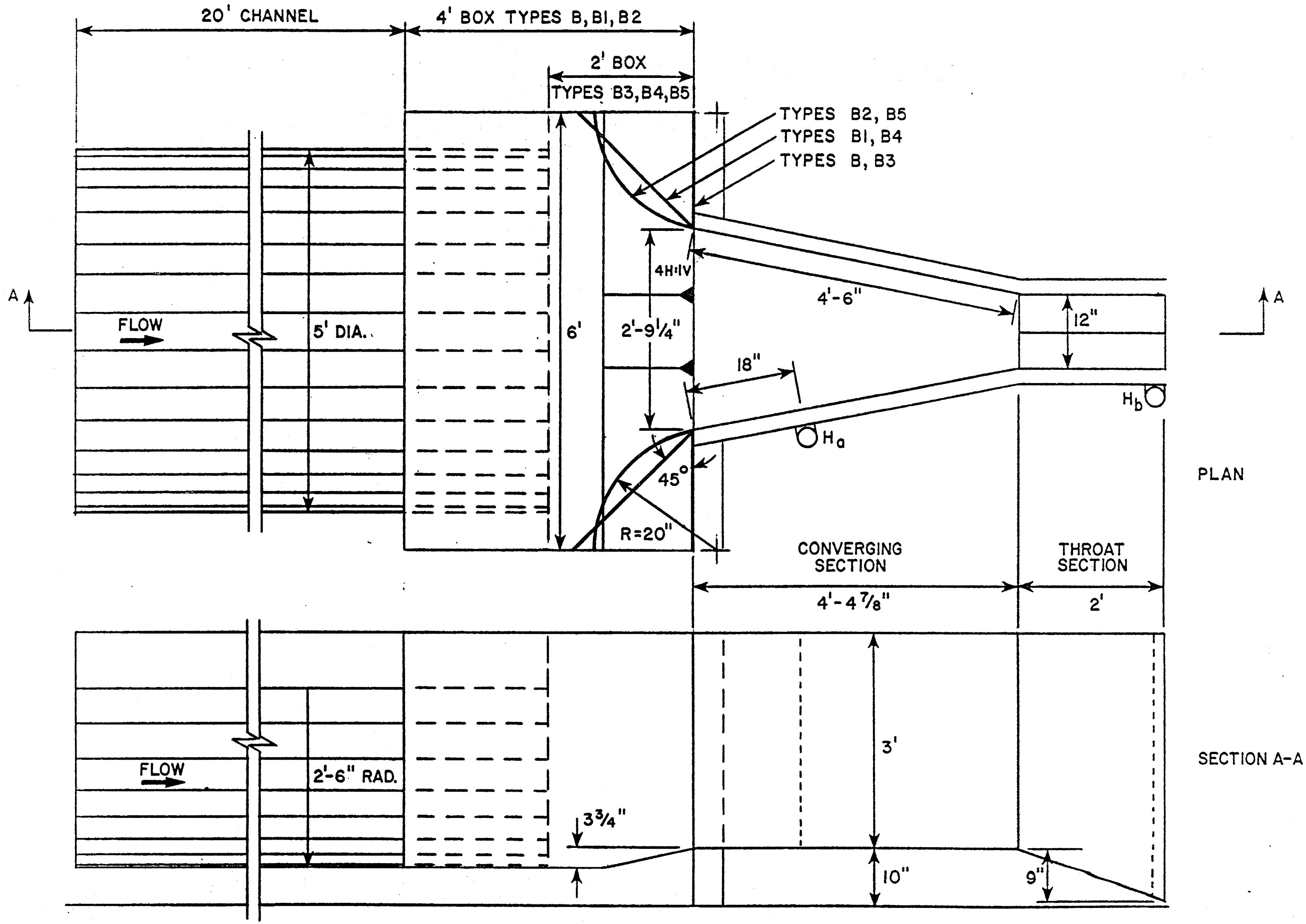
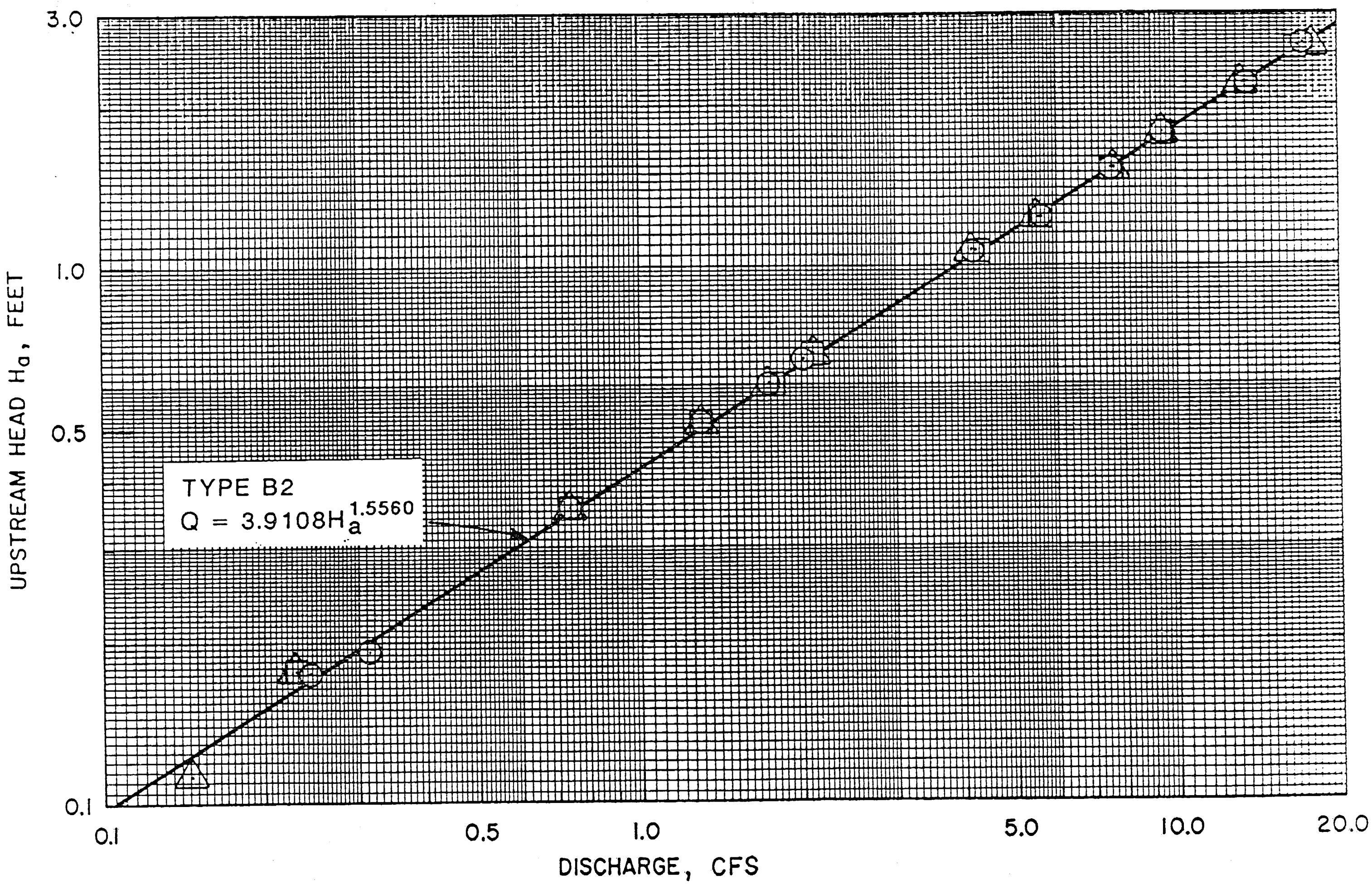



CHART 8

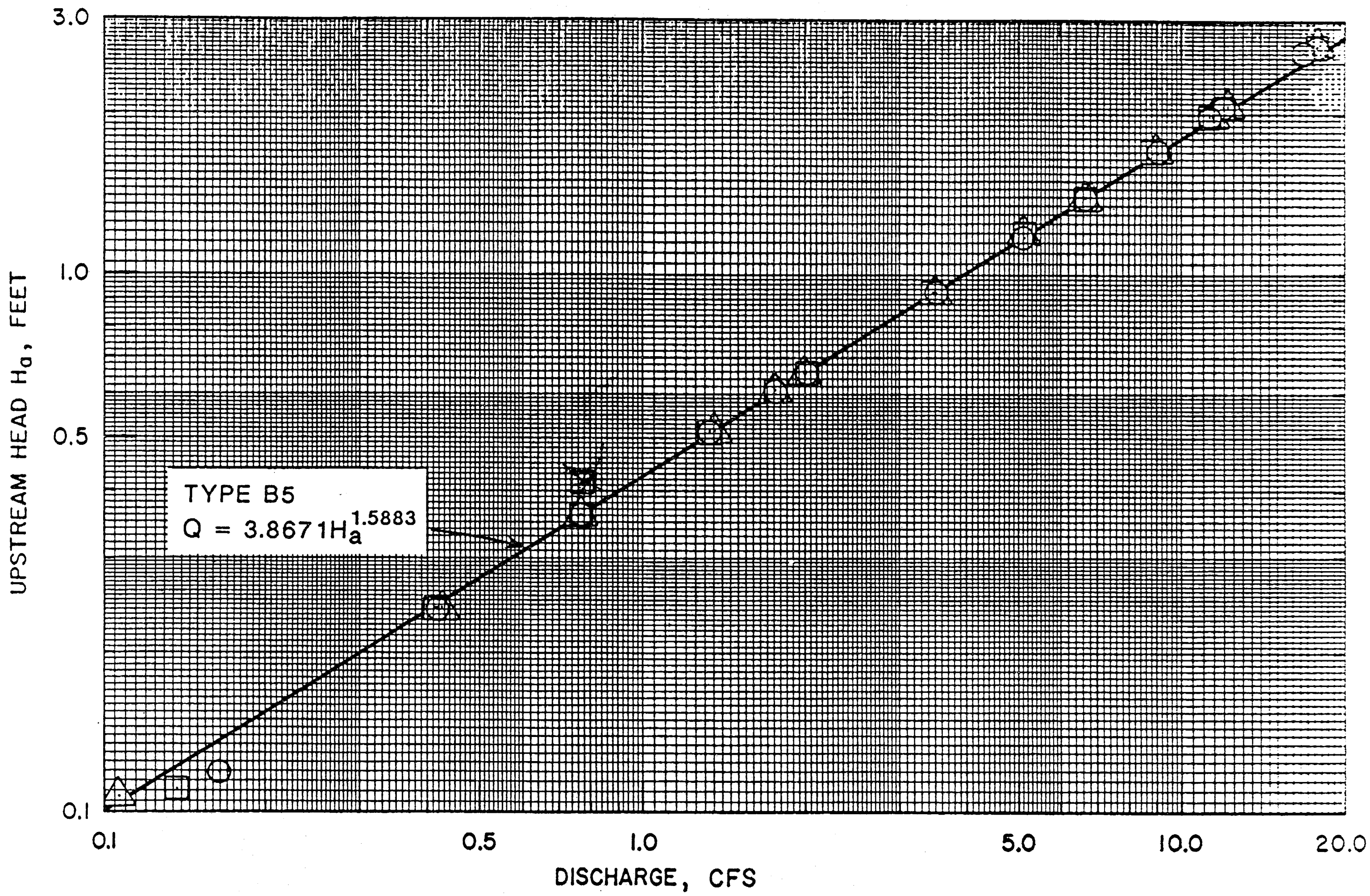
PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES B, B1, B2
TYPES B3, B4, B5




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B : NO WING WALLS
⊡ TYPE B1 : 45° WING WALLS
△ TYPE B2 : CURVED WING WALLS

CHART 9




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B3 : NO WING WALLS
⊡ TYPE B4 : 45° WING WALLS
△ TYPE B5 : CURVED WING WALLS

CHART 10

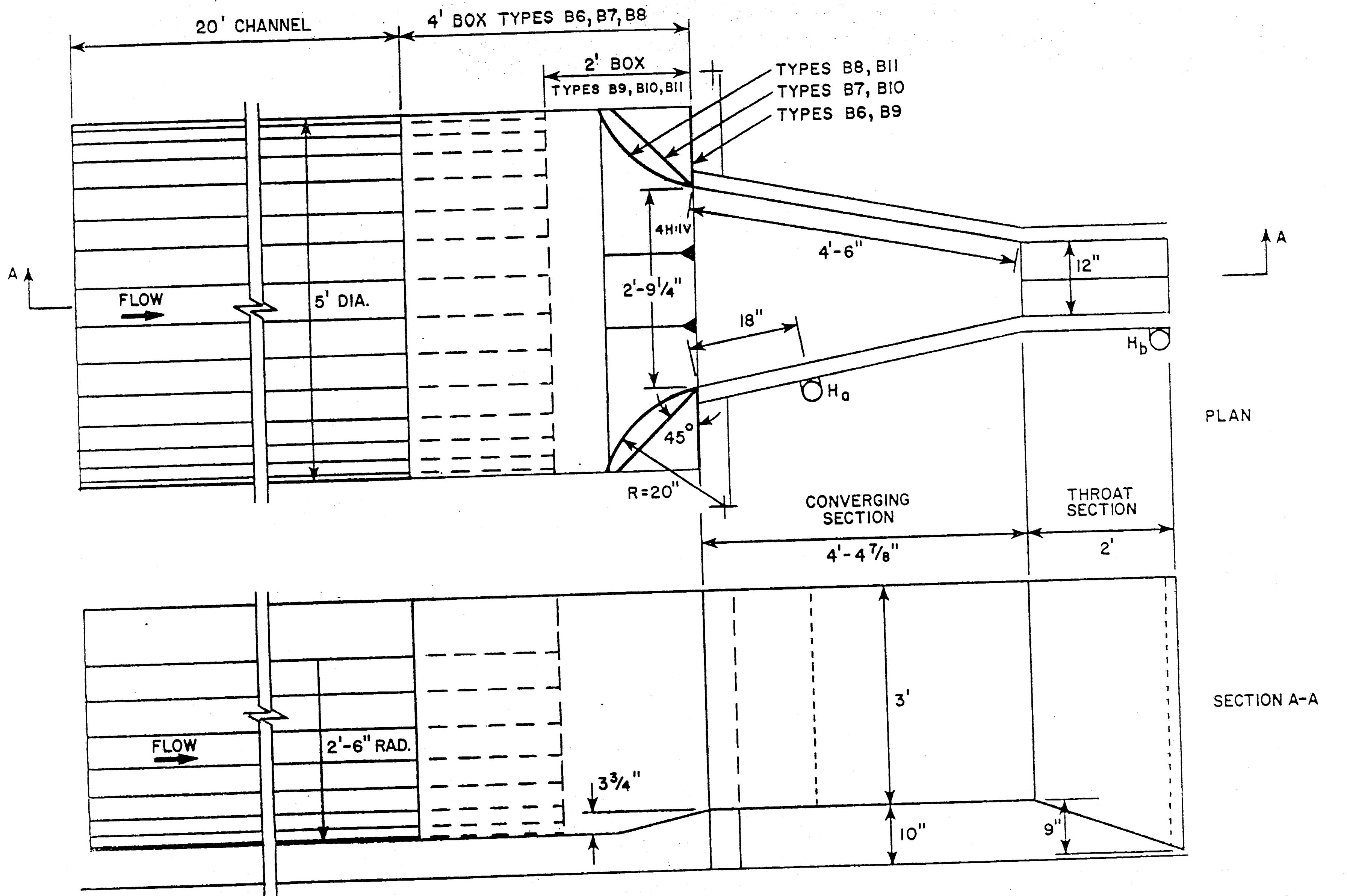
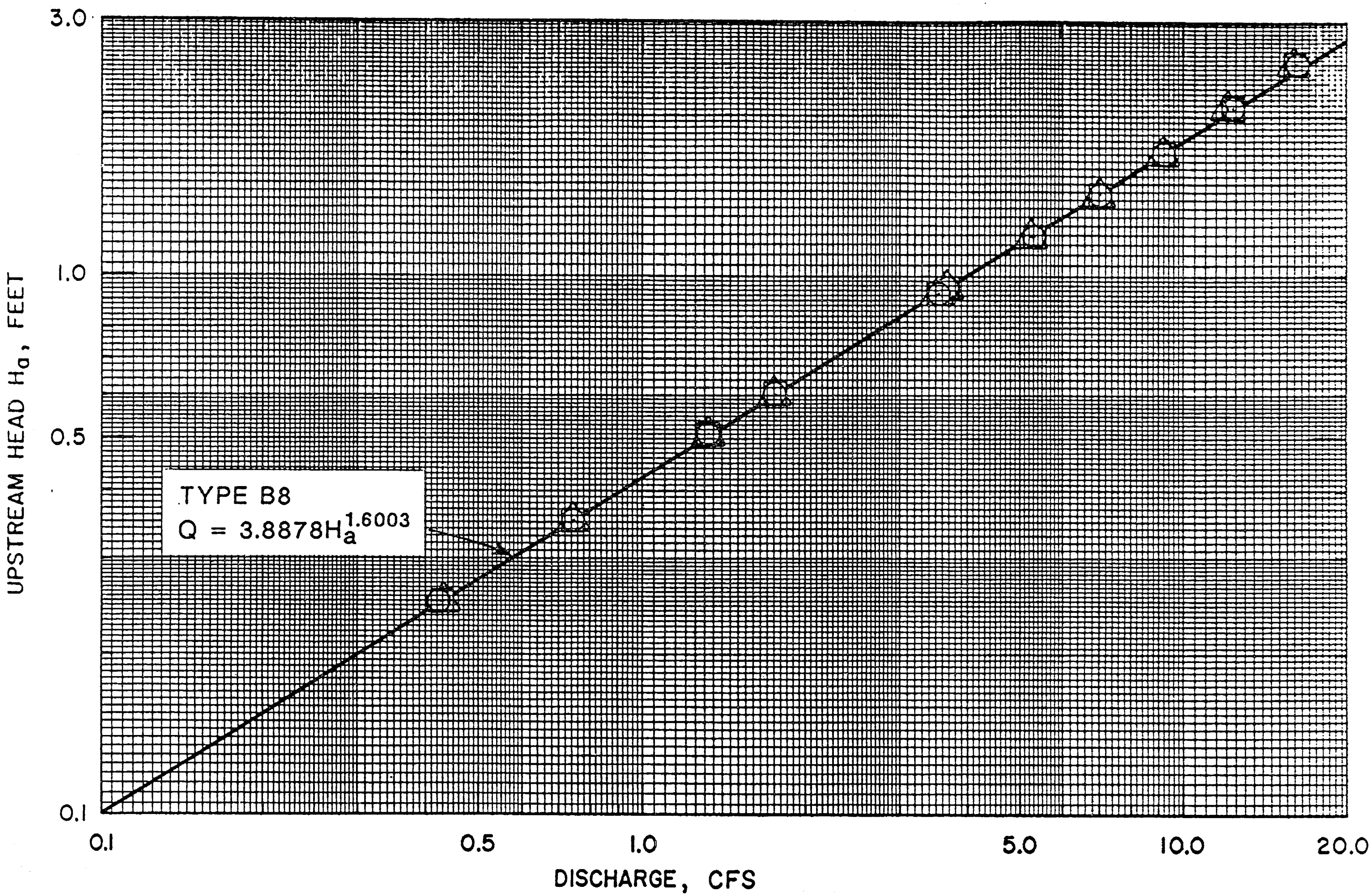



CHART 11

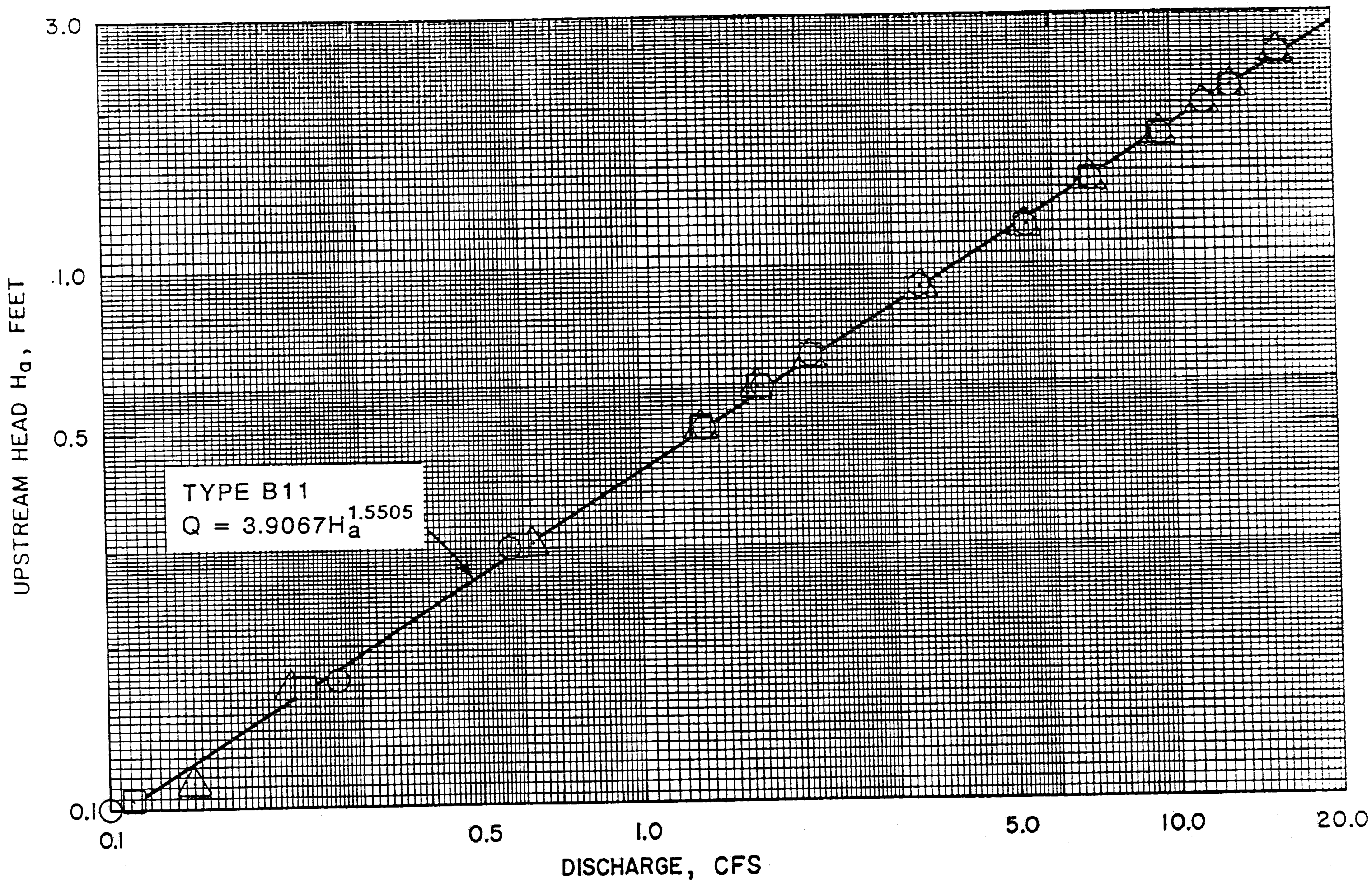
PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES B6, B7, B8
TYPES B9, B10, B11




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

○ TYPE B6 : NO WING WALLS
□ TYPE B7 : 45° WING WALLS
△ TYPE B8 : CURVED WING WALLS

CHART 12




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B9 : NO WING WALLS
⊡ TYPE B10 : 45° WING WALLS
△ TYPE B11 : CURVED WING WALLS

CHART 13

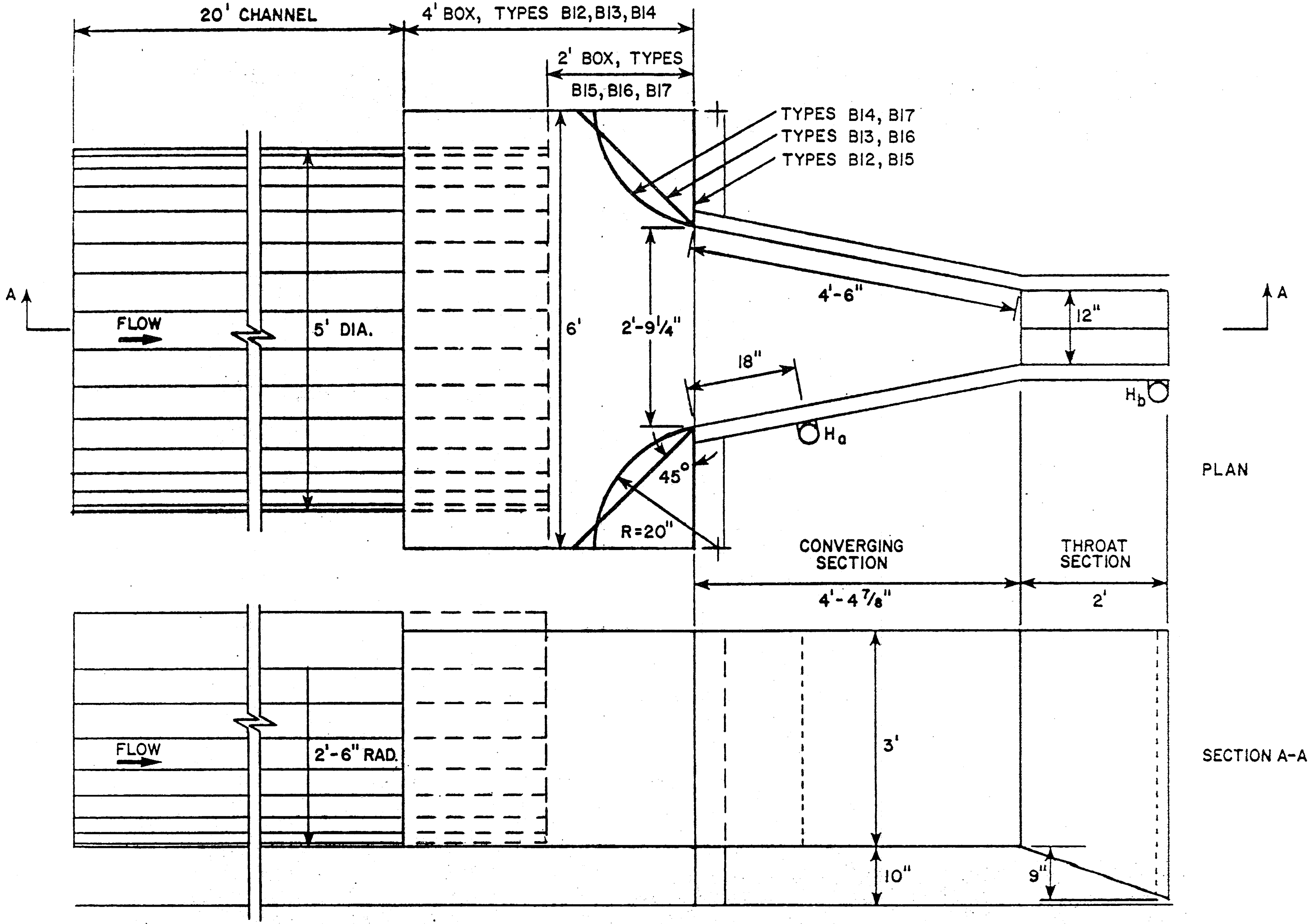
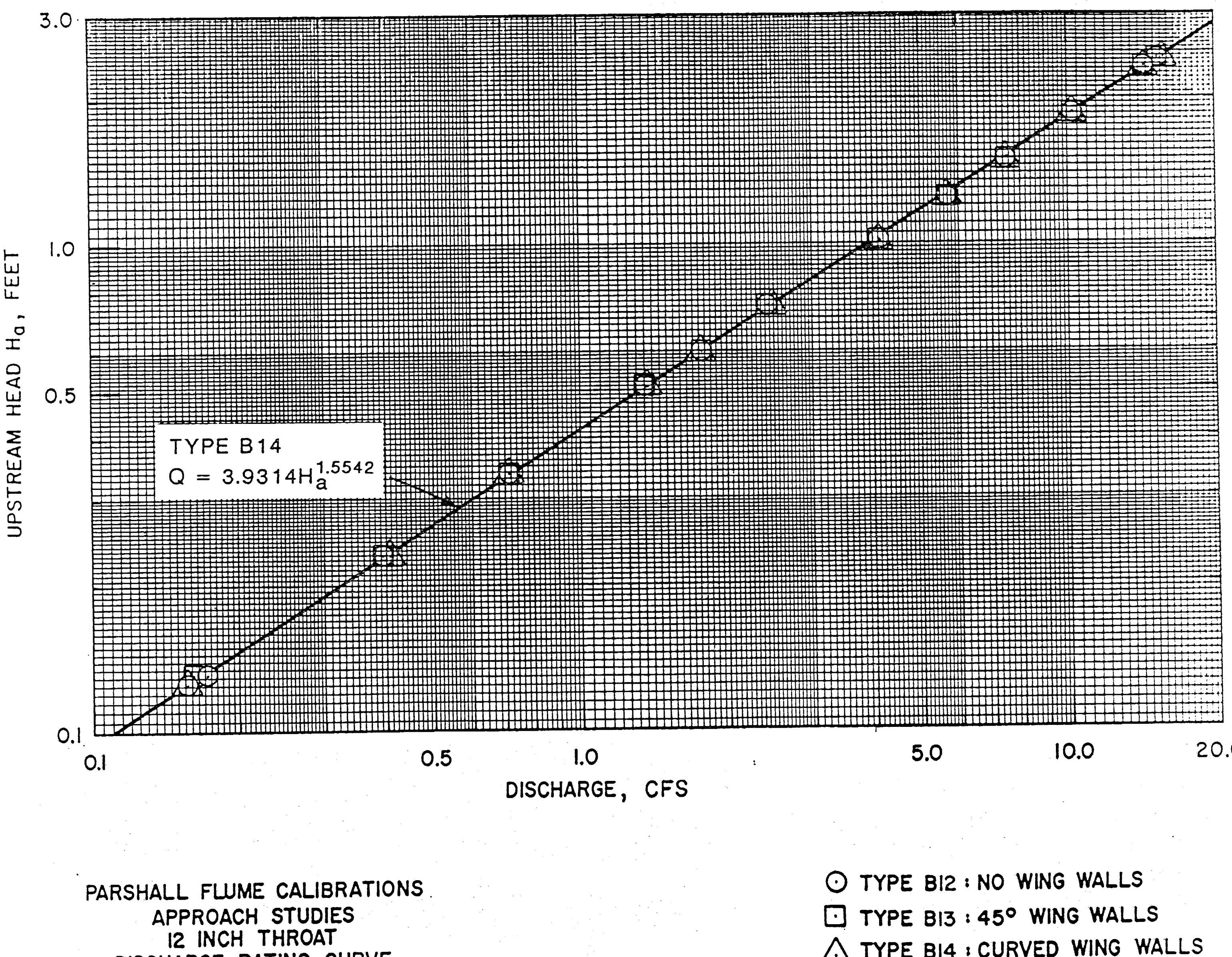


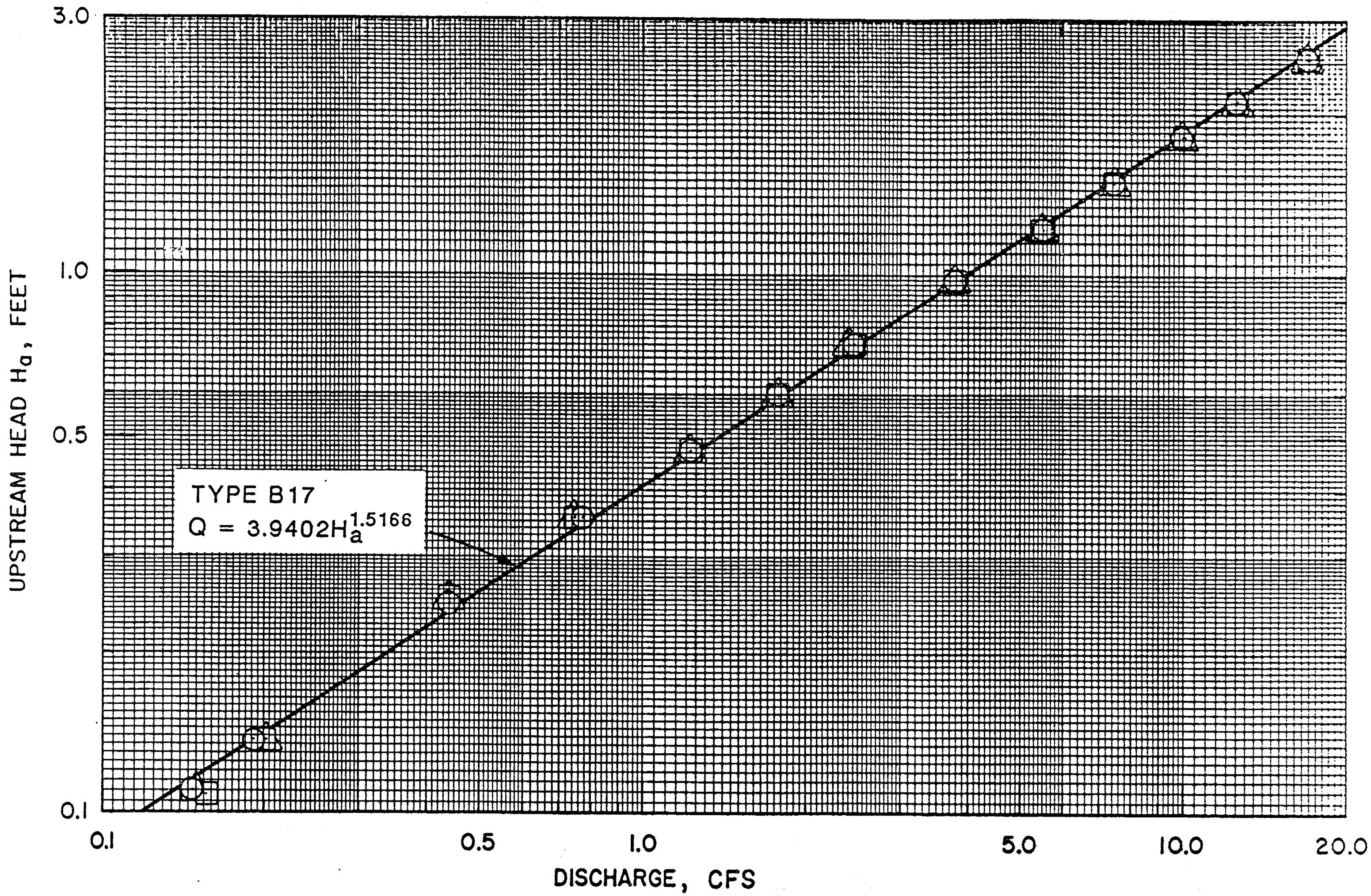

CHART 14

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES B12, B13, B14
TYPES B15, B16, B17




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 15




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B15 : NO WING WALLS
⊡ TYPE B16 : 45° WING WALLS
△ TYPE B17 : CURVED WING WALLS

CHART 16

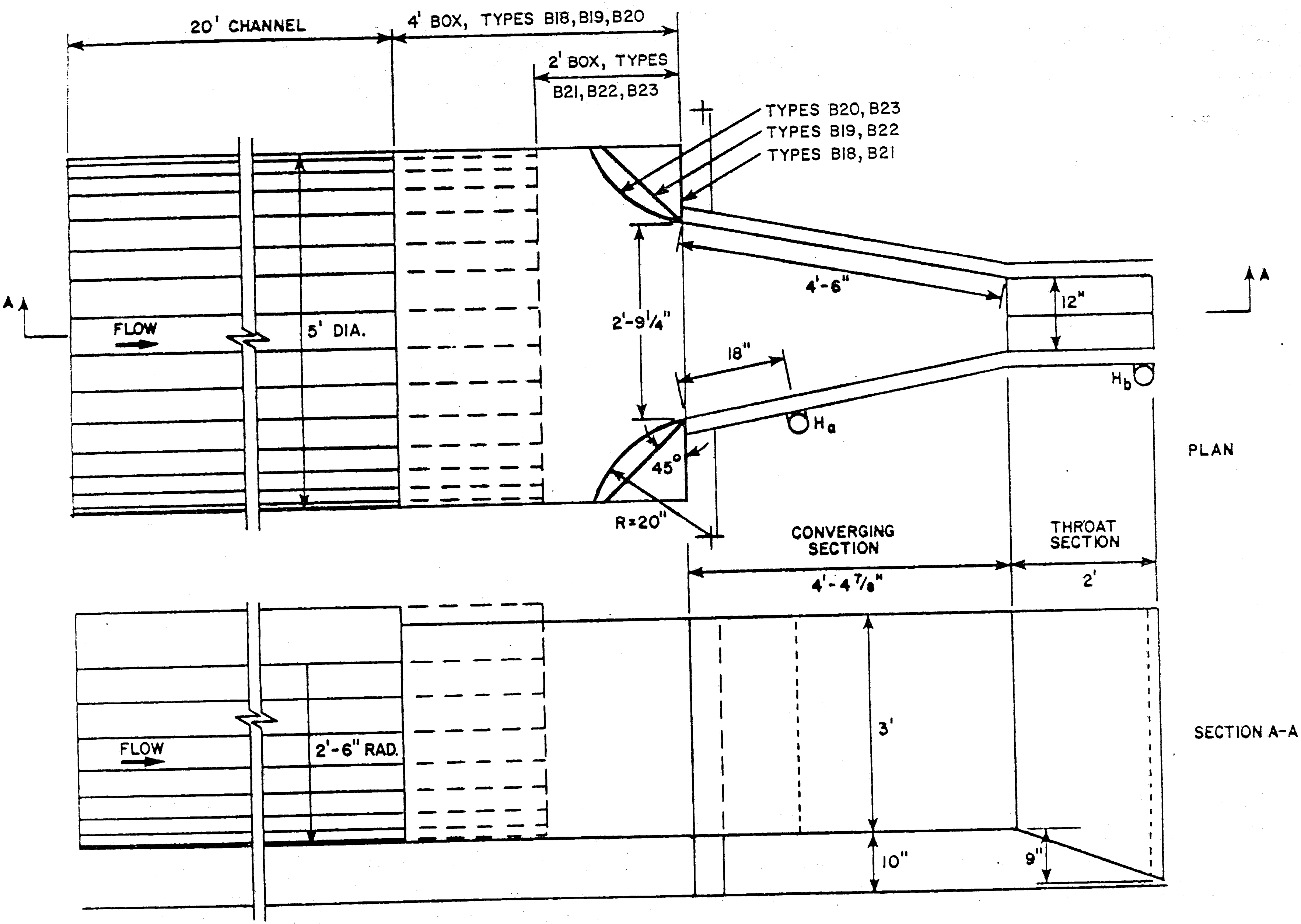
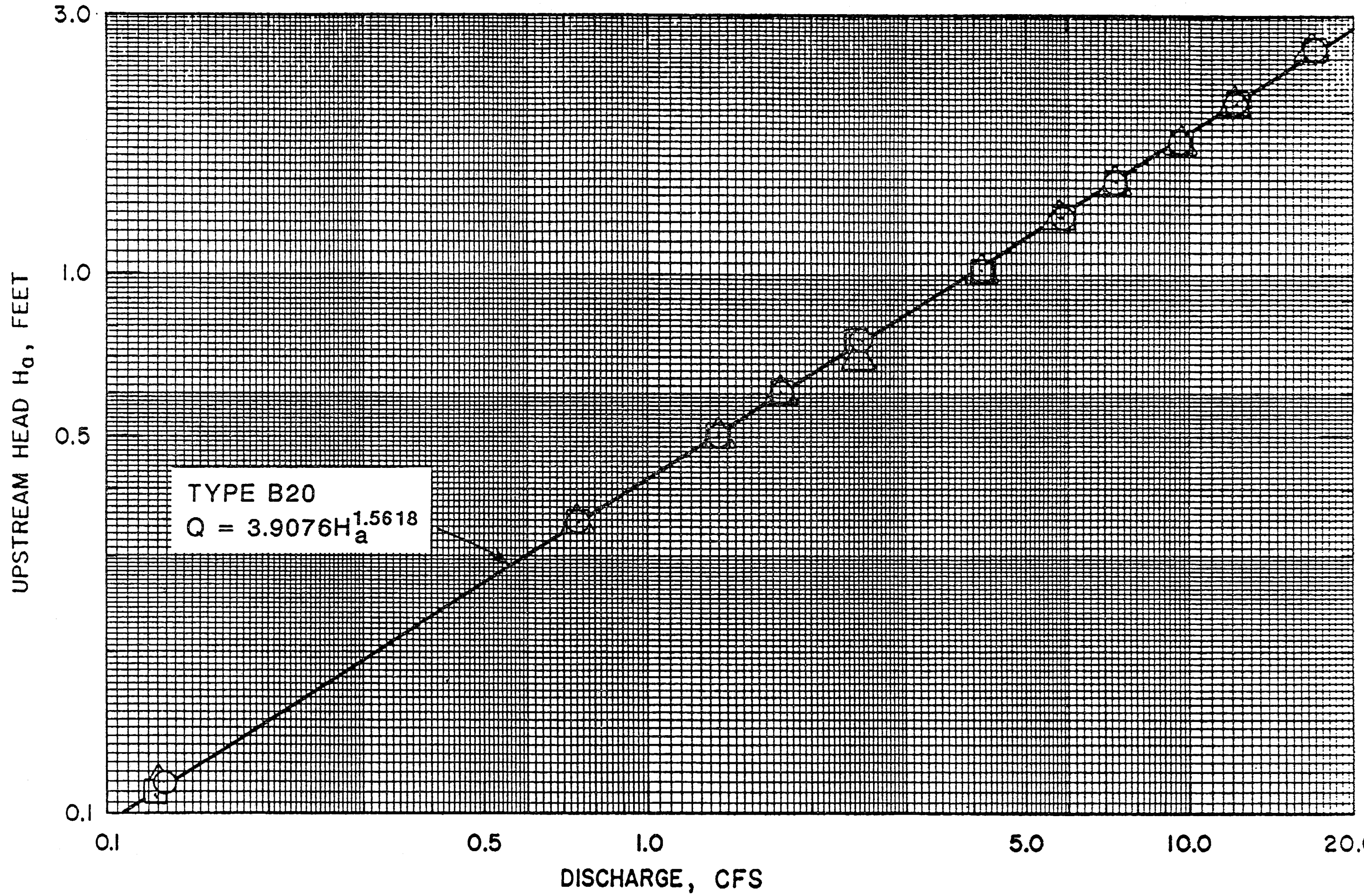



CHART 17

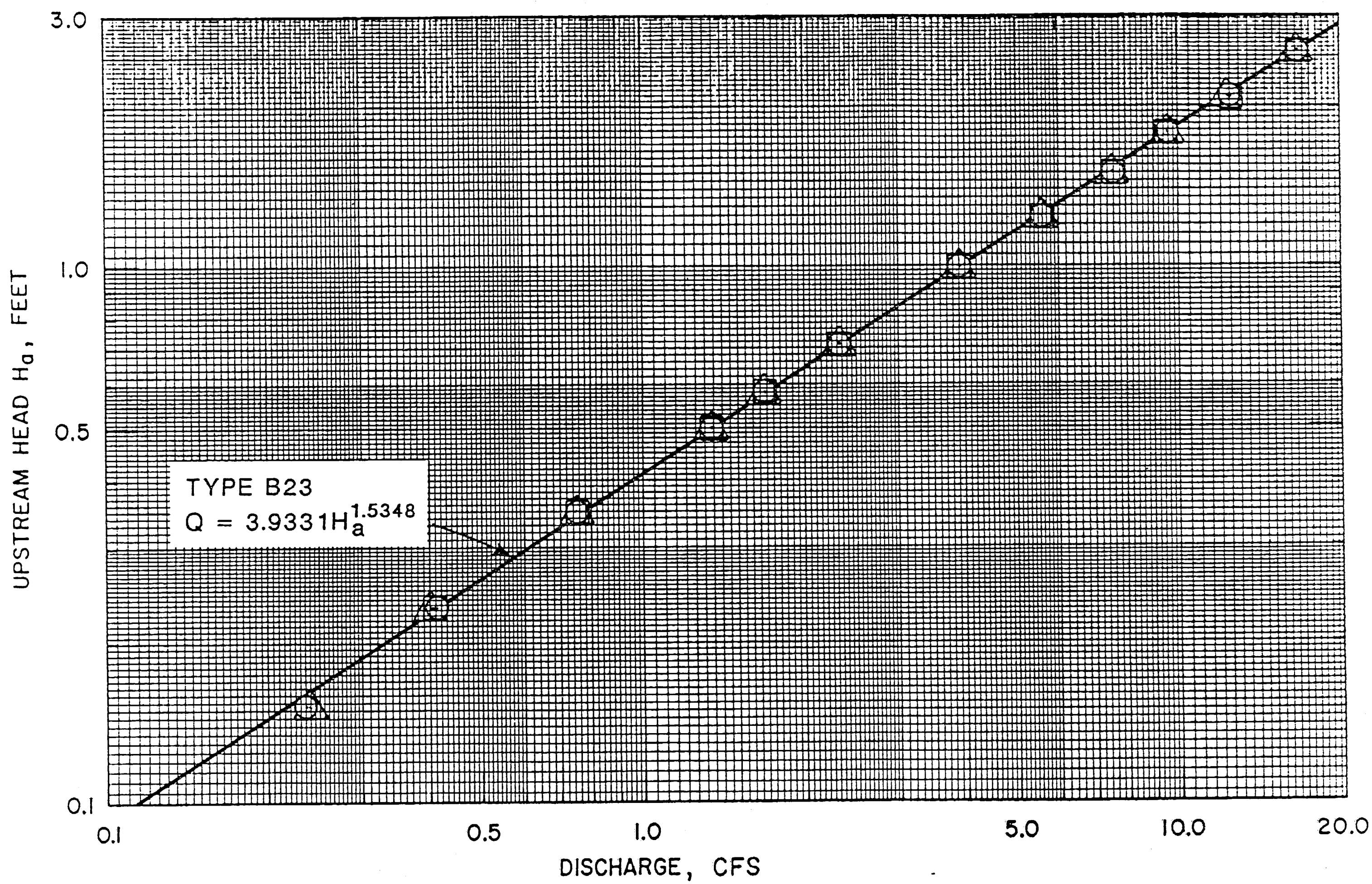
PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED-TYPES B18, B19, B20
TYPES B21, B22, B23




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B18 : NO WING WALLS
⊡ TYPE B19 : 45° WING WALLS
△ TYPE B20: CURVED WING WALLS

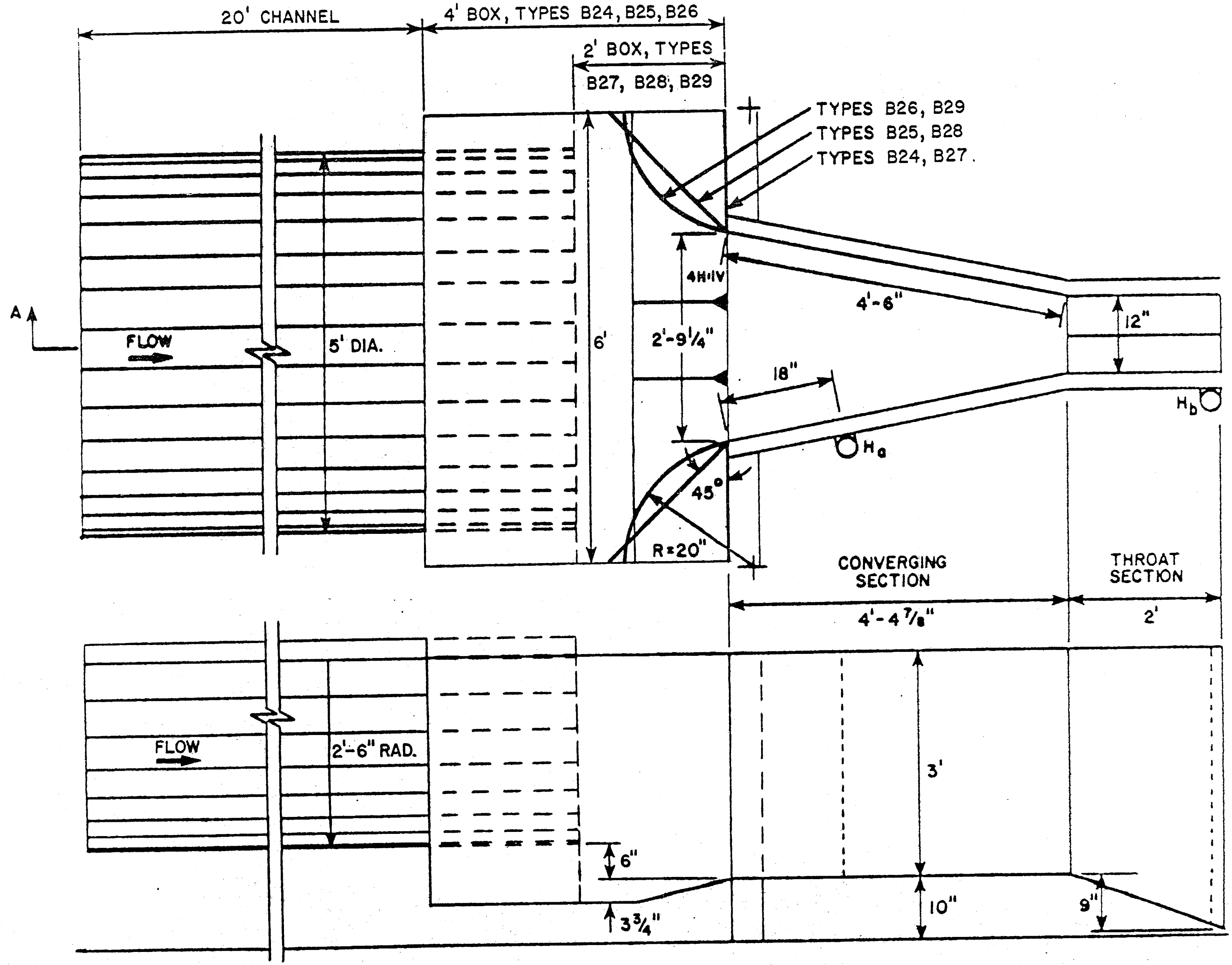
CHART 18




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

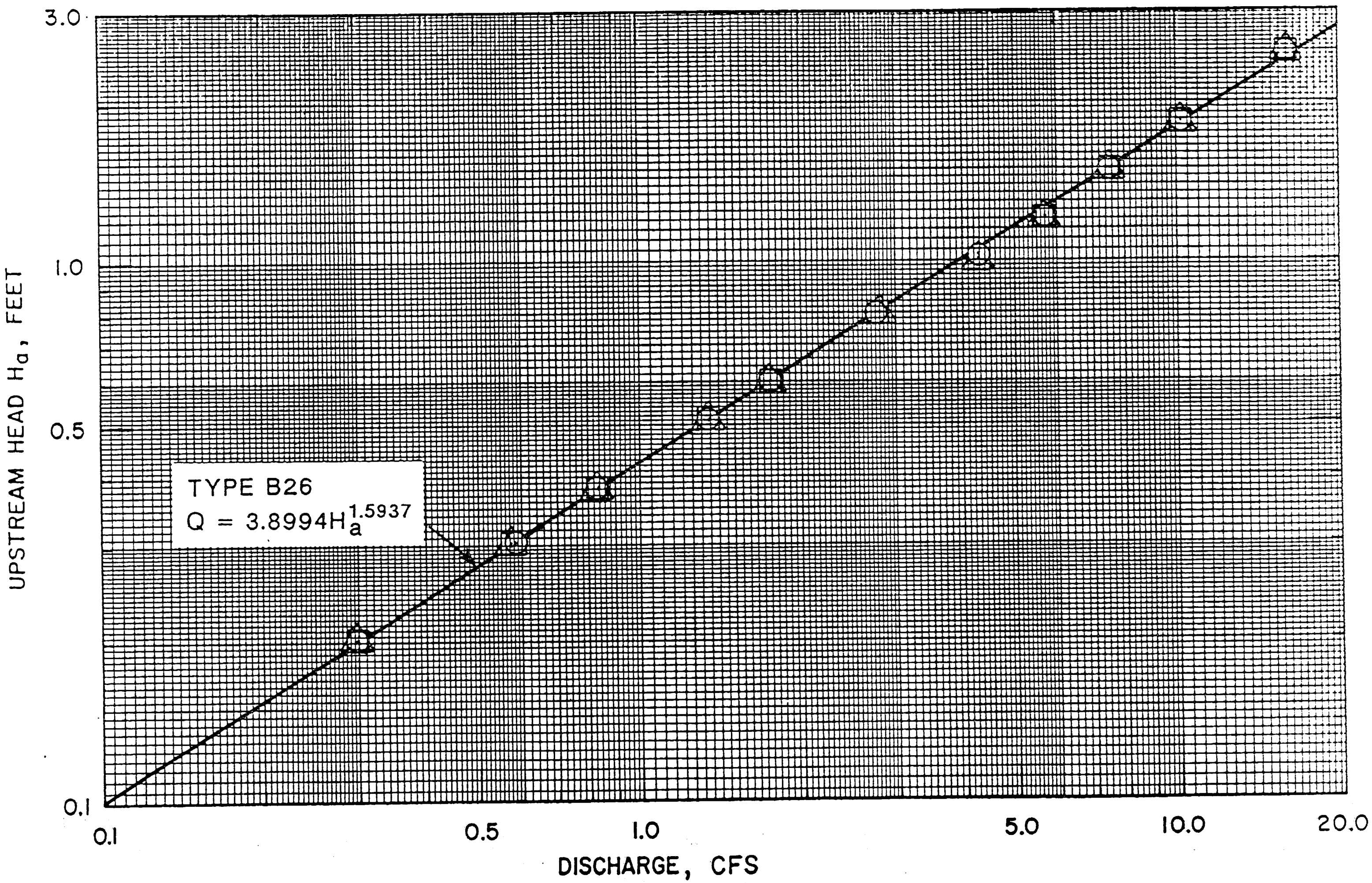
⊙ TYPE B21: NO WING WALLS
⊡ TYPE B22: 45° WING WALLS
△ TYPE B23: CURVED WING WALLS

CHART 19




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES B24, B25, B26
TYPES B27, B28, B29

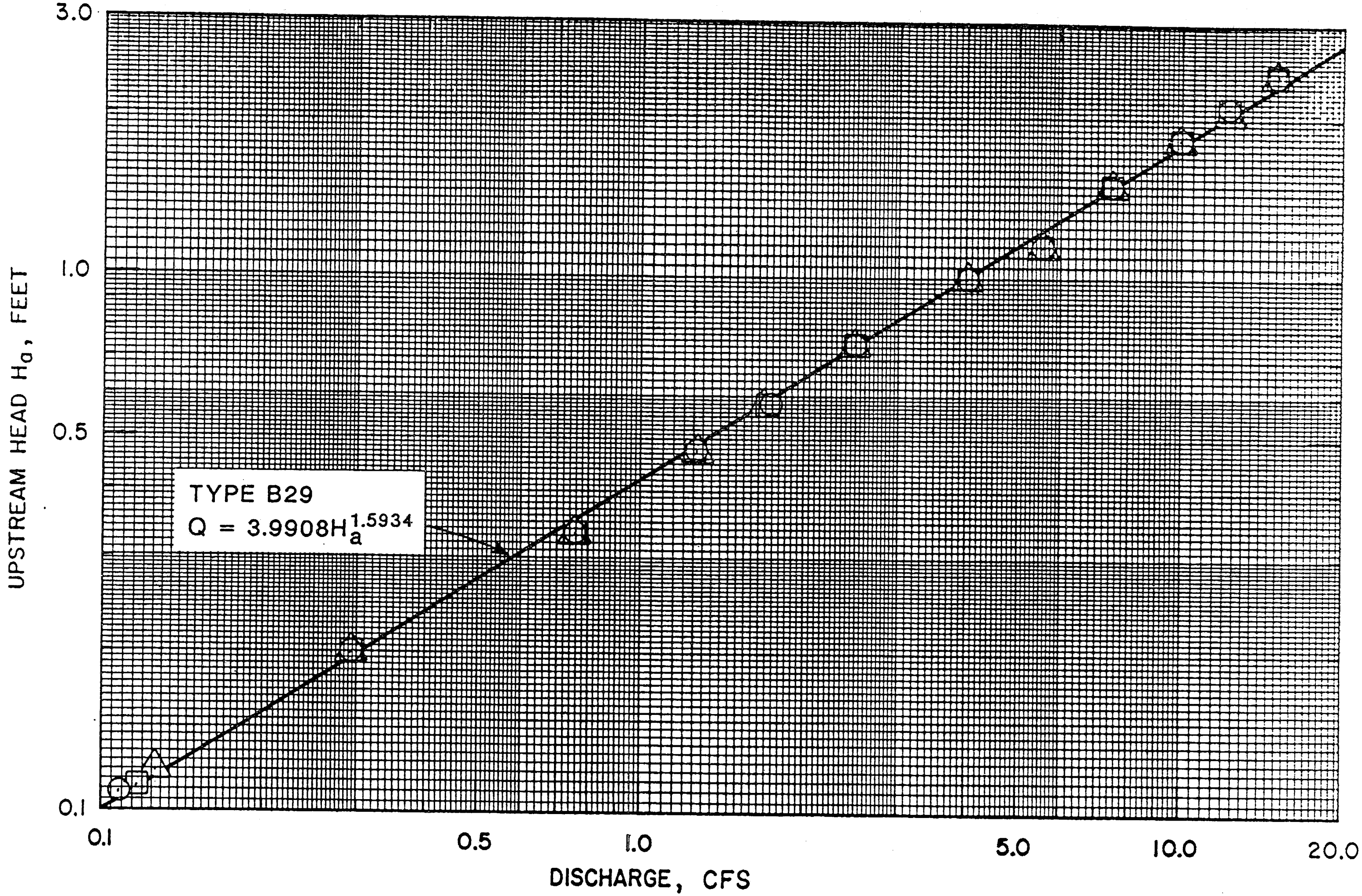
CHART 20




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B24: NO WING WALLS
⊡ TYPE B25: 45° WING WALLS
△ TYPE B26: CURVED WING WALLS

CHART 21




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B27: NO WING WALLS
⊡ TYPE B28: 45° WING WALLS
△ TYPE B29: CURVED WING WALLS

CHART .22

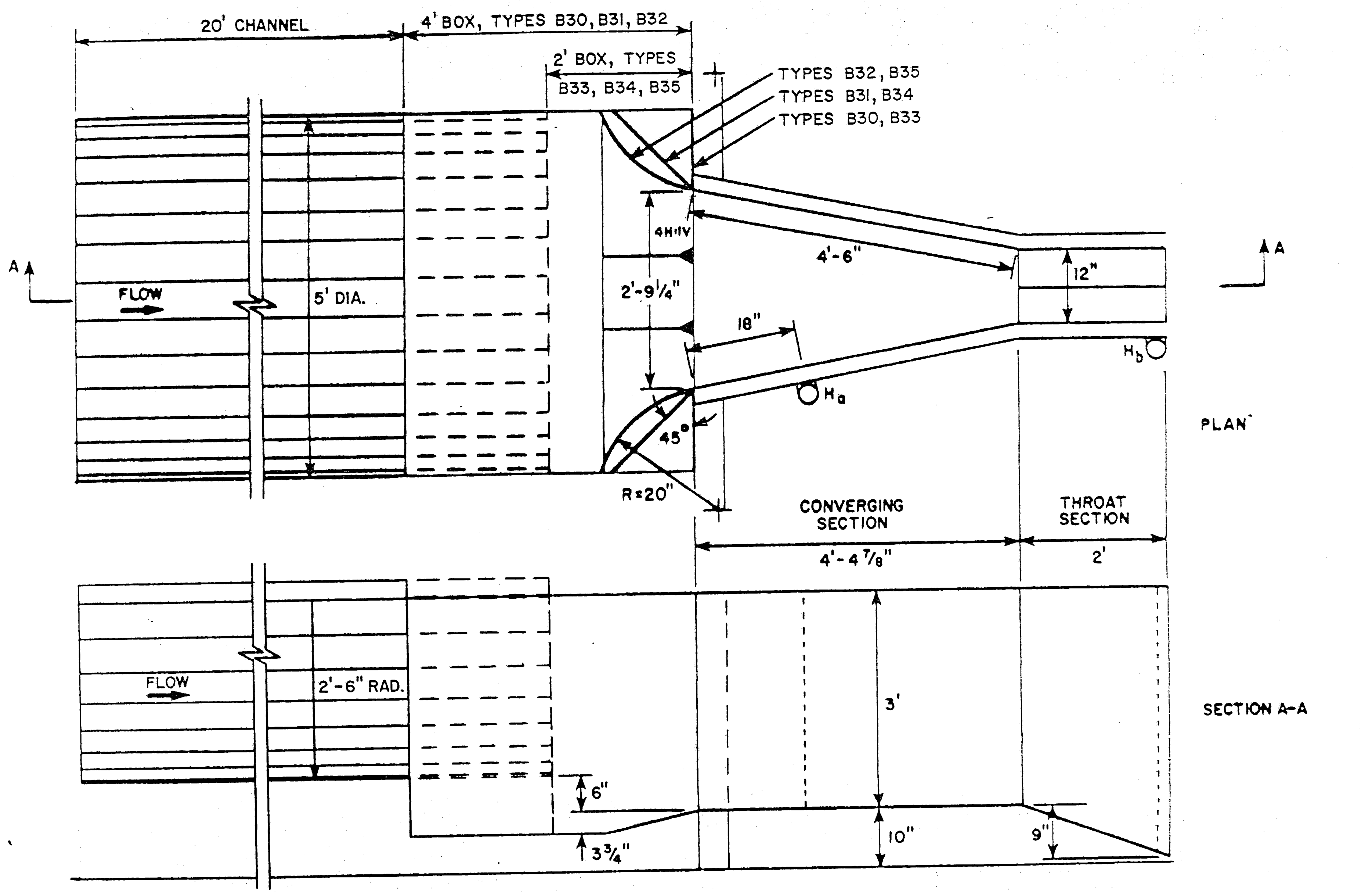
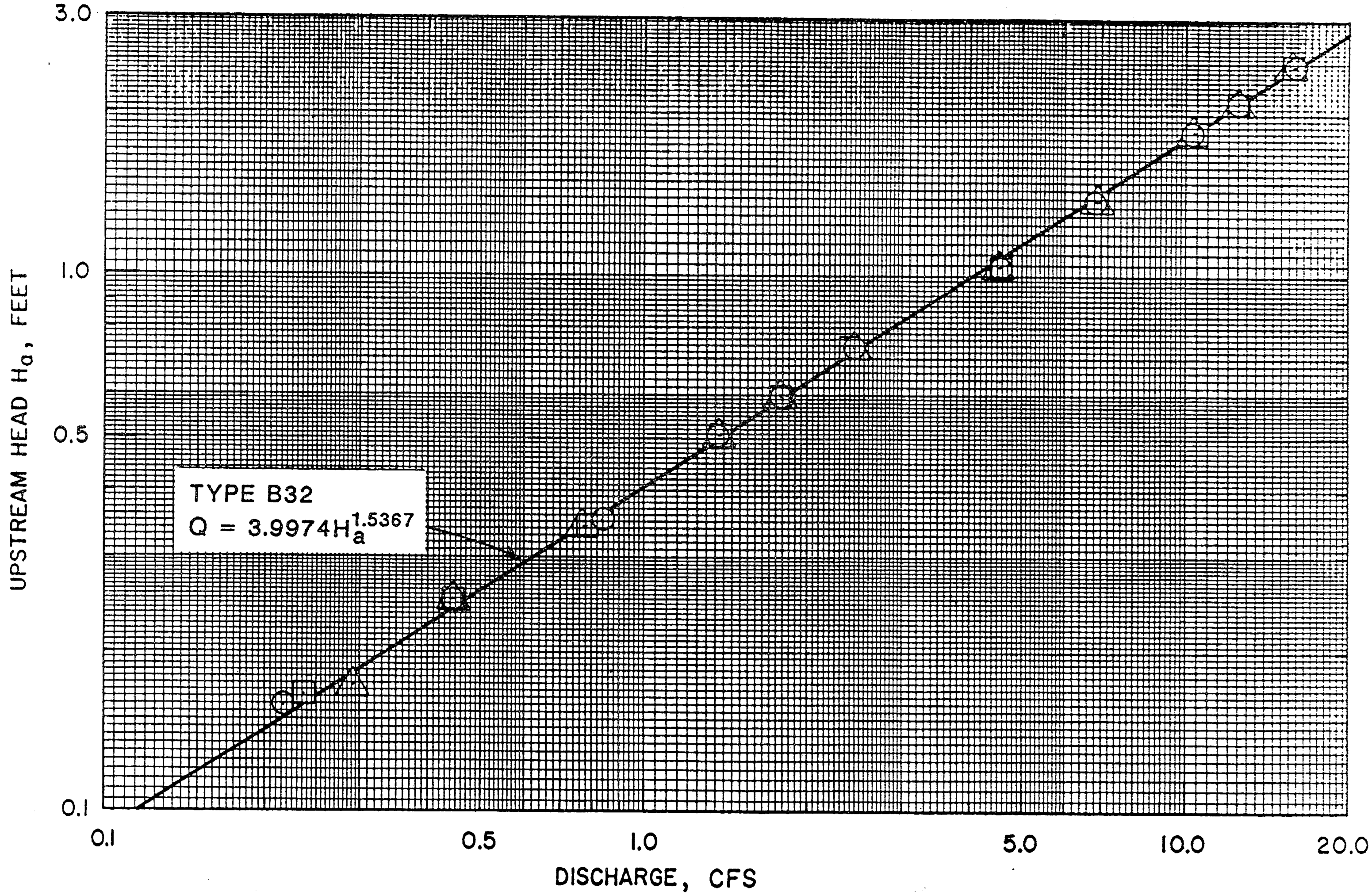



CHART 23

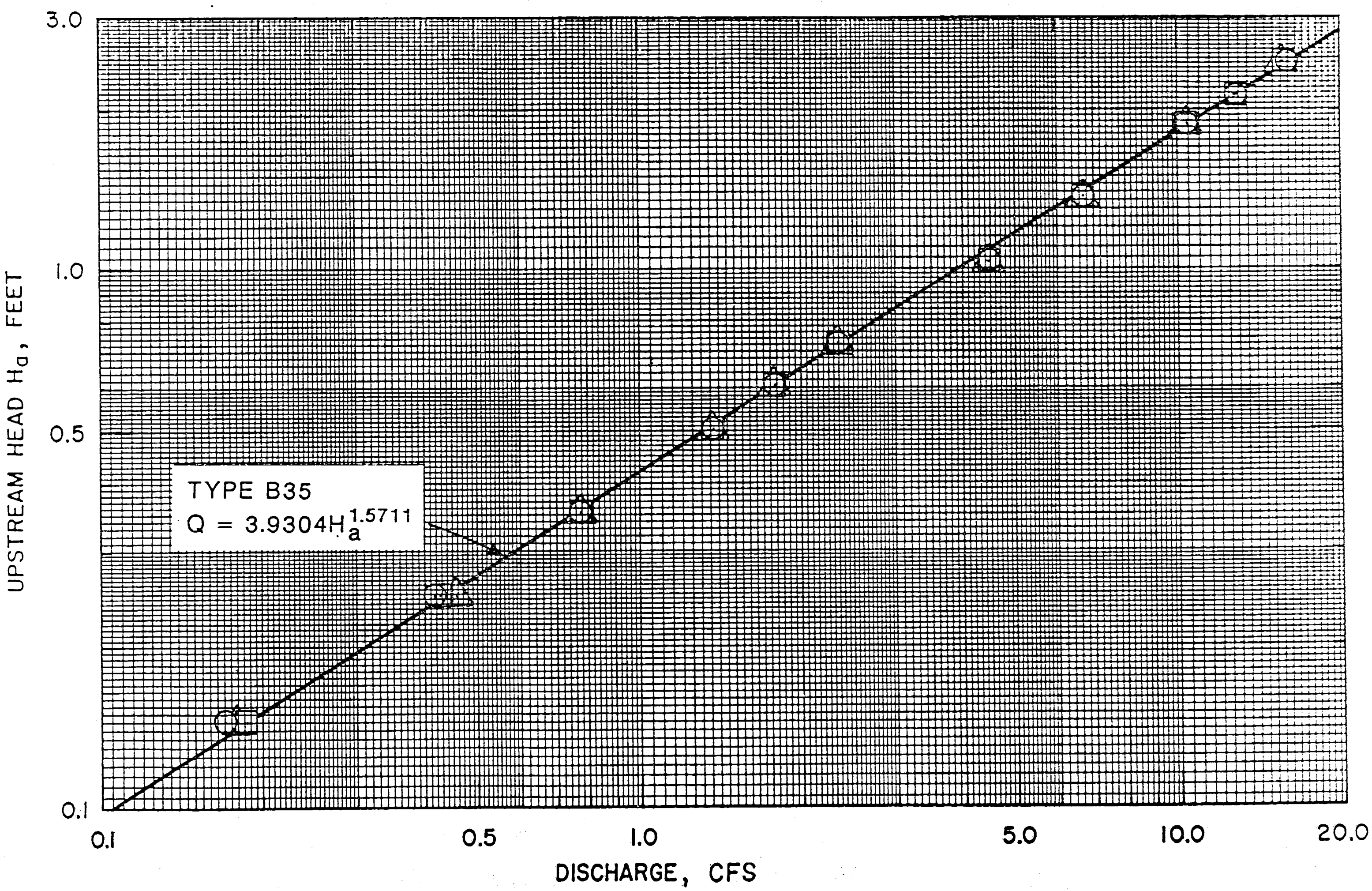
PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES B30, B31, B32
TYPES B33, B34, B35




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B30: NO WING WALLS
⊡ TYPE B31 : 45° WING WALLS
△ TYPE B32: CURVED WING WALLS

CHART 24




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE B33: NO WING WALLS
⊡ TYPE B34: 45° WING WALLS
△ TYPE B35: CURVED WING WALLS

CHART 25

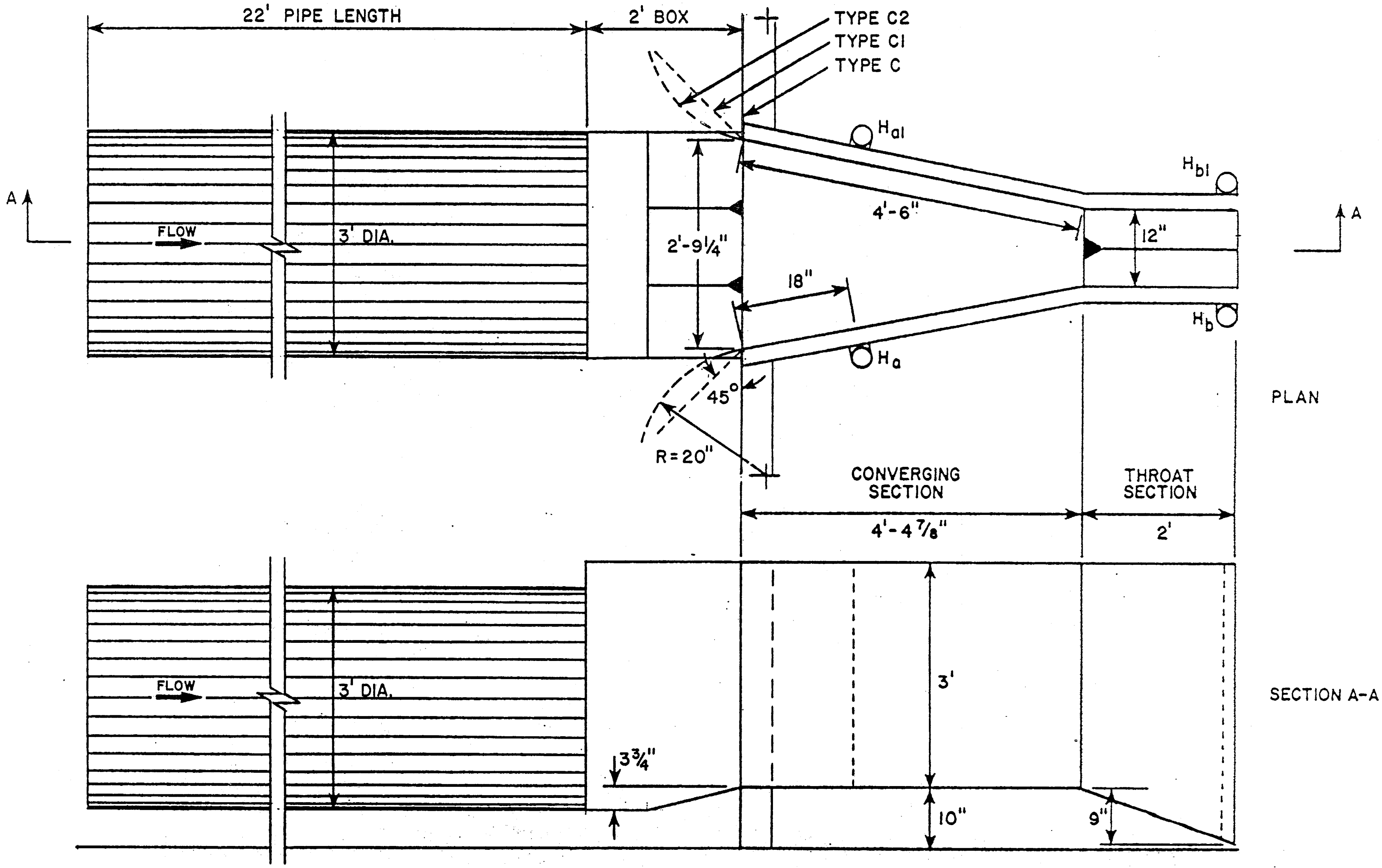
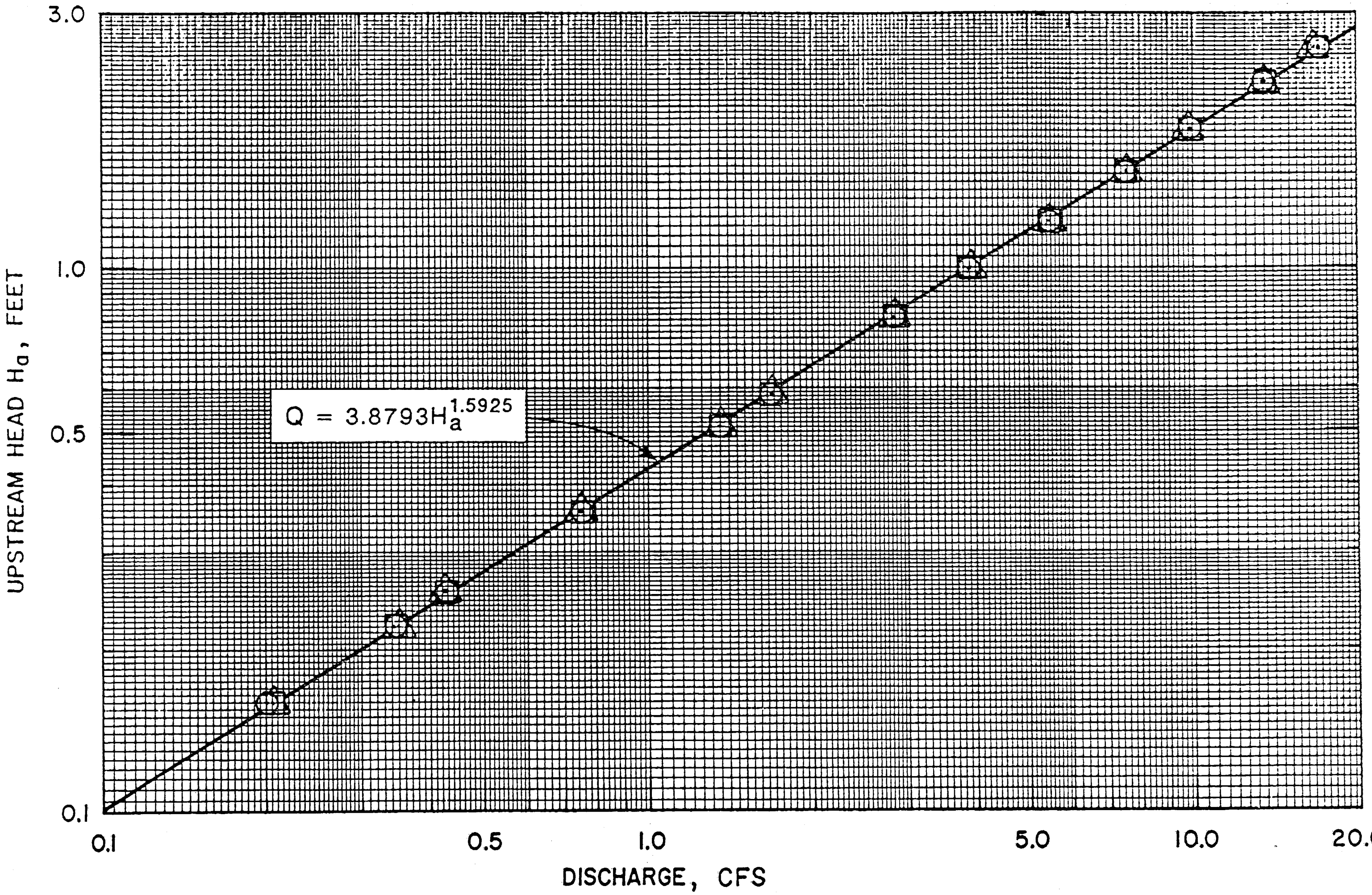



CHART 26

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES C, C1, C2




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE C : NO WING WALLS
⊡ TYPE C1 : 45° WING WALLS
△ TYPE C2 : CURVED WING WALLS

CHART 27

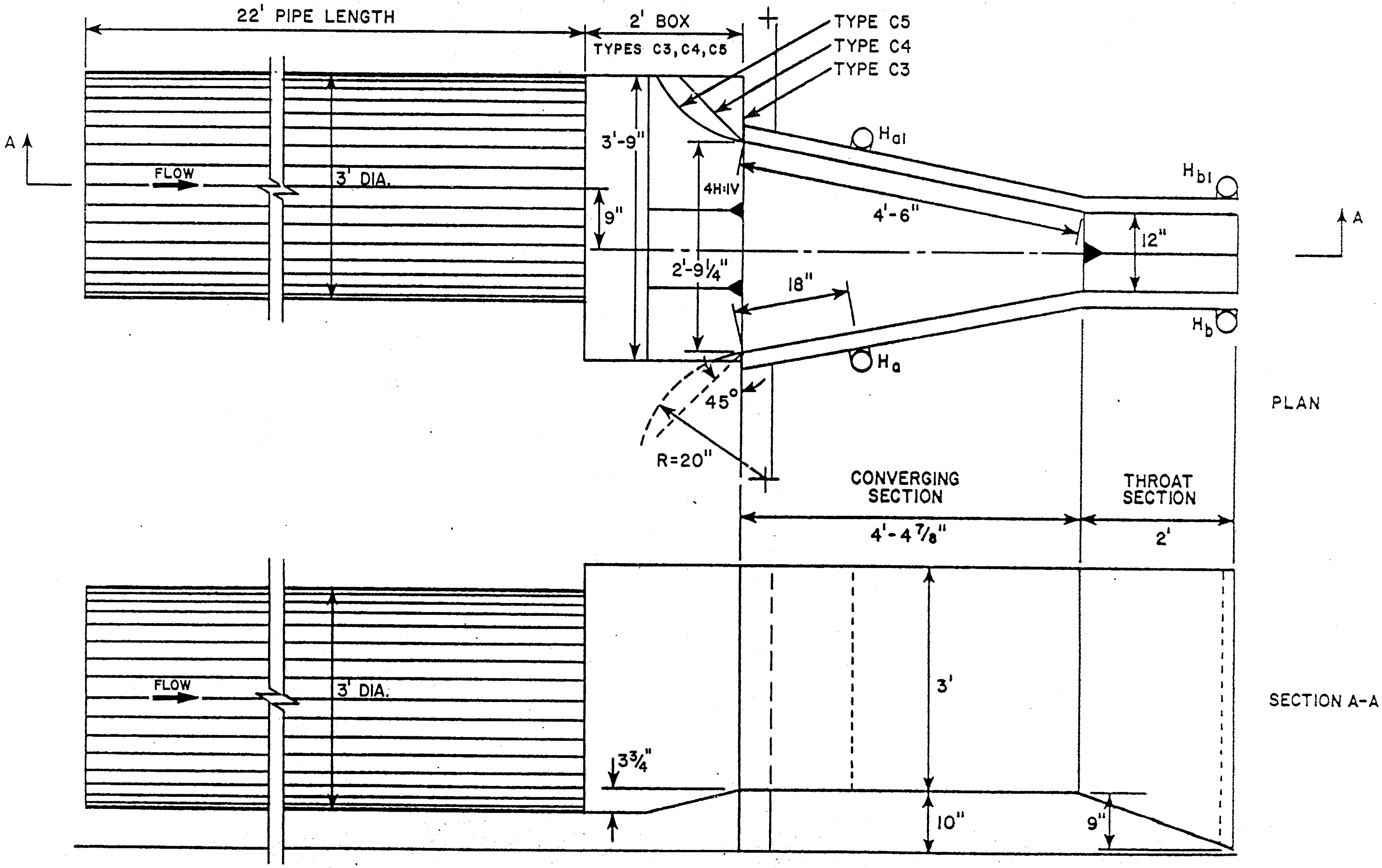
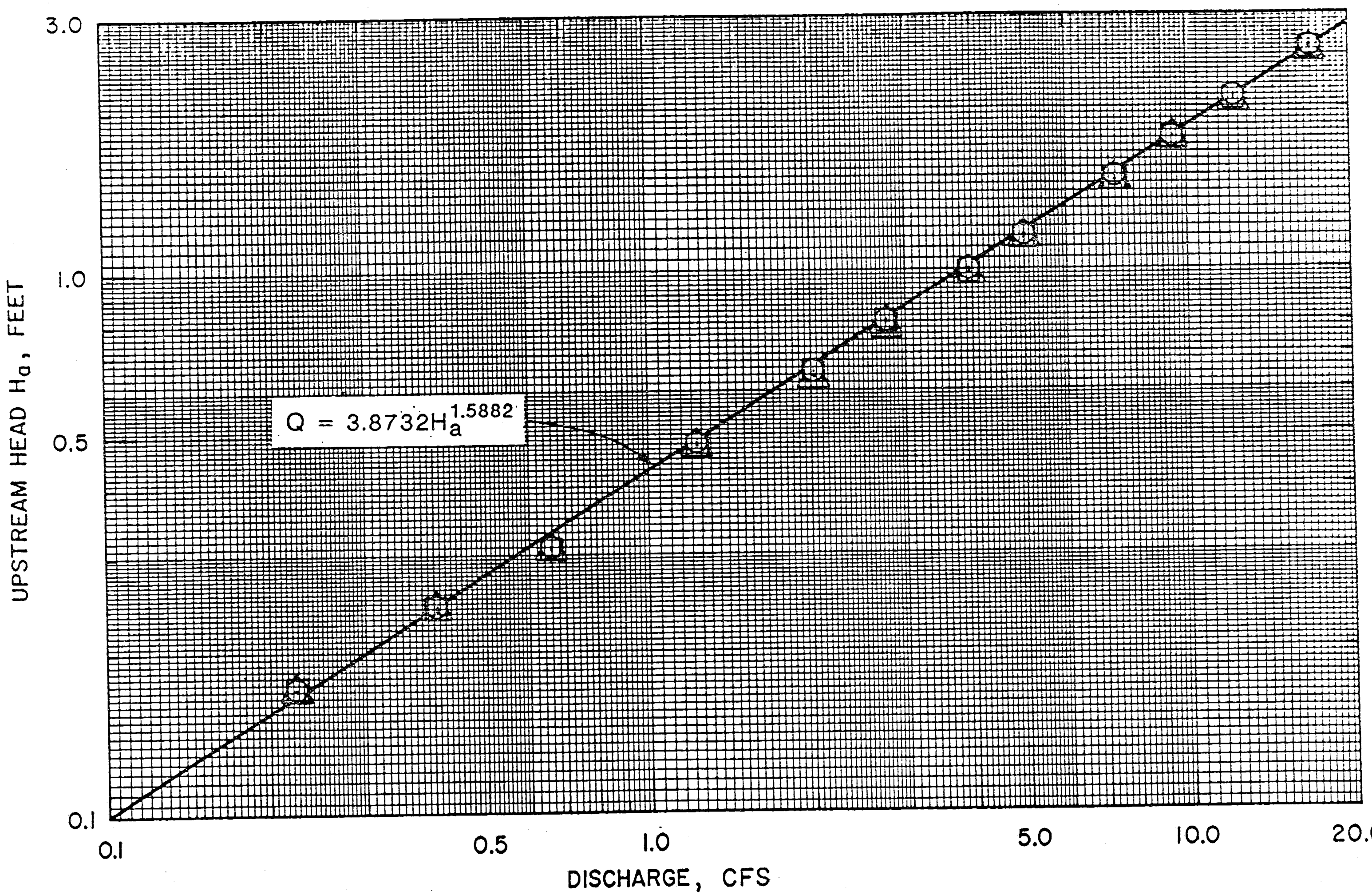


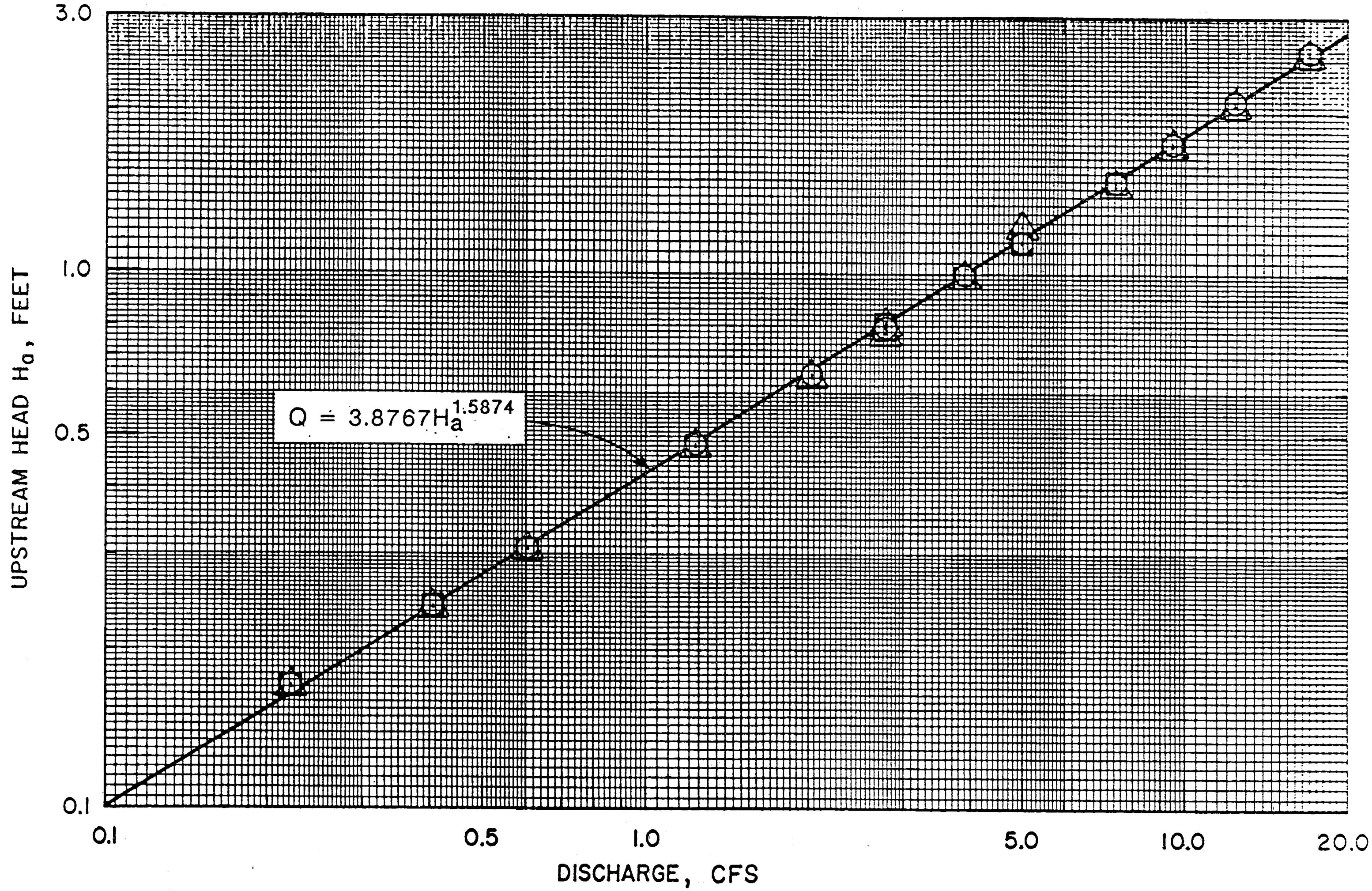

CHART 28

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES C3, C4, C5




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 29




TYPE C4

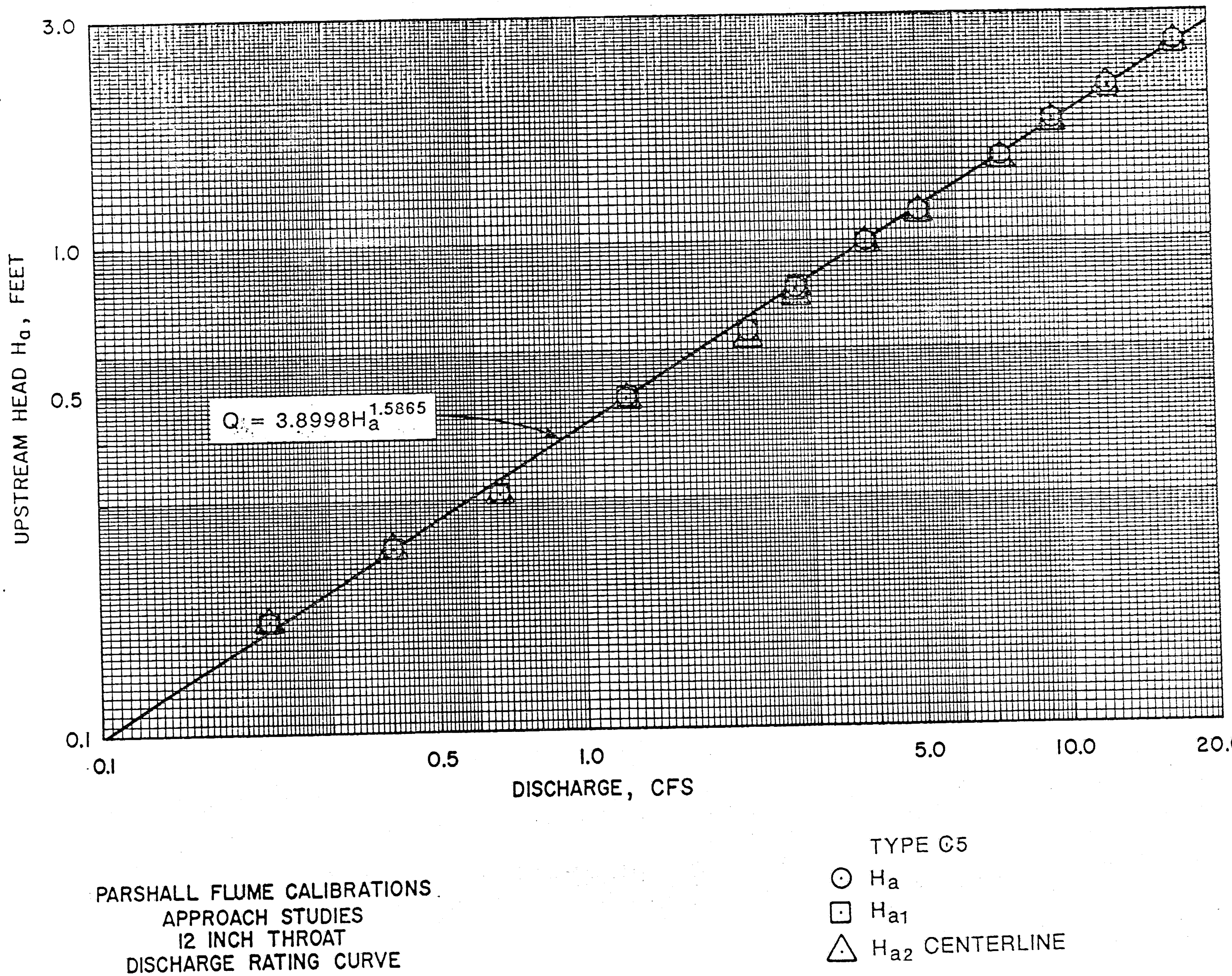
⊙ $H_a$

⊡ $H_{a1}$

△ $H_{a2}$ CENTERLINE

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 30




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 31

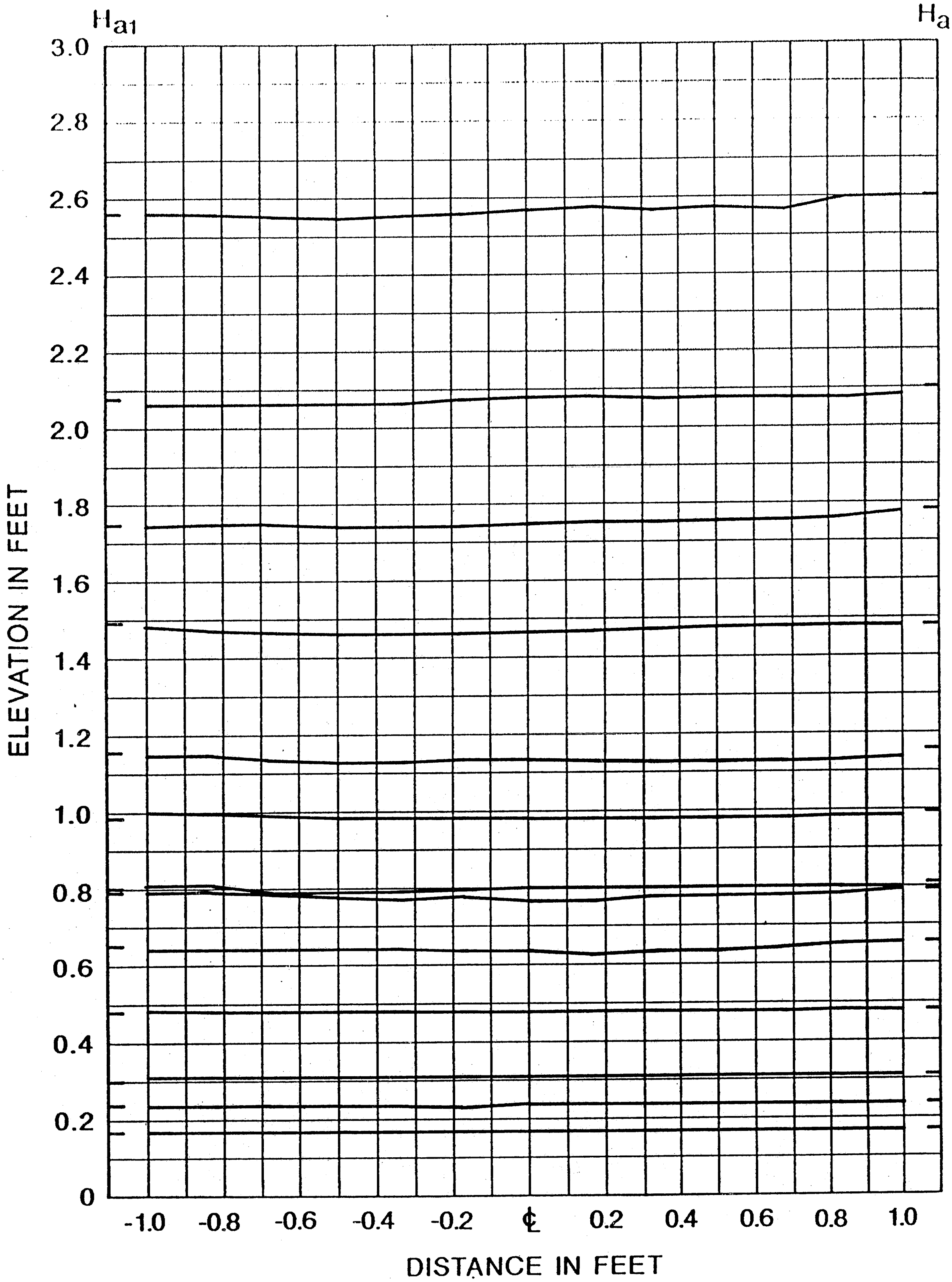



CHART 32

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
WATER SURFACE PROFILES - $H_{a2}$
TYPE C5

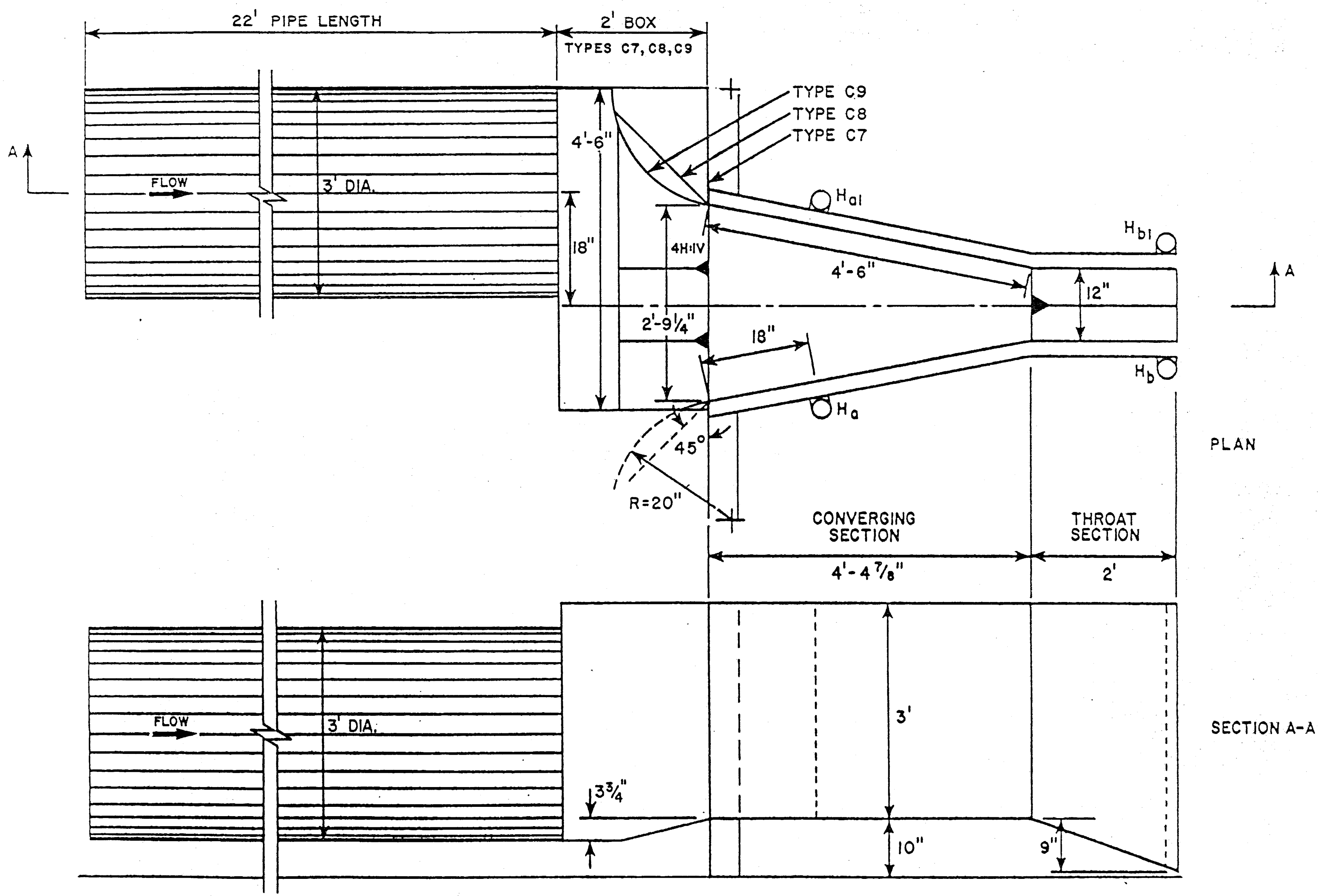
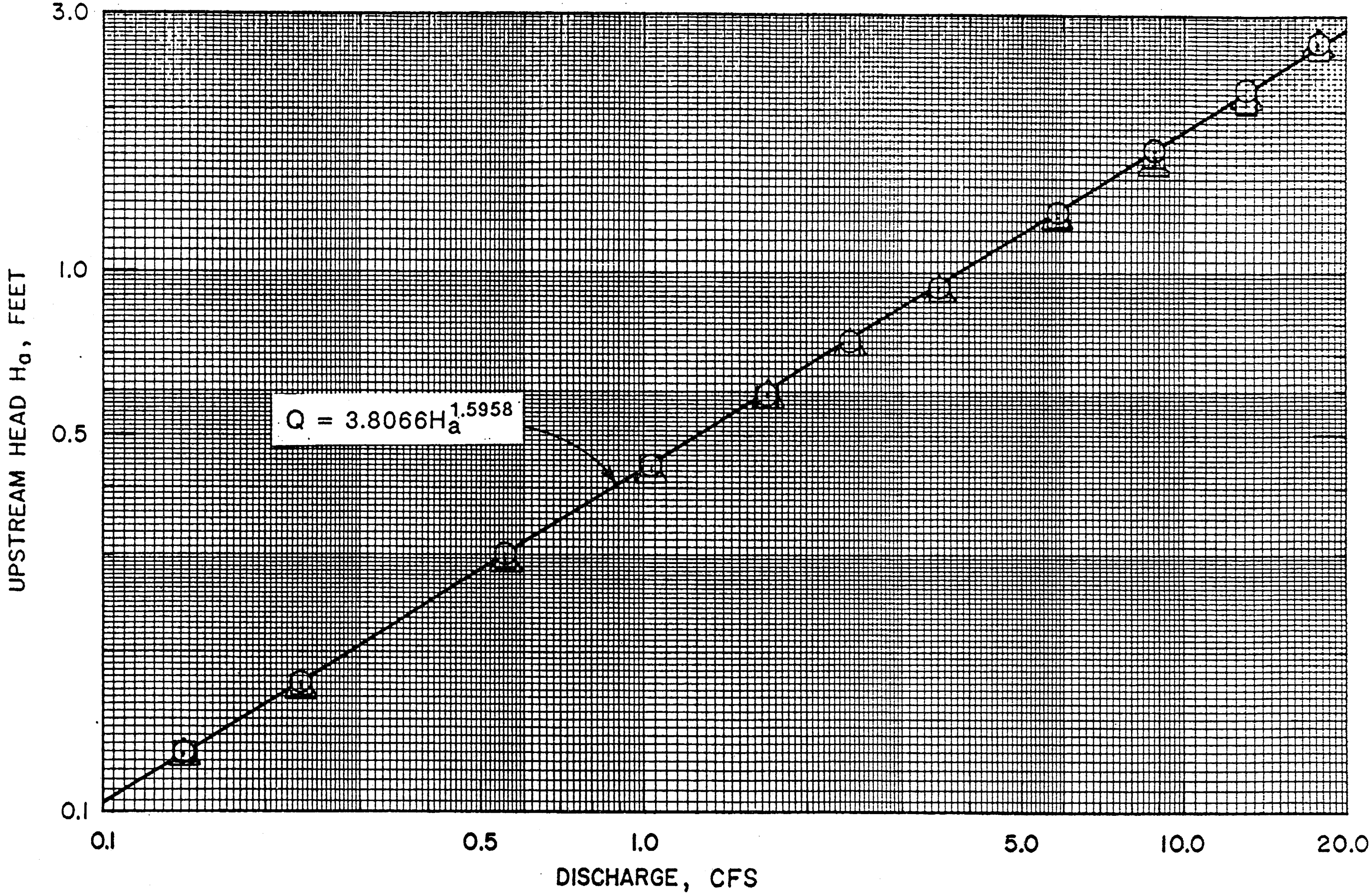



CHART 33

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPES C7, C8, C9




TYPE C7

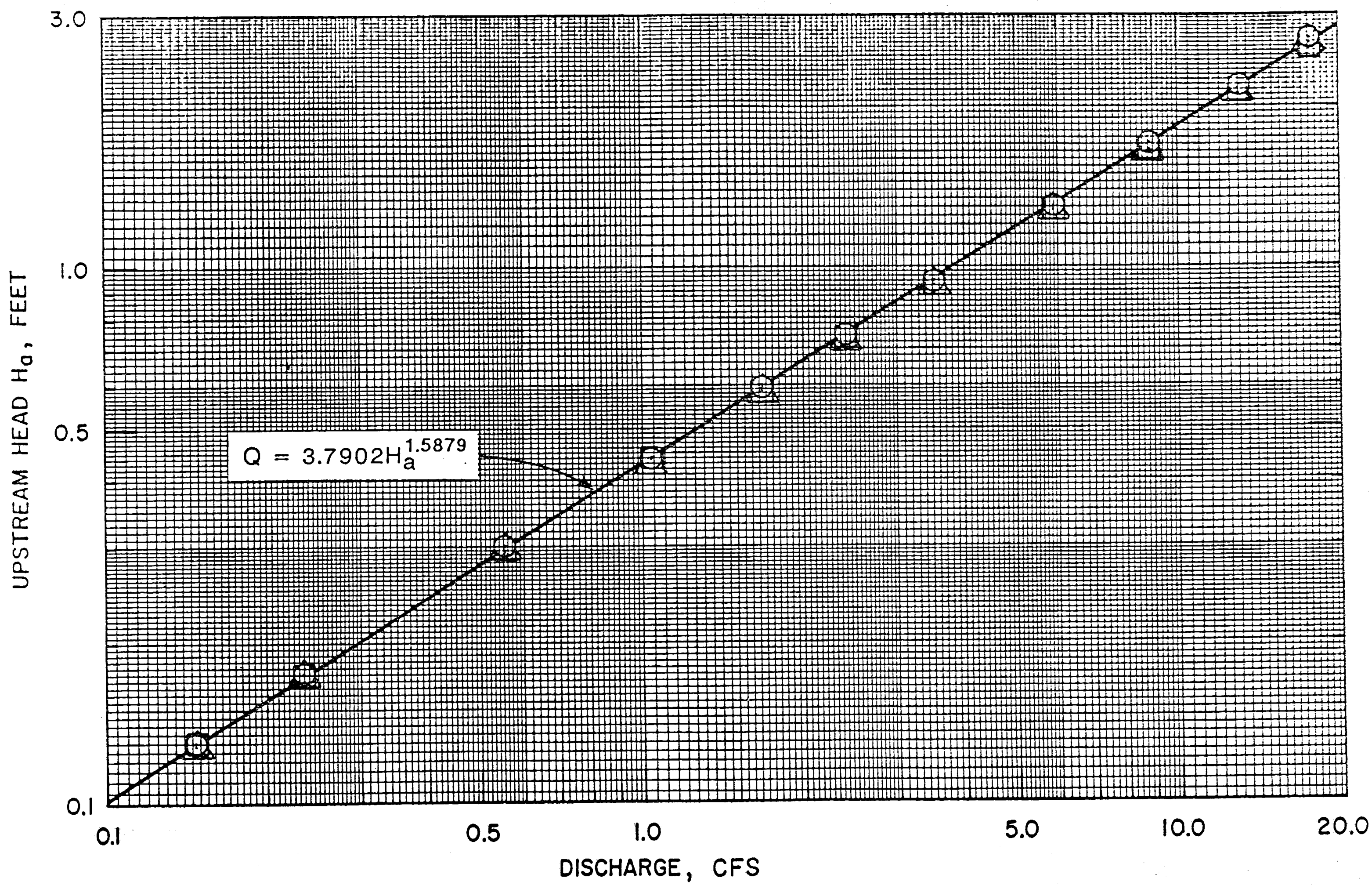
⊙ $H_a$

⊡ $H_{a1}$

△ $H_{a2}$ CENTERLINE

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

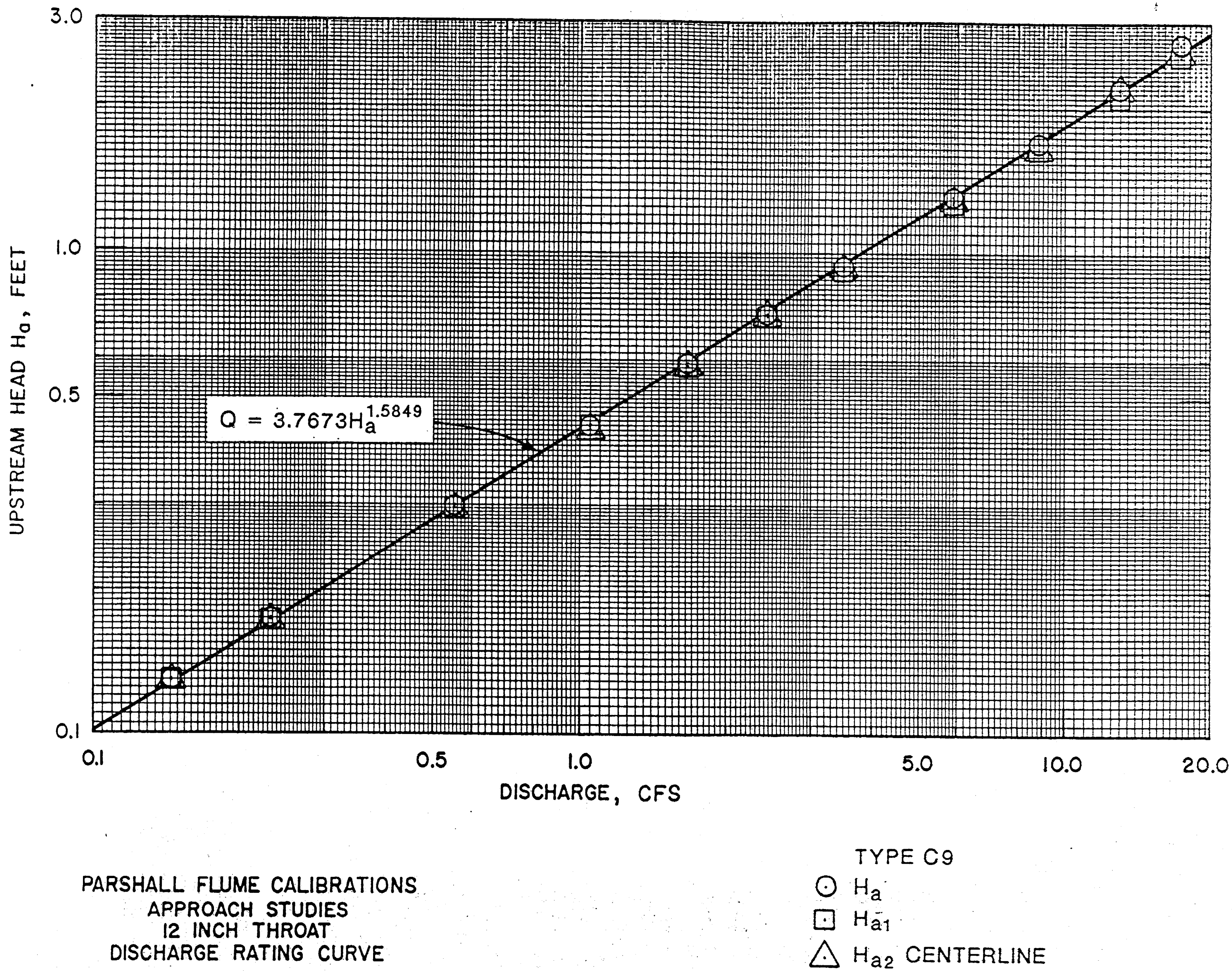
CHART 34




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

TYPE C8
⊙ $H_a$
⊡ $H_{a1}$
△ $H_{a2}$ CENTERLINE

CHART 35




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 36

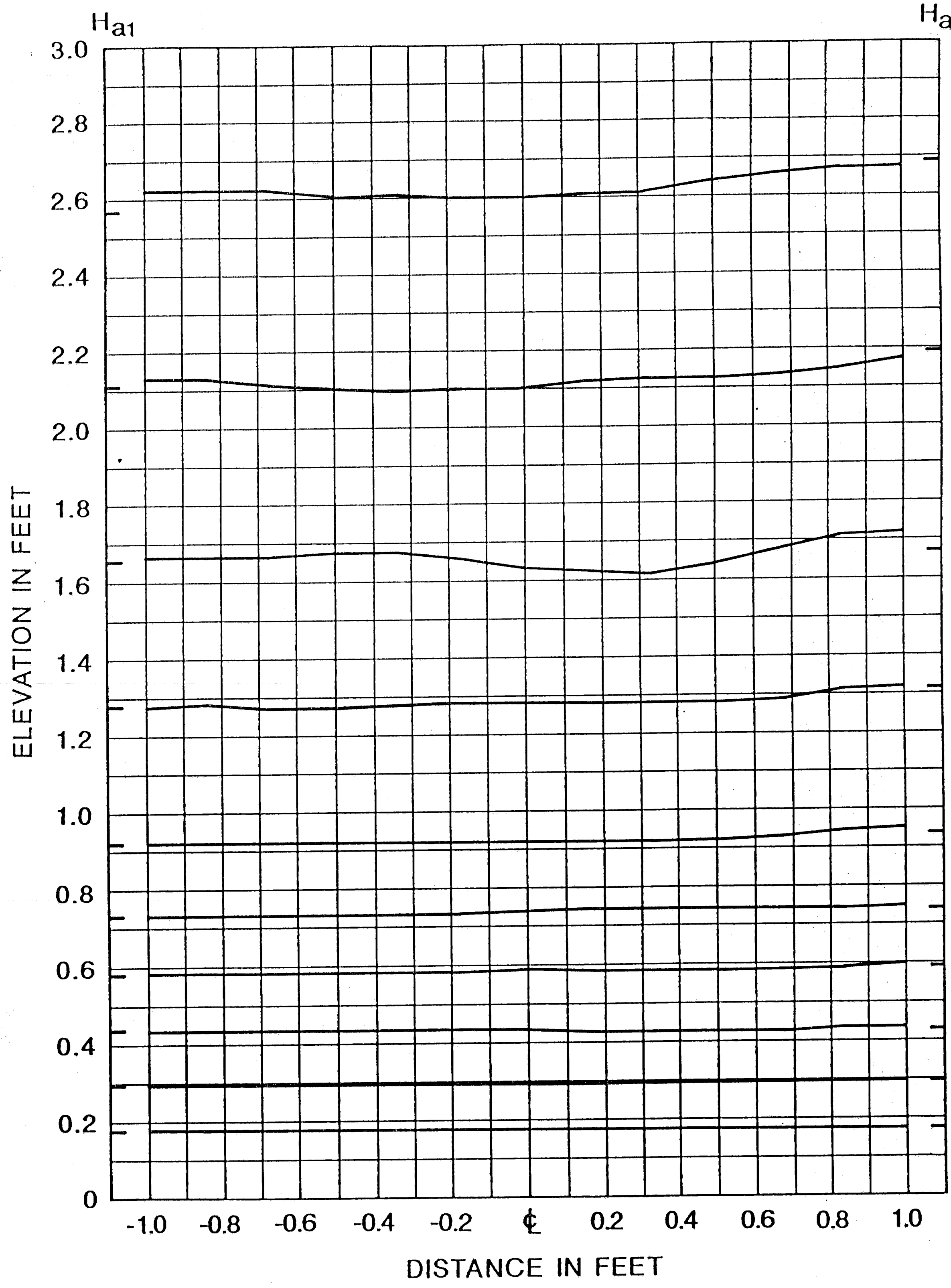



CHART 37

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
WATER SURFACE PROFILES - $H_{a2}$
TYPE C9

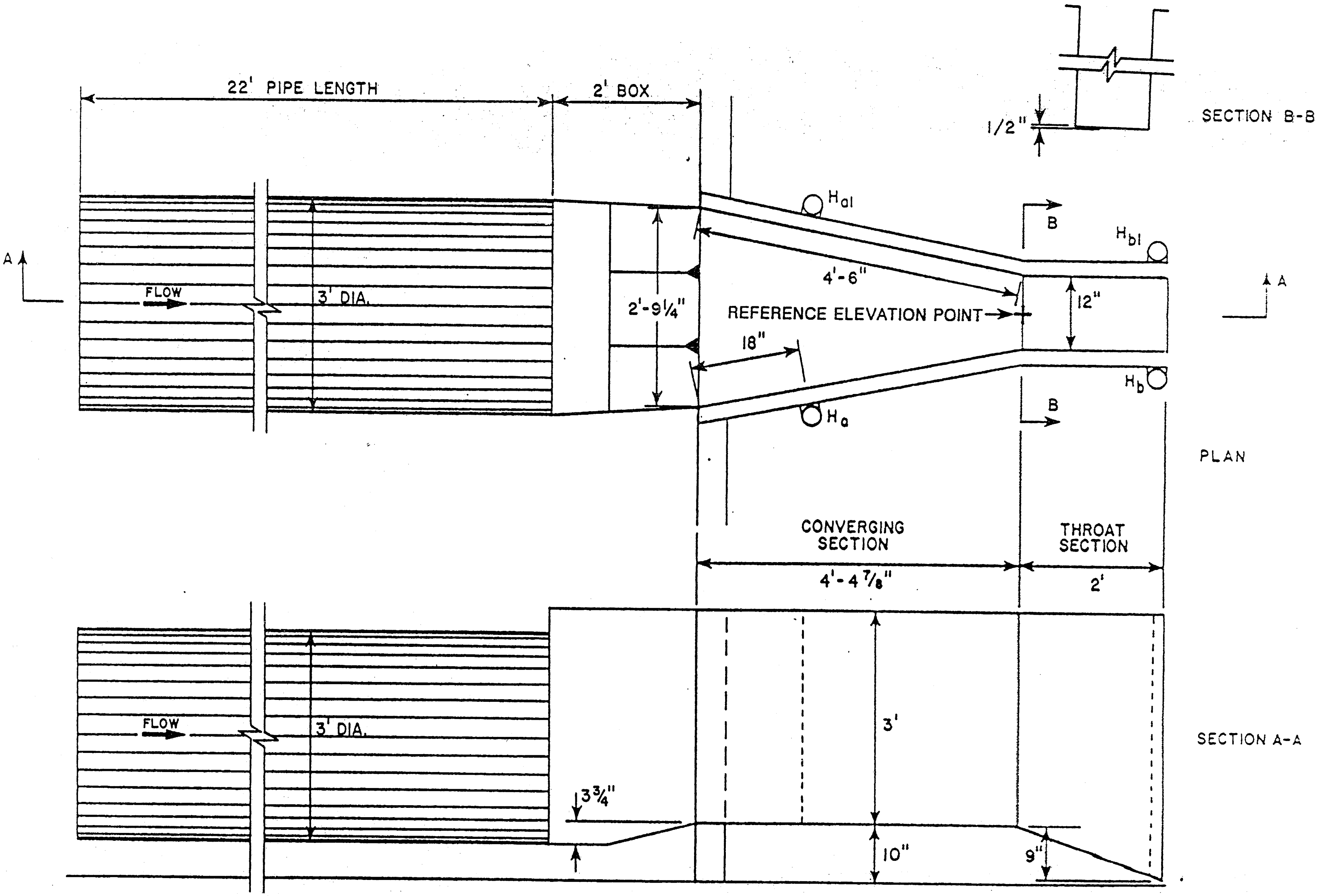
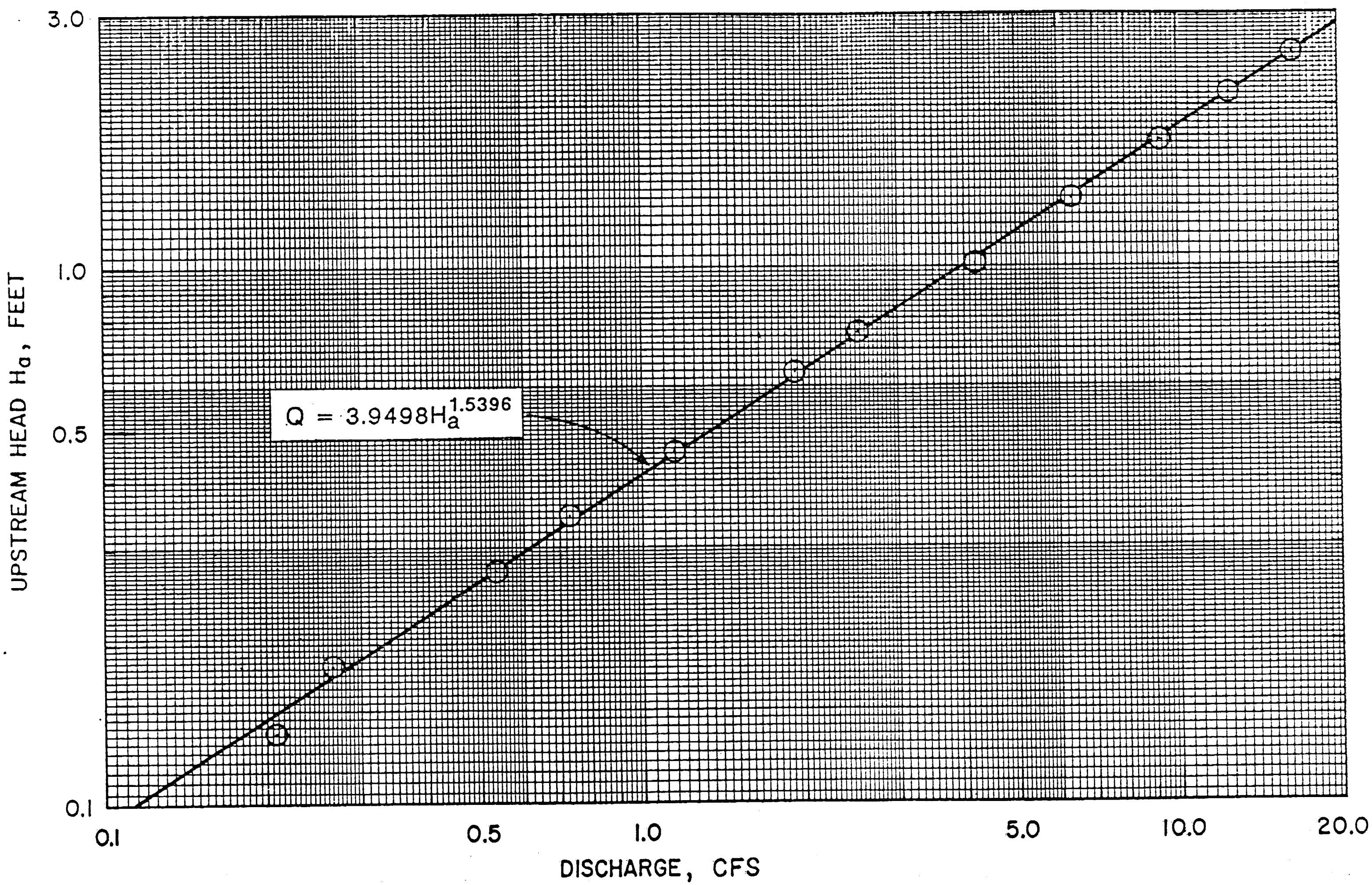



CHART 38

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPE C10




⊙ TYPE C10

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 39

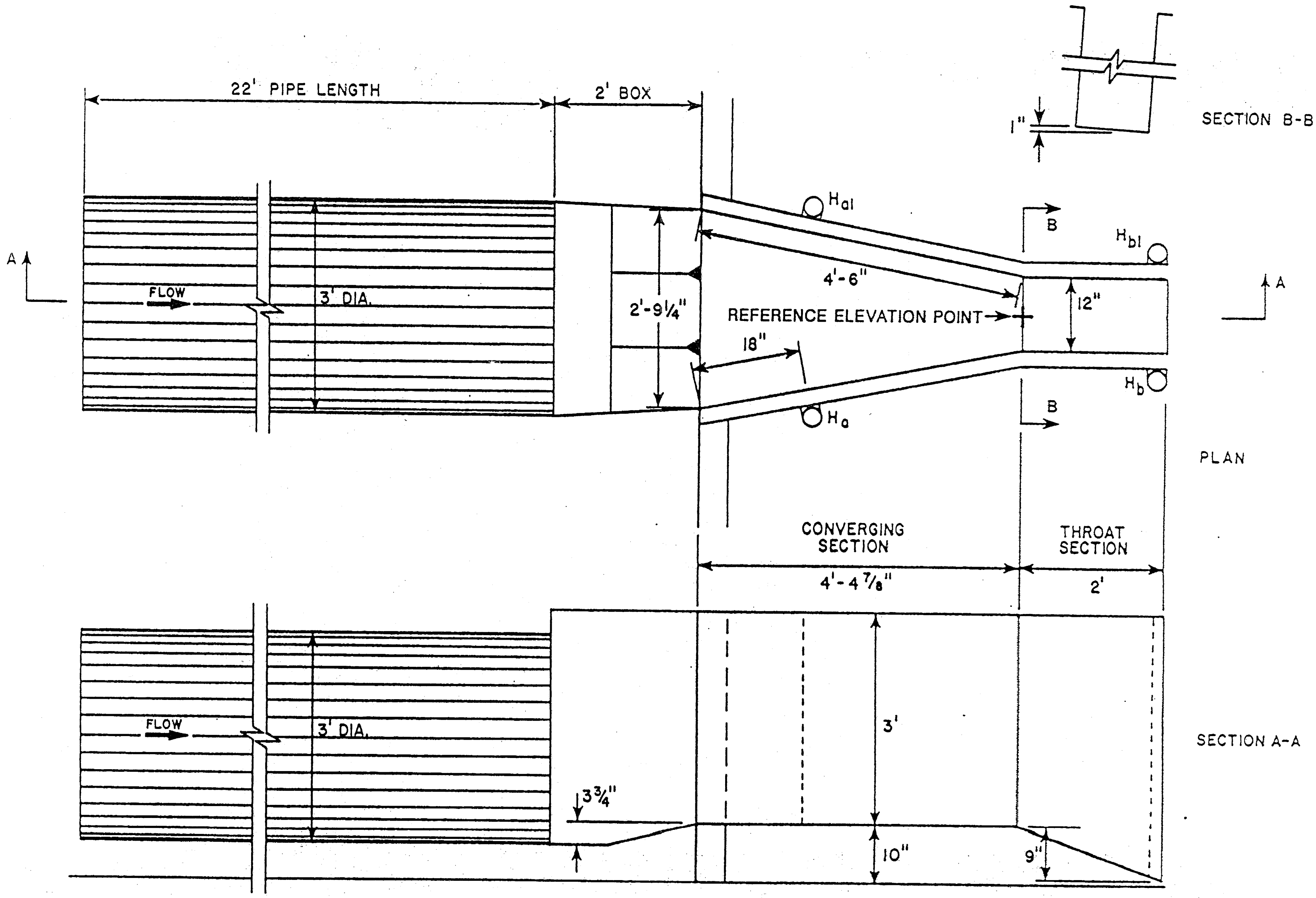
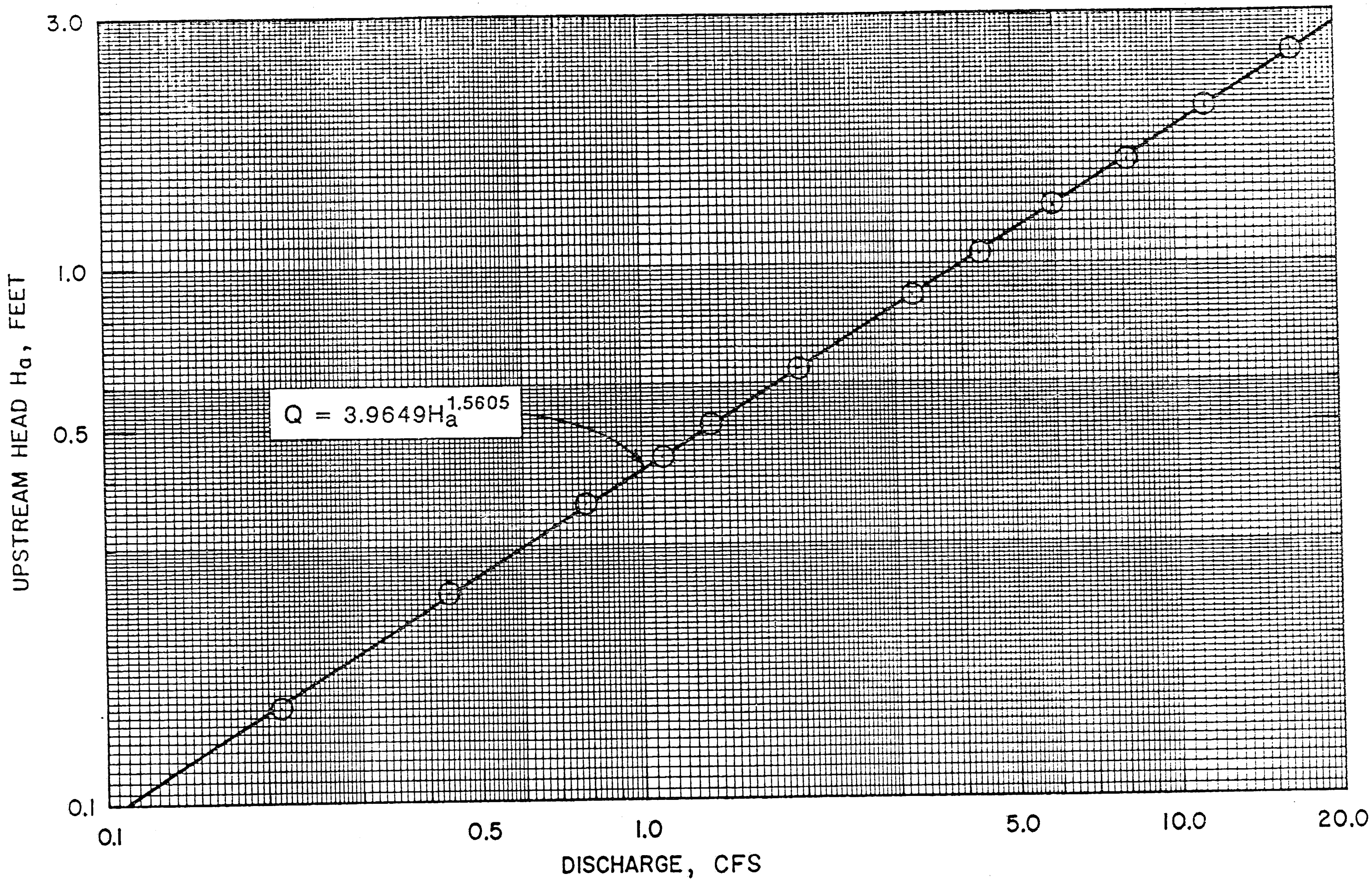



CHART 40

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPE C11




⊙ TYPE C11

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 41

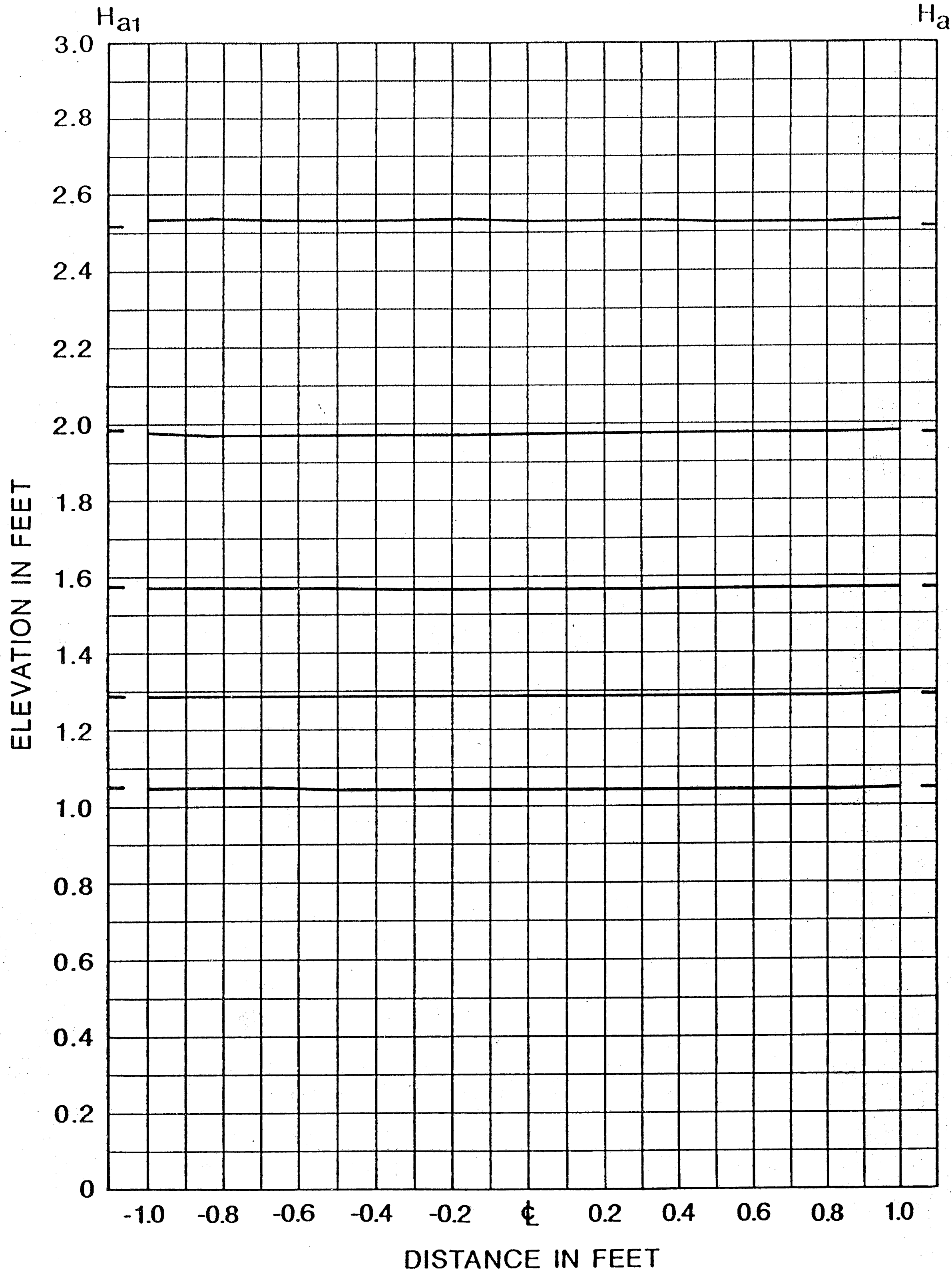



CHART 42

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
WATER SURFACE PROFILES - $H_{a2}$
TYPE C11

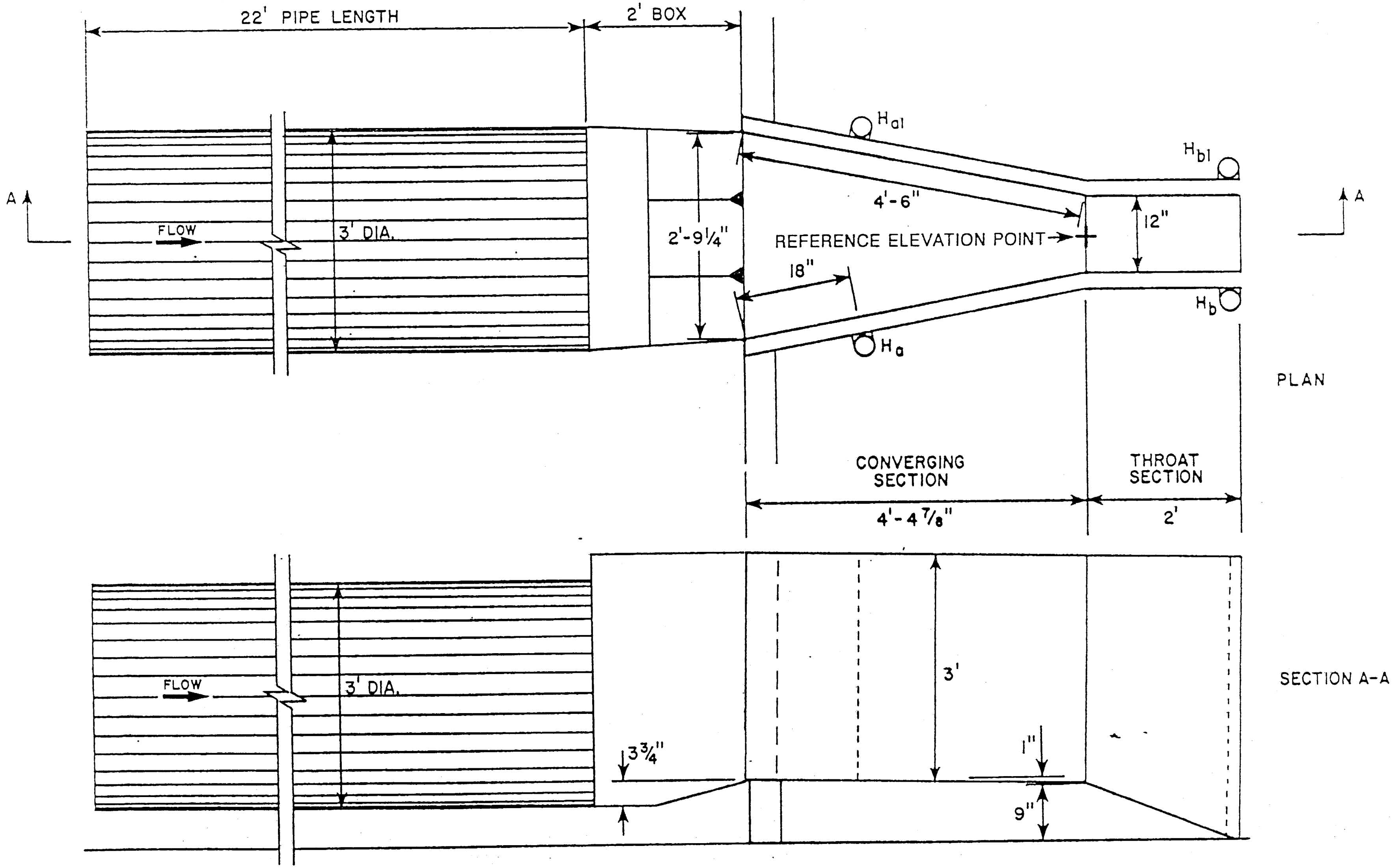
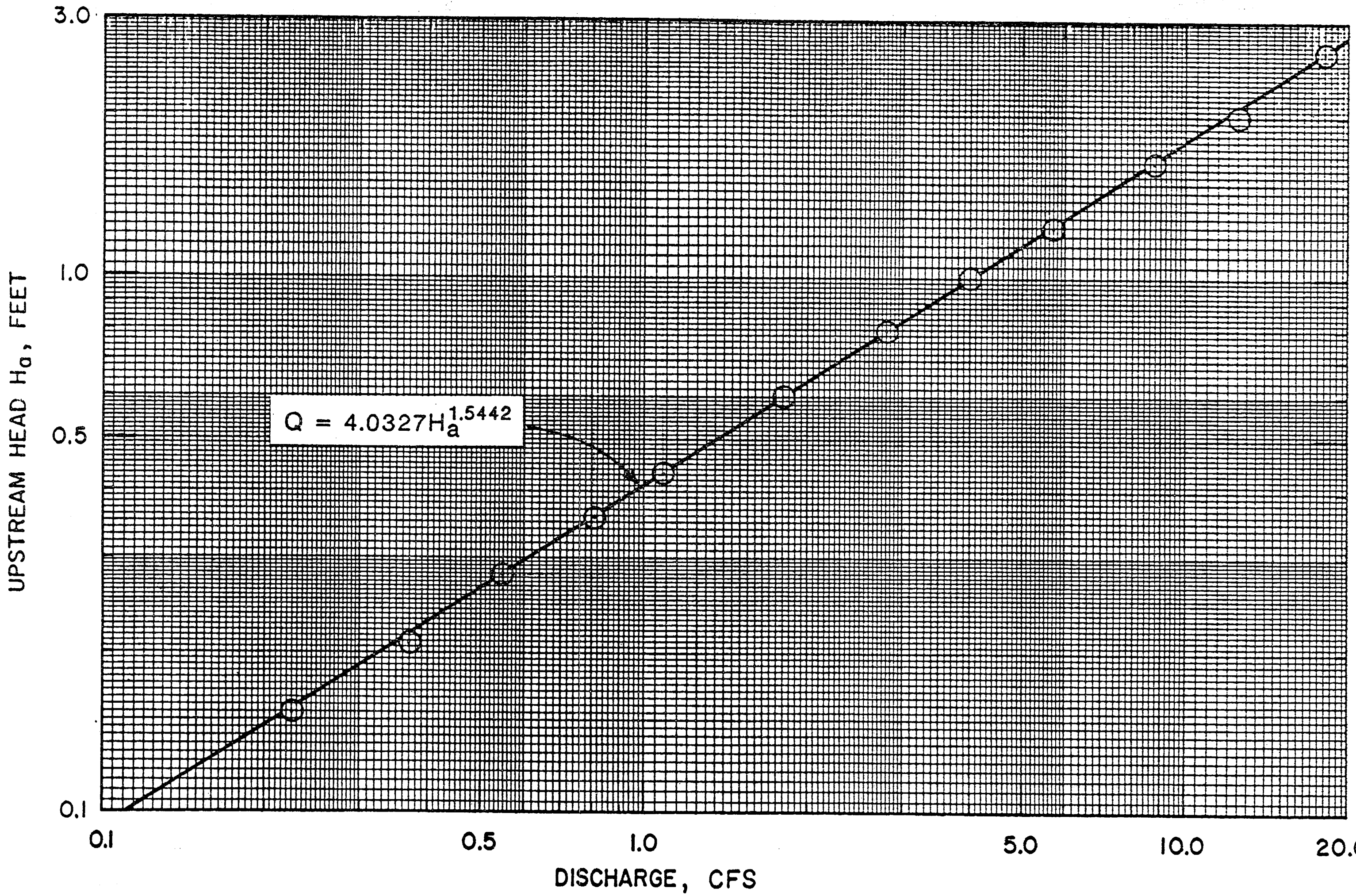



CHART 43

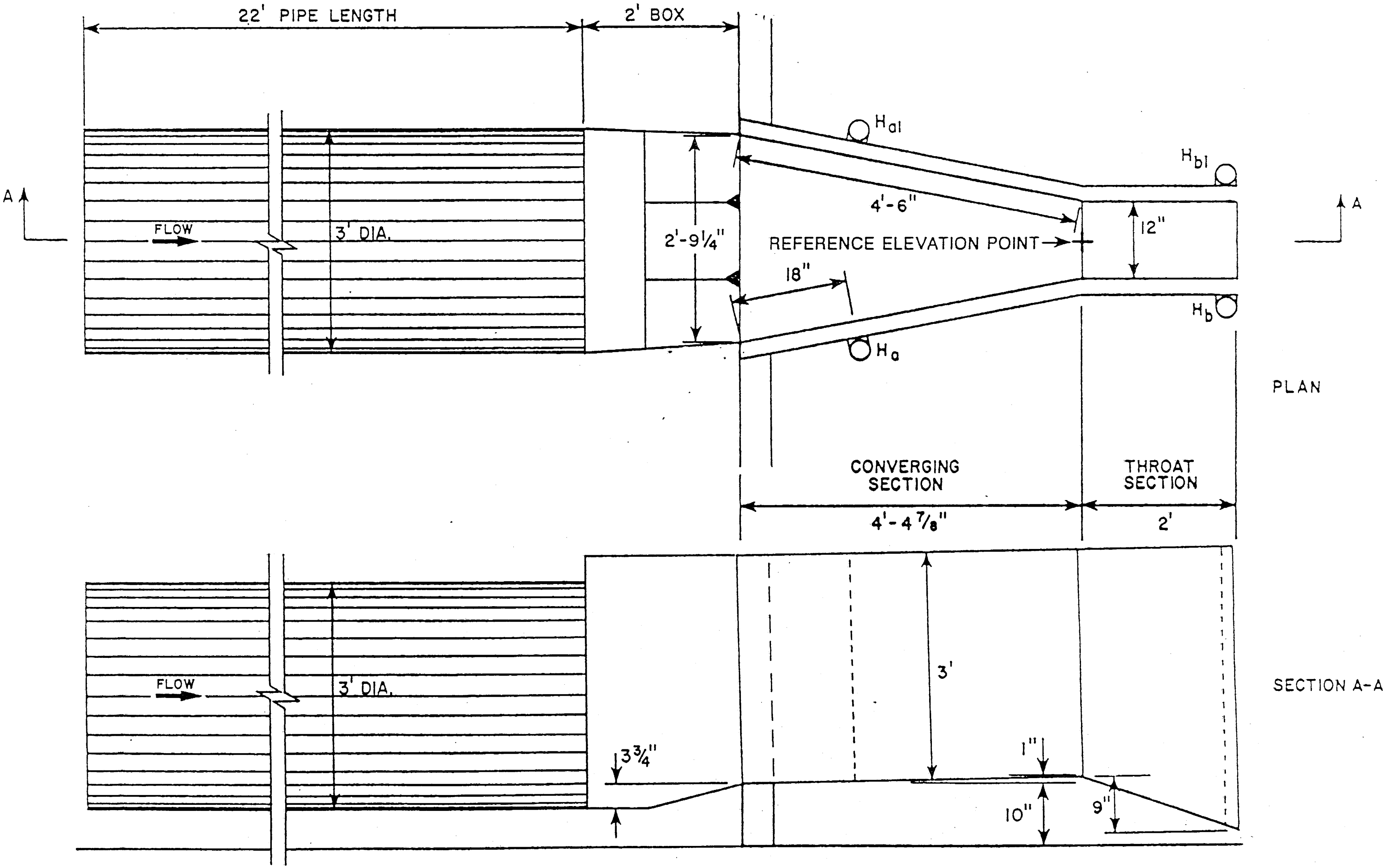
PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPE C12




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

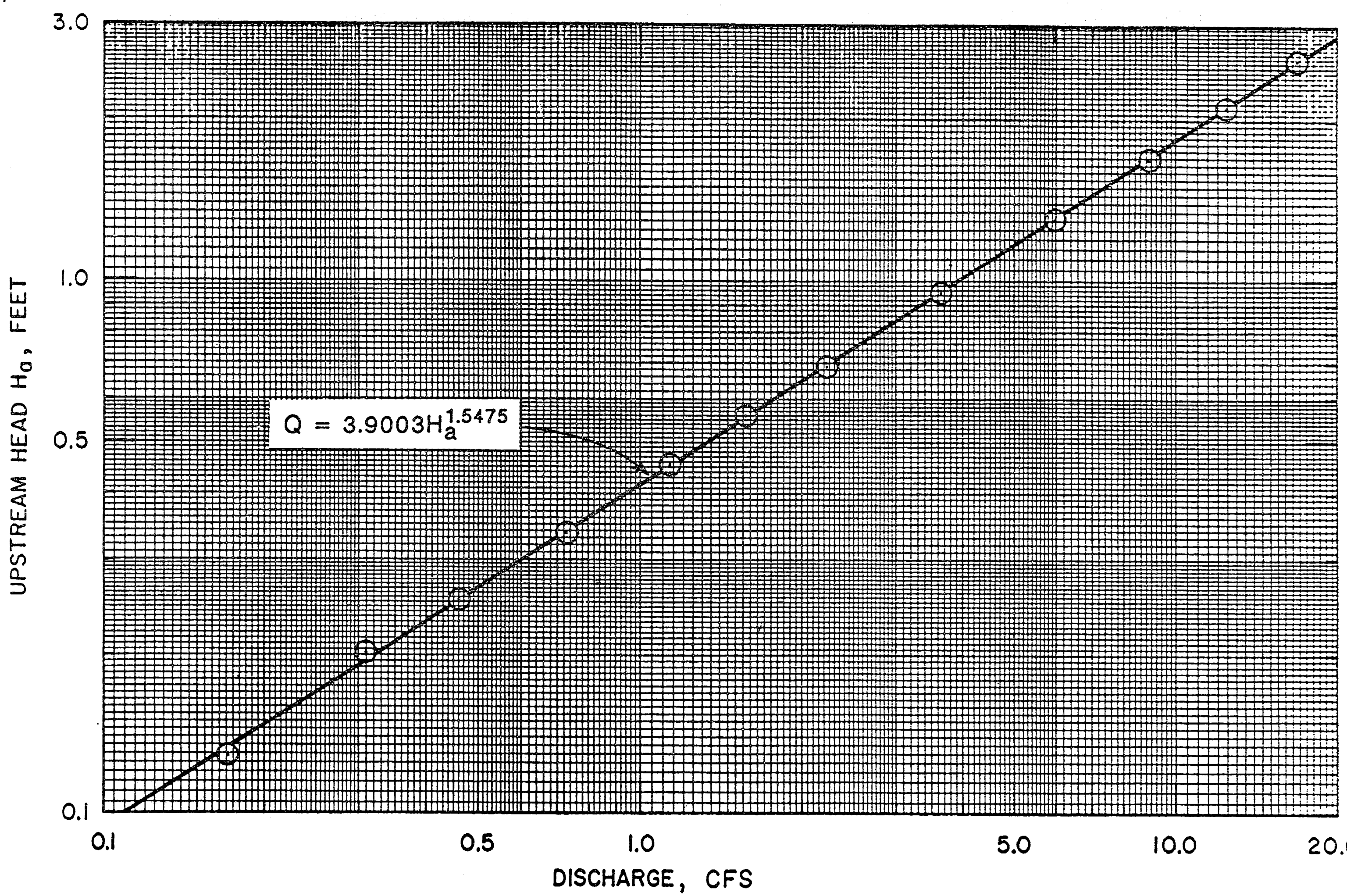
⊙ TYPE C12

CHART 44




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPE C13

CHART 45




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

⊙ TYPE C13

CHART 46

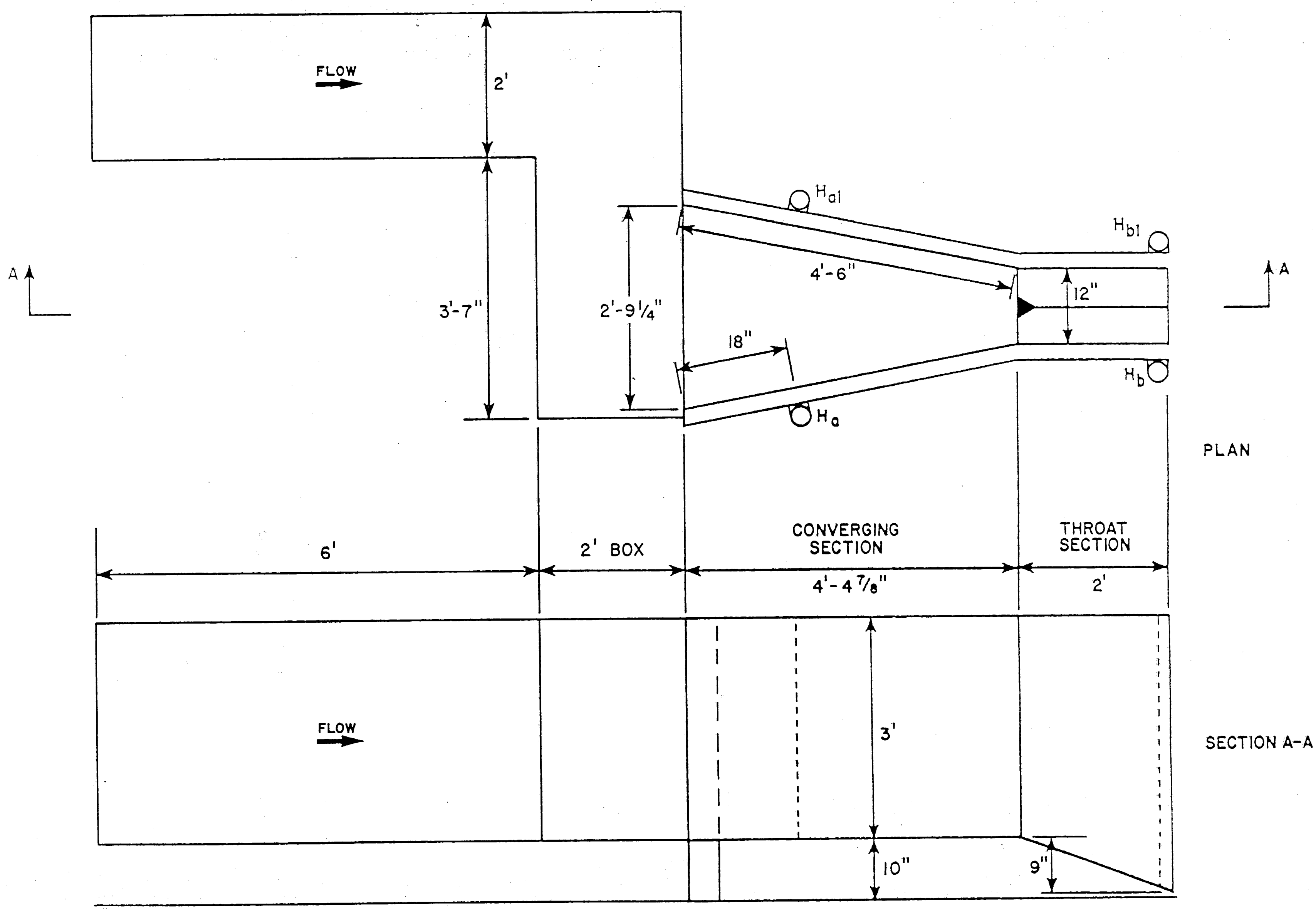
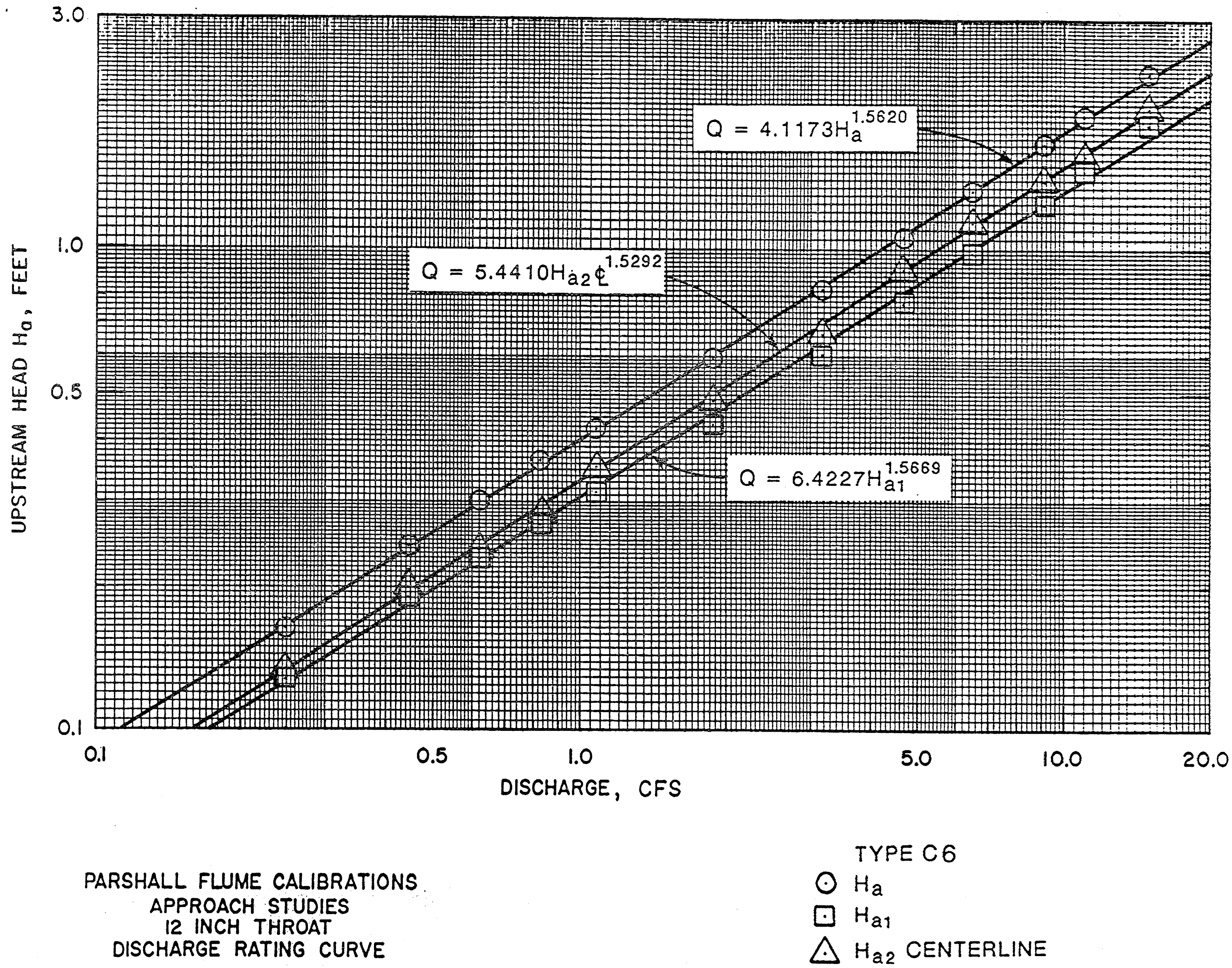



CHART 47

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
GEOMETRIES TESTED - TYPE C6




PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
DISCHARGE RATING CURVE

CHART 48

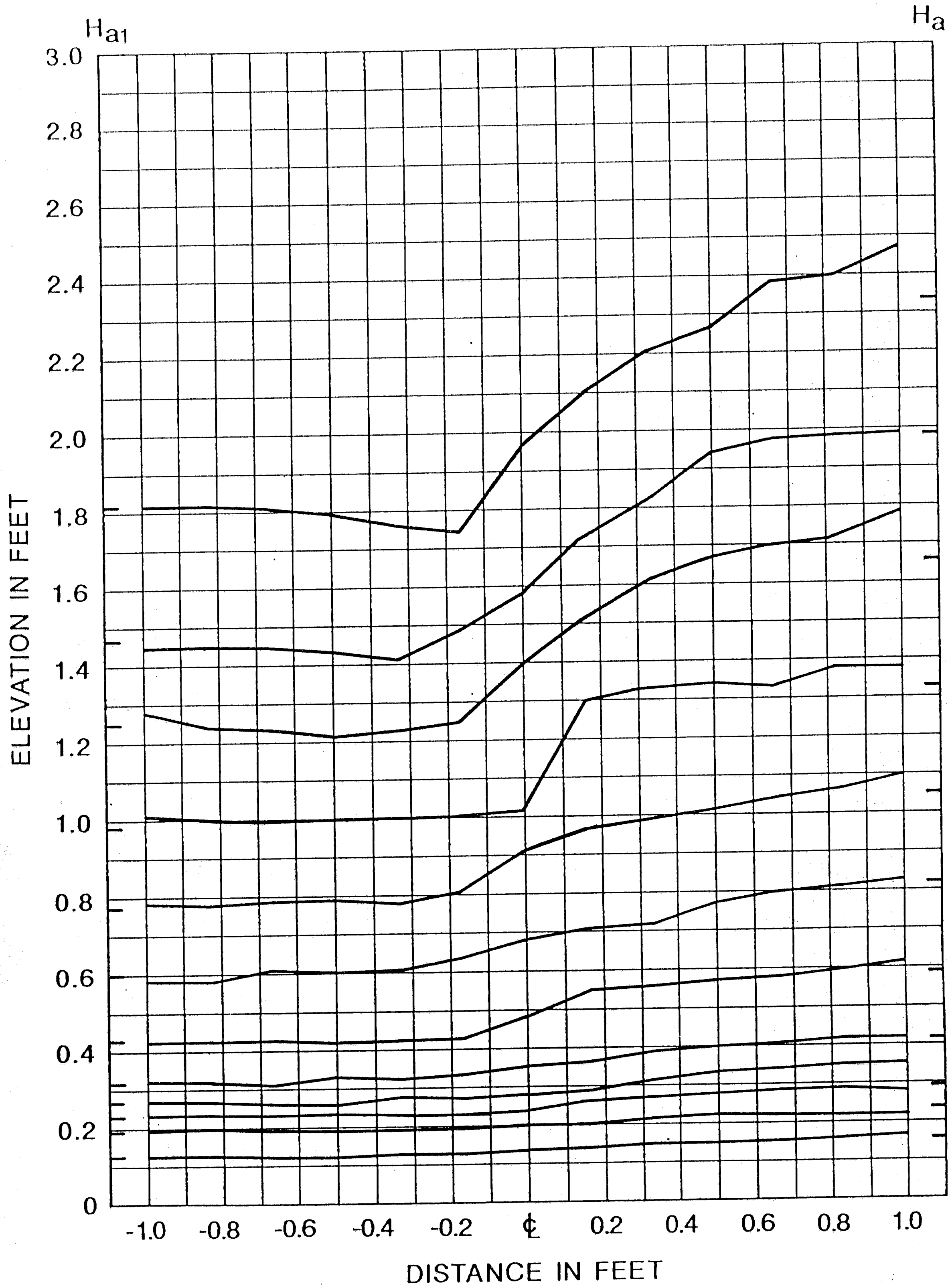



CHART 49

PARSHALL FLUME CALIBRATIONS
APPROACH STUDIES
12 INCH THROAT
WATER SURFACE PROFILES - $H_{a2}$
TYPE C6

# APPENDIX

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE A | Calibration Curve of Best Fit $Q = 3.9331\ H_a^{1.5693}$ | | | | |
| 2.550 | 16.773 | 17.089 | –1.85 | 16.627 | 0.88 |
| 2.257 | 14.021 | 14.110 | –0.63 | 13.808 | 1.54 |
| 2.040 | 12.092 | 12.040 | 0.43 | 11.839 | 2.14 |
| 2.040 | 11.992 | 12.040 | –0.40 | 11.839 | 1.29 |
| 1.850 | 10.438 | 10.328 | 1.07 | 10.202 | 2.31 |
| 1.850 | 10.374 | 10.328 | 0.45 | 10.202 | 1.68 |
| 1.603 | 8.272 | 8.248 | 0.29 | 8.203 | 0.84 |
| 1.073 | 4.570 | 4.393 | 4.03 | 4.453 | 2.63 |
| 0.838 | 2.981 | 2.980 | 0.02 | 3.057 | –2.47 |
| 0.582 | 1.682 | 1.682 | 0.00 | 1.755 | –4.16 |
| 0.582 | 1.681 | 1.682 | –0.06 | 1.755 | –4.22 |
| 0.582 | 1.680 | 1.682 | –0.12 | 1.755 | –4.27 |
| 0.481 | 1.233 | 1.247 | –1.14 | 1.313 | –6.10 |
| 0.460 | 1.147 | 1.163 | –1.36 | 1.227 | –6.51 |
| 0.460 | 1.143 | 1.163 | –1.70 | 1.227 | –6.83 |
| 0.304 | 0.6167 | 0.6070 | 1.59 | 0.6531 | –5.58 |
| 0.302 | 0.5968 | 0.6008 | –0.66 | 0.6466 | –7.70 |
| 0.185 | 0.2727 | 0.2784 | –2.06 | 0.3067 | –11.08 |
| 0.119 | 0.1425 | 0.1393 | 2.29 | 0.1567 | –9.06 |
| TYPE A1 | Calibration Curve of Best Fit $Q = 3.9154\ H_a^{1.5730}$ | | | | |
| 2.537 | 16.583 | 16.935 | –2.08 | 16.498 | 0.51 |
| 2.262 | 13.973 | 14.138 | –1.17 | 13.855 | 0.85 |
| 2.037 | 11.934 | 11.990 | –0.47 | 11.813 | 1.03 |
| 1.848 | 10.359 | 10.287 | 0.70 | 10.186 | 1.70 |
| 1.598 | 8.197 | 8.185 | 0.15 | 8.164 | 0.40 |
| 1.073 | 4.559 | 4.374 | 4.22 | 4.453 | 2.39 |
| 0.840 | 2.991 | 2.976 | 0.50 | 3.068 | –2.50 |
| 0.582 | 1.670 | 1.671 | –0.07 | 1.755 | –4.84 |
| 0.480 | 1.234 | 1.234 | 0.00 | 1.309 | –5.72 |
| 0.461 | 1.148 | 1.158 | –0.88 | 1.231 | –6.73 |
| 0.304 | 0.6023 | 0.6016 | 0.11 | 0.6531 | –7.78 |
| 0.304 | 0.6013 | 0.6016 | –0.06 | 0.6531 | –7.93 |
| 0.184 | 0.2739 | 0.2731 | 0.29 | 0.3042 | –9.95 |
| 0.119 | 0.1361 | 0.1376 | –1.09 | 0.1567 | –13.14 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE A2 | Calibration Curve of Best Fit $Q = 3.8886\ H_a^{1.5736}$ | | | | |
| 2.537 | 16.695 | 16.828 | –0.79 | 16.498 | 1.19 |
| 2.262 | 13.421 | 14.048 | –4.47 | 13.855 | –3.13 |
| 2.039 | 11.930 | 11.931 | –0.01 | 11.830 | 0.84 |
| 1.842 | 10.317 | 10.168 | 1.46 | 10.135 | 1.79 |
| 1.596 | 8.191 | 8.115 | 0.94 | 8.149 | 0.52 |
| 1.403 | 6.482 | 6.625 | –2.16 | 6.697 | –3.21 |
| 1.073 | 4.542 | 4.345 | 4.54 | 4.453 | 2.00 |
| 0.839 | 2.975 | 2.950 | 0.85 | 3.062 | –2.85 |
| 0.628 | 1.858 | 1.870 | –0.65 | 1.970 | –5.70 |
| 0.580 | 1.668 | 1.650 | 1.08 | 1.746 | –4.46 |
| 0.480 | 1.234 | 1.225 | 0.72 | 1.309 | –5.72 |
| 0.460 | 1.154 | 1.146 | 0.72 | 1.227 | –5.93 |
| 0.460 | 1.150 | 1.146 | 0.37 | 1.227 | –6.26 |
| 0.303 | 0.5999 | 0.5940 | 0.99 | 0.6499 | –7.69 |
| 0.187 | 0.2777 | 0.2779 | –0.09 | 0.3117 | –10.92 |
| 0.187 | 0.2750 | 0.2779 | –1.06 | 0.3117 | –11.79 |
| 0.119 | 0.1335 | 0.1365 | –2.18 | 0.1567 | –14.80 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B | Calibration Curve of Best Fit $Q = 3.8844\ H_a^{1.5890}$ | | | | |
| 2.614 | 17.234 | 17.882 | –3.63 | 17.266 | –0.19 |
| 2.232 | 13.620 | 13.912 | –2.10 | 13.576 | –2.33 |
| 1.770 | 9.507 | 9.624 | –1.22 | 9.538 | –0.33 |
| 1.532 | 7.644 | 7.651 | –0.09 | 7.656 | –0.16 |
| 1.247 | 5.744 | 5.516 | 4.12 | 5.597 | 2.62 |
| 1.070 | 4.351 | 4.325 | 0.59 | 4.434 | –1.87 |
| 0.673 | 2.053 | 2.070 | –0.84 | 2.189 | –6.22 |
| 0.605 | 1.761 | 1.748 | 0.75 | 1.862 | –5.41 |
| 0.605 | 1.755 | 1.748 | 0.40 | 1.862 | –5.73 |
| 0.505 | 1.326 | 1.312 | 1.09 | 1.414 | –6.23 |
| 0.356 | 0.7591 | 0.7526 | 0.86 | 0.8306 | –8.60 |
| 0.194 | 0.3171 | 0.2868 | 10.55 | 0.3297 | –3.82 |
| 0.175 | 0.2454 | 0.2435 | 0.78 | 0.2818 | –12.92 |
| 0.096 | 0.0844 | 0.0938 | –10.01 | 0.1130 | –25.31 |
| TYPE B1 | Calibration Curve of Best Fit $Q = 3.8553\ H_a^{1.6153}$ | | | | |
| 2.597 | 17.050 | 18.012 | –5.34 | 17.096 | –0.27 |
| 2.222 | 13.562 | 14.001 | –3.13 | 13.484 | 0.58 |
| 1.770 | 9.514 | 9.696 | –1.88 | 9.538 | –0.26 |
| 1.533 | 7.655 | 7.687 | –0.42 | 7.664 | –0.12 |
| 1.248 | 5.678 | 5.514 | 2.79 | 5.604 | 1.32 |
| 1.070 | 4.377 | 4.301 | 1.78 | 4.434 | –1.28 |
| 0.677 | 2.126 | 2.053 | 3.55 | 2.209 | –3.76 |
| 0.604 | 1.776 | 1.708 | 4.01 | 1.857 | –4.36 |
| 0.505 | 1.305 | 1.279 | 2.05 | 1.414 | –7.71 |
| 0.355 | 0.7655 | 0.7237 | 5.78 | 0.8270 | –7.44 |
| 0.177 | 0.2313 | 0.2351 | –1.63 | 0.2867 | –19.33 |
| 0.104 | 0.0908 | 0.0996 | –8.84 | 0.1276 | –28.86 |
| 0.097 | 0.0909 | 0.0890 | 2.13 | 0.1148 | –20.82 |
| TYPE B2 | Calibration Curve of Best Fit $Q = 3.9108\ H_a^{1.5560}$ | | | | |
| 2.600 | 18.000 | 17.297 | 4.07 | 17.126 | 5.10 |
| 2.216 | 13.428 | 13.489 | –0.45 | 13.428 | 0.00 |
| 1.771 | 9.515 | 9.517 | –0.02 | 9.547 | –0.33 |
| 1.533 | 7.705 | 7.603 | 1.35 | 7.664 | 0.54 |
| 1.247 | 5.643 | 5.514 | 2.35 | 5.597 | 0.82 |
| 1.070 | 4.233 | 4.345 | –2.58 | 4.434 | –4.53 |
| 0.677 | 2.139 | 2.131 | 0.36 | 2.209 | –3.17 |
| 0.604 | 1.750 | 1.785 | –1.94 | 1.857 | –5.76 |
| 0.508 | 1.339 | 1.363 | –1.78 | 1.427 | –6.16 |
| 0.354 | 0.7580 | 0.7772 | –2.47 | 0.8235 | –7.95 |
| 0.177 | 0.2322 | 0.2643 | –12.15 | 0.2867 | –19.02 |
| 0.111 | 0.1475 | 0.1279 | 15.35 | 0.1409 | 4.65 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |

Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$

| | | | | | |
|---|---|---|---|---|---|
| TYPE B3 | Calibration Curve of Best Fit $Q = 3.9054\ H_a^{1.5350}$ | | | | |
| 2.665 | 17.621 | 17.584 | 0.21 | 17.782 | –0.90 |
| 2.606 | 16.846 | 16.990 | –0.85 | 17.186 | –1.98 |
| 2.064 | 12.004 | 11.878 | 1.06 | 12.052 | –0.40 |
| 1.983 | 11.391 | 11.170 | 1.98 | 11.339 | 0.46 |
| 1.698 | 9.004 | 8.803 | 2.29 | 8.954 | 0.56 |
| 1.396 | 6.693 | 6.517 | 2.70 | 6.646 | 0.70 |
| 1.183 | 5.111 | 5.055 | 1.11 | 5.166 | –1.06 |
| 0.924 | 3.511 | 3.459 | 1.50 | 3.547 | –1.00 |
| 0.622 | 2.038 | 2.073 | –1.71 | 2.135 | –4.55 |
| 0.608 | 1.768 | 1.820 | –2.83 | 1.876 | –5.74 |
| 0.510 | 1.340 | 1.389 | –3.54 | 1.435 | –6.65 |
| 0.360 | 0.7761 | 0.8139 | –4.65 | 0.8448 | –8.13 |
| 0.248 | 0.4204 | 0.4594 | –8.48 | 0.4791 | –12.25 |
| 0.118 | 0.1655 | 0.1469 | 12.67 | 0.1547 | 6.99 |
| TYPE B4 | Calibration Curve of Best Fit $Q = 3.8865\ H_a^{1.5495}$ | | | | |
| 2.665 | 17.804 | 17.749 | 0.31 | 17.782 | 0.13 |
| 2.604 | 17.259 | 17.124 | 0.79 | 17.166 | 0.54 |
| 2.066 | 11.992 | 11.963 | 0.24 | 12.070 | –0.64 |
| 1.983 | 11.232 | 11.227 | 0.05 | 11.339 | –0.95 |
| 1.701 | 8.930 | 8.852 | 0.88 | 8.978 | –0.54 |
| 1.399 | 6.694 | 6.539 | 2.37 | 6.668 | 0.39 |
| 1.189 | 5.110 | 5.082 | 0.55 | 5.206 | –1.84 |
| 0.922 | 3.451 | 3.427 | 0.70 | 3.535 | –2.37 |
| 0.661 | 2.037 | 2.046 | –0.45 | 2.130 | –4.37 |
| 0.606 | 1.772 | 1.789 | –0.93 | 1.866 | –5.05 |
| 0.512 | 1.354 | 1.377 | –1.70 | 1.444 | –6.23 |
| 0.360 | 0.7697 | 0.7981 | –3.56 | 0.8448 | –8.89 |
| 0.249 | 0.4183 | 0.4508 | –7.21 | 0.4820 | –13.22 |
| 0.110 | 0.1382 | 0.1271 | 8.72 | 0.1390 | –0.59 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |

Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$

TYPE B5 Calibration Curve of Best Fit $Q = 3.8671\ H_a^{1.5883}$

| | | | | | |
|---|---|---|---|---|---|
| 2.666 | 17.676 | 18.356 | –3.70 | 17.792 | –0.65 |
| 2.605 | 17.309 | 17.694 | –2.17 | 17.176 | 0.78 |
| 2.064 | 12.096 | 12.225 | –1.05 | 12.052 | 0.37 |
| 1.980 | 11.494 | 11.444 | 0.44 | 11.313 | 1.60 |
| 1.700 | 8.986 | 8.983 | 0.04 | 8.970 | 0.18 |
| 1.399 | 6.712 | 6.592 | 1.83 | 6.668 | 0.66 |
| 1.191 | 5.221 | 5.105 | 2.28 | 5.219 | 0.04 |
| 0.922 | 3.460 | 3.399 | 1.79 | 3.535 | –2.12 |
| 0.659 | 2.001 | 1.994 | 0.35 | 2.120 | –5.63 |
| 0.606 | 1.762 | 1.745 | 0.95 | 1.866 | –5.59 |
| 0.516 | 1.376 | 1.352 | 1.77 | 1.461 | –5.83 |
| 0.360 | 0.7711 | 0.7632 | 1.03 | 0.8448 | –8.72 |
| 0.249 | 0.4283 | 0.4250 | 0.78 | 0.4820 | –11.15 |
| 0.107 | 0.1066 | 0.1111 | –4.05 | 0.1333 | –20.02 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B6 | Calibration Curve of Best Fit $Q = 3.8856\ H_a^{1.6128}$ | | | | |
| 2.493 | 16.184 | 16.955 | –4.55 | 16.065 | 0.74 |
| 2.090 | 12.303 | 12.758 | –3.57 | 12.284 | 0.16 |
| 1.720 | 9.221 | 9.318 | –1.04 | 9.131 | 0.98 |
| 1.431 | 7.006 | 6.926 | 1.16 | 6.902 | 1.51 |
| 1.201 | 5.341 | 5.221 | 2.30 | 5.286 | 1.04 |
| 0.960 | 3.696 | 3.638 | 1.59 | 3.759 | –1.68 |
| 0.937 | 3.538 | 3.499 | 1.13 | 3.623 | –2.34 |
| 0.604 | 1.763 | 1.723 | 2.31 | 1.857 | –5.06 |
| 0.510 | 1.335 | 1.312 | 1.78 | 1.435 | –7.00 |
| 0.354 | 0.7532 | 0.7279 | 3.47 | 0.8235 | –8.53 |
| 0.249 | 0.4227 | 0.4127 | 2.42 | 0.4820 | –12.31 |
| 0.090 | 0.0748 | 0.0800 | –6.45 | 0.1024 | –26.97 |
| TYPE B7 | Calibration Curve of Best Fit $Q = 3.8814\ H_a^{1.6053}$ | | | | |
| 2.493 | 15.997 | 16.821 | –4.90 | 16.065 | –0.42 |
| 2.089 | 12.274 | 12.664 | –3.08 | 12.275 | 0.00 |
| 1.720 | 9.217 | 9.270 | –0.57 | 9.131 | 0.94 |
| 1.445 | 6.933 | 7.009 | –1.08 | 7.005 | –1.02 |
| 1.196 | 5.323 | 5.173 | 2.89 | 5.253 | 1.34 |
| 0.960 | 3.705 | 3.635 | 1.92 | 3.759 | –1.44 |
| 0.938 | 3.564 | 3.502 | 1.76 | 3.629 | –1.78 |
| 0.604 | 1.765 | 1.728 | 2.15 | 1.857 | –4.95 |
| 0.508 | 1.356 | 1.309 | 3.62 | 1.427 | –4.97 |
| 0.354 | 0.7503 | 0.7328 | 2.38 | 0.8235 | –8.88 |
| 0.249 | 0.4245 | 0.4166 | 1.90 | 0.4820 | –11.94 |
| 0.091 | 0.0775 | 0.0828 | –6.38 | 0.1042 | –25.60 |
| TYPE B8 | Calibration Curve of Best Fit $Q = 3.8878\ H_a^{1.6003}$ | | | | |
| 2.494 | 16.048 | 16.783 | –4.38 | 16.075 | –0.16 |
| 2.079 | 12.180 | 12.542 | –2.89 | 12.185 | –0.04 |
| 1.719 | 9.172 | 9.252 | –0.86 | 9.123 | 0.53 |
| 1.443 | 7.035 | 6.992 | 0.62 | 6.990 | 0.65 |
| 1.190 | 5.249 | 5.136 | 2.21 | 5.213 | 0.70 |
| 0.962 | 3.670 | 3.654 | 0.44 | 3.771 | –2.68 |
| 0.938 | 3.567 | 3.509 | 1.64 | 3.629 | –1.70 |
| 0.605 | 1.775 | 1.740 | 2.04 | 1.862 | –4.65 |
| 0.508 | 1.351 | 1.315 | 2.72 | 1.427 | –5.32 |
| 0.354 | 0.7544 | 0.7379 | 2.24 | 0.8235 | –8.39 |
| 0.250 | 0.4353 | 0.4229 | 2.93 | 0.4850 | –10.24 |
| 0.091 | 0.0787 | 0.0839 | –6.22 | 0.1042 | –24.45 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |

Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$

| | | | | | |
|---|---|---|---|---|---|
| TYPE B9 | Calibration Curve of Best Fit $Q = 3.8925\ H_a^{1.5653}$ | | | | |
| 2.485 | 15.790 | 16.182 | –2.42 | 15.986 | –1.23 |
| 2.163 | 12.960 | 13.022 | –0.48 | 12.942 | 0.14 |
| 2.006 | 11.532 | 11.574 | –0.36 | 11.540 | –0.07 |
| 1.754 | 9.402 | 9.380 | 0.23 | 9.408 | –0.06 |
| 1.450 | 7.036 | 6.963 | 1.04 | 7.041 | –0.08 |
| 1.199 | 5.313 | 5.171 | 2.74 | 5.273 | 0.77 |
| 0.909 | 3.370 | 3.353 | 0.52 | 3.459 | –2.58 |
| 0.679 | 2.111 | 2.124 | –0.59 | 2.219 | –4.87 |
| 0.595 | 1.733 | 1.727 | 0.35 | 1.815 | –4.52 |
| 0.502 | 1.323 | 1.324 | –0.04 | 1.401 | –5.59 |
| 0.301 | 0.5715 | 0.5943 | –3.84 | 0.6433 | –11.17 |
| 0.174 | 0.2707 | 0.2520 | 7.41 | 0.2794 | –3.10 |
| 0.099 | 0.1000 | 0.1043 | –4.08 | 0.1184 | –15.55 |
| TYPE B10 | Calibration Curve of Best Fit $Q = 3.8947\ H_a^{1.5685}$ | | | | |
| 2.482 | 15.887 | 16.208 | –1.98 | 15.927 | –0.44 |
| 2.162 | 12.912 | 13.053 | –1.08 | 12.933 | –0.16 |
| 2.006 | 11.490 | 11.606 | –1.00 | 11.540 | –0.43 |
| 1.756 | 9.461 | 9.419 | 0.44 | 9.424 | 0.39 |
| 1.450 | 7.045 | 6.976 | 1.00 | 7.041 | 0.05 |
| 1.199 | 5.339 | 5.177 | 3.12 | 5.273 | 1.26 |
| 0.907 | 3.347 | 3.342 | 0.16 | 3.448 | –2.92 |
| 0.677 | 2.131 | 2.112 | 0.89 | 2.209 | –3.54 |
| 0.593 | 1.723 | 1.716 | 0.41 | 1.806 | –4.58 |
| 0.500 | 1.317 | 1.313 | 0.29 | 1.393 | –5.44 |
| 0.303 | 0.5909 | 0.5986 | –1.28 | 0.6499 | –9.07 |
| 0.168 | 0.2344 | 0.2373 | –1.24 | 0.2648 | –11.49 |
| 0.103 | 0.1106 | 0.1102 | 0.38 | 0.1258 | –12.07 |
| TYPE B11 | Calibration Curve of Best Fit $Q = 3.9067\ H_a^{1.5505}$ | | | | |
| 2.490 | 15.863 | 16.074 | –1.31 | 16.035 | –1.07 |
| 2.164 | 12.840 | 12.931 | –0.70 | 12.952 | –0.86 |
| 2.004 | 11.508 | 11.479 | 0.25 | 11.523 | –0.13 |
| 1.759 | 9.500 | 9.378 | 1.30 | 9.448 | 0.55 |
| 1.447 | 7.054 | 6.928 | 1.82 | 7.019 | 0.49 |
| 1.198 | 5.331 | 5.170 | 3.12 | 5.266 | 1.24 |
| 0.907 | 3.392 | 3.358 | 1.01 | 3.448 | –1.62 |
| 0.675 | 2.096 | 2.124 | –1.32 | 2.199 | –4.69 |
| 0.594 | 1.694 | 1.742 | –2.76 | 1.810 | –6.43 |
| 0.499 | 1.316 | 1.330 | –1.02 | 1.389 | –5.23 |
| 0.307 | 0.6300 | 0.6261 | 0.63 | 0.6630 | –4.97 |
| 0.167 | 0.2194 | 0.2436 | –9.92 | 0.2624 | –16.40 |
| 0.112 | 0.1443 | 0.1311 | 10.06 | 0.1429 | 0.99 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B12 | Calibration Curve of Best Fit $Q = 3.9042\ H_a^{1.5517}$ | | | | |
| 2.440 | 15.372 | 15.583 | –1.35 | 15.548 | –1.13 |
| 2.331 | 14.404 | 14.516 | –0.77 | 14.503 | –0.68 |
| 1.863 | 10.260 | 10.252 | 0.08 | 10.312 | –0.50 |
| 1.521 | 7.531 | 7.484 | 0.63 | 7.573 | –0.55 |
| 1.248 | 5.633 | 5.506 | 2.31 | 5.064 | 0.52 |
| 1.025 | 4.136 | 4.057 | 1.95 | 4.153 | –0.41 |
| 0.739 | 2.438 | 2.442 | –0.16 | 2.524 | –3.42 |
| 0.602 | 1.770 | 1.776 | –0.36 | 1.848 | –4.20 |
| 0.508 | 1.348 | 1.365 | –1.24 | 1.427 | –5.53 |
| 0.338 | 0.7155 | 0.7254 | –1.36 | 0.7675 | –6.77 |
| 0.231 | 0.3958 | 0.4018 | –1.50 | 0.4300 | –7.96 |
| 0.132 | 0.1725 | 0.1686 | 2.30 | 0.1835 | –5.98 |
| 0.126 | 0.1563 | 0.1569 | –0.37 | 0.1709 | –8.56 |
| TYPE B13 | Calibration Curve of Best Fit $Q = 3.9070\ H_a^{1.5672}$ | | | | |
| 2.435 | 15.432 | 15.760 | –2.08 | 15.499 | –0.43 |
| 2.330 | 14.481 | 14.708 | –1.55 | 14.494 | –0.09 |
| 1.862 | 10.316 | 10.350 | –0.33 | 10.303 | 0.12 |
| 1.514 | 7.483 | 7.484 | –0.01 | 7.520 | –0.49 |
| 1.248 | 5.676 | 5.529 | 2.66 | 5.604 | 1.28 |
| 1.022 | 4.140 | 4.043 | 2.41 | 4.135 | 0.13 |
| 0.740 | 2.447 | 2.437 | 0.40 | 2.530 | –3.26 |
| 0.602 | 1.764 | 1.764 | 0.00 | 1.848 | –4.52 |
| 0.508 | 1.349 | 1.352 | –0.20 | 1.427 | –5.46 |
| 0.338 | 0.7118 | 0.7138 | –0.28 | 0.7675 | –7.26 |
| 0.231 | 0.3968 | 0.3931 | 0.94 | 0.4300 | –7.72 |
| 0.132 | 0.1605 | 0.1635 | –1.86 | 0.1835 | –12.52 |
| TYPE B14 | Calibration Curve of Best Fit $Q = 3.9314\ H_a^{1.5542}$ | | | | |
| 2.435 | 15.698 | 15.676 | 0.14 | 15.499 | 1.28 |
| 2.326 | 14.494 | 15.599 | –0.72 | 14.456 | 0.26 |
| 1.862 | 10.286 | 10.331 | –0.44 | 10.303 | –0.17 |
| 1.514 | 7.475 | 7.490 | –0.20 | 7.520 | –0.60 |
| 1.248 | 5.665 | 5.547 | 2.12 | 5.604 | 1.09 |
| 1.025 | 4.125 | 4.085 | 0.97 | 4.153 | –0.68 |
| 0.743 | 2.481 | 2.478 | 0.14 | 2.545 | –2.52 |
| 0.602 | 1.760 | 1.787 | –1.48 | 1.848 | –4.74 |
| 0.508 | 1.370 | 1.372 | –0.16 | 1.427 | –3.99 |
| 0.338 | 0.7120 | 0.7284 | –2.26 | 0.7675 | –7.23 |
| 0.229 | 0.4055 | 0.3977 | 1.95 | 0.4244 | –4.44 |
| 0.126 | 0.1572 | 0.1572 | 0.00 | 0.1709 | –8.03 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B15 | Calibration Curve of Best Fit $Q = 3.9338\ H_a^{1.5223}$ | | | | |
| 2.578 | 16.748 | 16.631 | 0.71 | 16.906 | –0.93 |
| 2.116 | 12.446 | 12.313 | 1.08 | 12.517 | –0.57 |
| 1.820 | 9.940 | 9.789 | 1.55 | 9.952 | –0.12 |
| 1.501 | 7.435 | 7.300 | 1.85 | 7.422 | 0.18 |
| 1.230 | 5.496 | 5.391 | 1.95 | 5.482 | 0.27 |
| 0.975 | 3.807 | 3.785 | 0.58 | 3.849 | –1.09 |
| 0.742 | 2.466 | 2.498 | –1.27 | 2.540 | –2.91 |
| 0.601 | 1.766 | 1.812 | –2.55 | 1.843 | –4.17 |
| 0.473 | 1.209 | 1.259 | –3.93 | 1.280 | –5.54 |
| 0.353 | 0.7765 | 0.8061 | –3.67 | 0.8199 | –5.30 |
| 0.245 | 0.4430 | 0.4623 | –4.18 | 0.4703 | –5.80 |
| 0.138 | 0.1935 | 0.1930 | 0.28 | 0.1963 | –1.43 |
| 0.110 | 0.1479 | 0.1366 | 8.25 | 0.1390 | 6.39 |
| TYPE B16 | Calibration Curve of Best Fit $Q = 3.9499\ H_a^{1.5134}$ | | | | |
| 2.573 | 17.010 | 16.510 | 3.03 | 16.856 | 0.91 |
| 2.112 | 12.539 | 12.246 | 2.40 | 12.481 | 0.47 |
| 1.820 | 10.016 | 9.776 | 2.45 | 9.952 | 0.65 |
| 1.499 | 7.425 | 7.289 | 1.87 | 7.407 | 0.25 |
| 1.230 | 5.519 | 5.403 | 2.14 | 5.482 | 0.69 |
| 0.975 | 3.792 | 3.801 | –0.25 | 3.849 | –1.48 |
| 0.742 | 2.457 | 2.515 | –2.29 | 2.540 | –3.26 |
| 0.601 | 1.773 | 1.828 | –3.00 | 1.843 | –3.79 |
| 0.473 | 1.211 | 1.272 | –4.80 | 1.280 | –5.39 |
| 0.353 | 0.7569 | 0.8169 | –7.35 | 0.8199 | –7.69 |
| 0.249 | 0.4415 | 0.4817 | –8.35 | 0.4820 | –8.41 |
| 0.138 | 0.2005 | 0.1972 | 1.68 | 0.1963 | 2.13 |
| 0.108 | 0.1557 | 0.1361 | 14.42 | 0.1352 | 15.17 |
| TYPE B17 | Calibration Curve of Best Fit $Q = 3.9402\ H_a^{1.5166}$ | | | | |
| 2.557 | 16.782 | 16.364 | 2.56 | 16.697 | 0.51 |
| 2.114 | 12.562 | 12.263 | 2.44 | 12.499 | 0.51 |
| 1.820 | 9.978 | 9.771 | 2.12 | 9.952 | 0.27 |
| 1.499 | 7.415 | 7.280 | 1.85 | 7.407 | 0.11 |
| 1.230 | 5.512 | 5.394 | 2.20 | 5.482 | 0.56 |
| 0.976 | 3.794 | 3.798 | –0.10 | 3.855 | –1.58 |
| 0.738 | 2.398 | 2.486 | –3.52 | 2.519 | –4.81 |
| 0.602 | 1.769 | 1.825 | –3.07 | 1.848 | –4.25 |
| 0.473 | 1.220 | 1.266 | –3.63 | 1.280 | –4.69 |
| 0.353 | 0.7558 | 0.8122 | –6.95 | 0.8199 | –7.82 |
| 0.248 | 0.4430 | 0.4755 | –6.83 | 0.4791 | –7.53 |
| 0.138 | 0.2039 | 0.1955 | 4.32 | 0.1963 | 3.86 |
| 0.109 | 0.1503 | 0.1367 | 9.97 | 0.1371 | 9.63 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B18 | Calibration Curve of Best Fit $Q = 3.8973\ H_a^{1.5552}$ | | | | |
| 2.607 | 17.070 | 17.296 | –1.31 | 17.196 | –0.73 |
| 2.083 | 12.103 | 12.201 | –0.80 | 12.221 | –0.97 |
| 1.770 | 9.546 | 9.471 | 0.79 | 9.538 | 0.08 |
| 1.493 | 7.273 | 7.269 | 0.06 | 7.362 | –1.21 |
| 1.286 | 5.813 | 5.763 | 0.87 | 5.866 | –0.90 |
| 1.028 | 4.145 | 4.068 | 1.88 | 4.172 | –0.64 |
| 0.748 | 2.497 | 2.481 | 0.64 | 2.571 | –2.89 |
| 0.602 | 1.773 | 1.770 | 0.17 | 1.848 | –4.04 |
| 0.508 | 1.354 | 1.359 | –0.39 | 1.427 | –5.11 |
| 0.350 | 0.7463 | 0.7616 | –2.00 | 0.8093 | –7.79 |
| 0.114 | 0.1283 | 0.1331 | –3.58 | 0.1468 | –12.59 |
| 0.095 | 0.1041 | 0.1002 | 3.88 | 0.1112 | –6.40 |
| TYPE B19 | Calibration Curve of Best Fit $Q = 3.9227^{1.5459}$ | | | | |
| 2.604 | 17.084 | 17.224 | –0.81 | 17.166 | –0.48 |
| 2.081 | 12.285 | 12.179 | 0.87 | 12.203 | 0.67 |
| 1.770 | 9.652 | 9.483 | 1.79 | 9.538 | 1.19 |
| 1.495 | 7.317 | 7.304 | 0.18 | 7.377 | –0.81 |
| 1.286 | 5.899 | 5.787 | 1.93 | 5.866 | 0.57 |
| 1.028 | 4.160 | 4.094 | 1.62 | 4.172 | –0.28 |
| 0.744 | 2.461 | 2.483 | –0.90 | 2.550 | –3.50 |
| 0.602 | 1.759 | 1.790 | –1.73 | 1.848 | –4.79 |
| 0.508 | 1.355 | 1.377 | –1.59 | 1.427 | –5.04 |
| 0.351 | 0.7446 | 0.7775 | –4.23 | 0.8129 | –8.40 |
| 0.109 | 0.1232 | 0.1275 | –3.38 | 0.1371 | –10.14 |
| 0.087 | 0.0960 | 0.0900 | 6.68 | 0.0973 | –1.31 |
| TYPE B20 | Calibration Cuve of Best Fit $Q = 3.9076\ H_a^{1.5618}$ | | | | |
| 2.585 | 16.962 | 17.222 | –1.51 | 16.976 | –0.08 |
| 2.078 | 12.147 | 12.246 | –0.81 | 12.176 | –0.24 |
| 1.771 | 9.676 | 9.541 | 1.42 | 9.547 | 1.36 |
| 1.493 | 7.380 | 7.307 | 0.99 | 7.362 | 0.25 |
| 1.284 | 5.773 | 5.774 | –0.02 | 5.852 | –1.35 |
| 1.024 | 4.143 | 4.055 | 2.17 | 4.147 | –0.10 |
| 0.746 | 2.465 | 2.473 | –0.31 | 2.561 | –3.74 |
| 0.600 | 1.763 | 1.760 | 0.19 | 1.838 | –4.09 |
| 0.508 | 1.353 | 1.357 | –0.28 | 1.427 | –5.18 |
| 0.351 | 0.7481 | 0.7617 | –1.78 | 0.8129 | –7.97 |
| 0.114 | 0.1256 | 0.1315 | –4.50 | 0.1468 | –14.43 |
| 0.087 | 0.0903 | 0.0862 | 4.72 | 0.0973 | –7.17 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B21 | Calibration Curve of Best Fit $Q = 3.9253\ H_a^{1.5358}$ | | | | |
| 2.565 | 16.758 | 16.678 | 0.48 | 16.776 | –0.11 |
| 2.110 | 12.519 | 12.357 | 1.31 | 12.463 | 0.45 |
| 1.788 | 9.669 | 9.582 | 0.91 | 9.684 | –0.18 |
| 1.518 | 7.611 | 7.452 | 2.13 | 7.550 | 0.81 |
| 1.257 | 5.5705 | 5.577 | –0.12 | 5.666 | –1.68 |
| 1.003 | 3.936 | 3.943 | –0.19 | 4.018 | –2.05 |
| 0.710 | 2.285 | 2.320 | –1.50 | 2.375 | –3.79 |
| 0.583 | 1.681 | 1.714 | –1.92 | 1.760 | –4.47 |
| 0.505 | 1.355 | 1.375 | –1.43 | 1.414 | –4.18 |
| 0.352 | 0.7566 | 0.7897 | –4.19 | 0.8164 | –7.32 |
| 0.235 | 0.4148 | 0.4246 | –2.30 | 0.4414 | –6.02 |
| 0.153 | 0.2356 | 0.2196 | 7.26 | 0.2297 | 2.57 |
| TYPE B22 | Calibration Curve of Best Fit $Q = 3.9540\ H_a^{1.5369}$ | | | | |
| 2.557 | 16.693 | 16.737 | –0.26 | 16.697 | –0.02 |
| 2.070 | 12.570 | 12.096 | 3.92 | 12.105 | 3.84 |
| 1.788 | 9.595 | 9.658 | –0.66 | 9.686 | –0.94 |
| 1.513 | 7.571 | 7.472 | 1.33 | 7.512 | 0.78 |
| 1.257 | 5.654 | 5.620 | 0.61 | 5.666 | –0.21 |
| 1.000 | 3.972 | 3.954 | 0.46 | 4.000 | –0.70 |
| 0.714 | 2.321 | 2.356 | –1.49 | 2.396 | –3.11 |
| 0.583 | 1.693 | 1.725 | –1.88 | 1.760 | –3.78 |
| 0.506 | 1.353 | 1.388 | –2.51 | 1.418 | –4.61 |
| 0.352 | 0.7597 | 0.7945 | –4.39 | 0.8164 | –6.94 |
| 0.233 | 0.4100 | 0.4214 | –2.71 | 0.4357 | –5.90 |
| 0.153 | 0.2389 | 0.2208 | 8.20 | 0.2297 | 4.01 |
| TYPE B23 | Calibration Curve of Best Fit $Q = 3.9331\ H_a^{1.5348}$ | | | | |
| 2.557 | 16.649 | 16.616 | 0.20 | 16.697 | –0.28 |
| 2.103 | 12.478 | 12.309 | 1.37 | 12.400 | 0.63 |
| 1.788 | 9.735 | 9.596 | 1.45 | 9.686 | 0.50 |
| 1.513 | 7.557 | 7.426 | 1.76 | 7.512 | 0.59 |
| 1.257 | 5.643 | 5.587 | 1.00 | 5.666 | –0.40 |
| 0.999 | 3.906 | 3.927 | –0.54 | 3.994 | –2.20 |
| 0.714 | 2.317 | 2.345 | –1.20 | 2.396 | –3.28 |
| 0.581 | 1.670 | 1.709 | –2.29 | 1.750 | –4.59 |
| 0.505 | 1.354 | 1.378 | –1.76 | 1.414 | –4.25 |
| 0.352 | 0.7587 | 0.7921 | –4.21 | 0.8164 | –7.07 |
| 0.235 | 0.4057 | 0.4260 | –4.77 | 0.4414 | –8.09 |
| 0.153 | 0.2420 | 0.2205 | 9.75 | 0.2297 | 5.35 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B24 | Calibration Curve of Best Fit $Q = 3.8846\ H_a^{1.5924}$ | | | | |
| 2.487 | 16.070 | 16.574 | –3.04 | 16.006 | 0.40 |
| 2.349 | 14.690 | 15.134 | –2.93 | 14.674 | 0.11 |
| 1.837 | 10.132 | 10.231 | –0.97 | 10.093 | 0.38 |
| 1.500 | 7.493 | 7.409 | 1.14 | 7.414 | 1.06 |
| 1.238 | 5.677 | 5.458 | 4.02 | 5.536 | 2.55 |
| 0.999 | 4.059 | 3.878 | 4.66 | 3.994 | 1.63 |
| 0.798 | 2.723 | 2.712 | 0.40 | 2.837 | –4.03 |
| 0.603 | 1.738 | 1.736 | 0.12 | 1.852 | –6.17 |
| 0.514 | 1.347 | 1.346 | 0.07 | 1.453 | –7.27 |
| 0.380 | 0.8311 | 0.8321 | –0.12 | 0.9173 | –9.39 |
| 0.304 | 0.5808 | 0.5833 | –0.42 | 0.6531 | –11.07 |
| 0.202 | 0.2963 | 0.3042 | –2.60 | 0.3506 | –15.49 |
| TYPE B25 | Calibration Curve of Best Fit $Q = 3.8984\ H_a^{1.5924}$ | | | | |
| 2.487 | 15.889 | 16.633 | –4.47 | 16.006 | –0.73 |
| 2.341 | 14.484 | 15.105 | –4.11 | 14.598 | –0.78 |
| 1.840 | 10.109 | 10.294 | –1.80 | 10.118 | –0.09 |
| 1.499 | 7.486 | 7.427 | 0.79 | 7.407 | 1.07 |
| 1.224 | 5.714 | 5.379 | 6.24 | 5.441 | 5.02 |
| 0.982 | 4.067 | 3.787 | 7.39 | 3.891 | 4.53 |
| 0.803 | 2.786 | 2.749 | 1.35 | 2.864 | –2.74 |
| 0.603 | 1.747 | 1.742 | 0.28 | 1.852 | –5.68 |
| 0.512 | 1.343 | 1.343 | 0.03 | 1.444 | –6.99 |
| 0.380 | 0.8335 | 0.8351 | –0.19 | 0.9173 | –9.13 |
| 0.300 | 0.5722 | 0.5731 | –0.16 | 0.6401 | –10.61 |
| 0.202 | 0.2913 | 0.3053 | –4.59 | 0.3506 | –16.91 |
| TYPE B26 | Calibration Curve of Best Fit $Q = 3.8994\ H_a^{1.5937}$ | | | | |
| 2.487 | 16.021 | 16.657 | –3.82 | 16.006 | 0.09 |
| 2.341 | 14.579 | 15.126 | –3.61 | 14.598 | –0.13 |
| 1.843 | 10.122 | 10.332 | –2.03 | 10.144 | –0.21 |
| 1.496 | 7.495 | 7.409 | 1.15 | 7.384 | 1.50 |
| 1.224 | 5.710 | 5.381 | 6.11 | 5.441 | 4.95 |
| 0.988 | 4.080 | 3.825 | 6.66 | 3.927 | 3.89 |
| 0.798 | 2.770 | 2.722 | 1.78 | 2.837 | –2.37 |
| 0.603 | 1.744 | 1.741 | 0.15 | 1.852 | –5.84 |
| 0.513 | 1.335 | 1.346 | –0.81 | 1.448 | –7.82 |
| 0.384 | 0.8293 | 0.8483 | –2.24 | 0.9320 | –11.02 |
| 0.301 | 0.5716 | 0.5754 | –0.66 | 0.6433 | –11.15 |
| 0.202 | 0.2985 | 0.3047 | –2.05 | 0.3506 | –14.86 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B27 | Calibration Curve of Best Fit $Q = 3.9837\ H_a^{1.5964}$ | | | | |
| 2.388 | 15.097 | 15.988 | –5.57 | 15.046 | 0.34 |
| 2.093 | 12.235 | 12.953 | –5.54 | 12.310 | –0.61 |
| 1.820 | 9.992 | 10.363 | –3.58 | 9.952 | 0.41 |
| 1.492 | 7.491 | 7.546 | –0.72 | 7.354 | 1.86 |
| 1.153 | 5.575 | 5.000 | 11.49 | 4.968 | 12.22 |
| 0.980 | 4.051 | 3.857 | 5.02 | 3.879 | 4.44 |
| 0.744 | 2.495 | 2.485 | 0.42 | 2.550 | –2.17 |
| 0.586 | 1.735 | 1.697 | 2.22 | 1.773 | –2.16 |
| 0.484 | 1.264 | 1.251 | 1.06 | 1.326 | –4.64 |
| 0.338 | 0.7464 | 0.7051 | 5.86 | 0.7675 | –2.75 |
| 0.199 | 0.2912 | 0.3027 | –3.79 | 0.3427 | –15.03 |
| 0.108 | 0.1080 | 0.1141 | –5.34 | 0.1352 | –20.11 |
| TYPE B28 | Calibration Curve of Best Fit $Q = 3.9684\ H_a^{1.5842}$ | | | | |
| 2.405 | 15.097 | 15.936 | –5.26 | 15.210 | –0.74 |
| 2.094 | 12.230 | 12.797 | –4.43 | 12.319 | –0.72 |
| 1.821 | 9.972 | 10.257 | –2.77 | 9.960 | 0.12 |
| 1.496 | 7.491 | 7.512 | –0.28 | 7.384 | 1.45 |
| 1.153 | 5.580 | 4.972 | 12.22 | 4.968 | 12.32 |
| 0.994 | 4.047 | 3.931 | 2.96 | 3.964 | 2.11 |
| 0.752 | 2.494 | 2.527 | –1.29 | 2.592 | –3.79 |
| 0.586 | 1.695 | 1.702 | –0.40 | 1.773 | –4.42 |
| 0.477 | 1.264 | 1.228 | 2.90 | 1.296 | –2.51 |
| 0.335 | 0.7514 | 0.7018 | 7.07 | 0.7571 | –0.76 |
| 0.200 | 0.2926 | 0.3100 | –5.60 | 0.3453 | –15.27 |
| 0.111 | 0.1176 | 0.1220 | –3.57 | 0.1409 | –16.56 |
| TYPE B29 | Calibration Curve of Best Fit $Q = 3.9908\ H_a^{1.5934}$ | | | | |
| 2.405 | 15.159 | 16.156 | –6.17 | 15.120 | –0.33 |
| 2.046 | 12.320 | 12.487 | –1.34 | 11.892 | 3.60 |
| 1.821 | 9.983 | 10.371 | –3.75 | 9.960 | 0.23 |
| 1.497 | 7.479 | 7.590 | –1.47 | 7.392 | 1.18 |
| 1.155 | 5.572 | 5.021 | 10.98 | 4.981 | 11.87 |
| 0.992 | 4.049 | 3.940 | 2.77 | 3.951 | 2.47 |
| 0.753 | 2.513 | 2.539 | –1.04 | 2.597 | –3.25 |
| 0.588 | 1.704 | 1.712 | –0.49 | 1.783 | –4.41 |
| 0.479 | 1.275 | 1.235 | 3.23 | 1.305 | –2.28 |
| 0.333 | 0.7493 | 0.6920 | 8.28 | 0.7503 | –0.13 |
| 0.199 | 0.2919 | 0.3047 | –4.20 | 0.3427 | –14.82 |
| 0.119 | 0.1272 | 0.1343 | –5.28 | 0.1567 | –18.82 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B30 | Calibration Curve of Best Fit $Q = 3.9903\ H_a^{1.5678}$ | | | | |
| 2.465 | 15.964 | 16.417 | –2.76 | 15.791 | 1.10 |
| 2.125 | 12.591 | 13.009 | –3.21 | 12.598 | –0.06 |
| 1.868 | 10.407 | 10.628 | –2.08 | 10.354 | 0.51 |
| 1.392 | 6.899 | 6.702 | 2.94 | 6.617 | 4.26 |
| 1.045 | 4.597 | 4.275 | 7.52 | 4.277 | 7.48 |
| 0.739 | 2.462 | 2.484 | –0.87 | 2.524 | –2.47 |
| 0.599 | 1.795 | 1.787 | 0.46 | 1.834 | –2.10 |
| 0.509 | 1.368 | 1.384 | –1.17 | 1.431 | –4.41 |
| 0.355 | 0.8409 | 0.7868 | 6.88 | 0.8270 | 1.68 |
| 0.252 | 0.4412 | 0.4597 | –4.03 | 0.4909 | –10.12 |
| 0.159 | 0.2169 | 0.2233 | –2.88 | 0.2435 | –10.94 |
| TYPE B31 | Calibration Curve of Best Fit $Q = 3.9600\ H_a^{1.5602}$ | | | | |
| 2.464 | 15.699 | 16.171 | –2.92 | 15.781 | 0.52 |
| 2.123 | 12.522 | 12.817 | –2.31 | 12.580 | –0.46 |
| 1.876 | 10.442 | 10.568 | –1.19 | 10.421 | 0.20 |
| 1.398 | 6.843 | 6.679 | 2.45 | 6.661 | 2.74 |
| 1.043 | 4.553 | 4.229 | 7.67 | 4.265 | 6.76 |
| 0.741 | 2.413 | 2.481 | –2.73 | 2.535 | –4.80 |
| 0.599 | 1.806 | 1.780 | 1.46 | 1.834 | –1.51 |
| 0.509 | 1.372 | 1.381 | –0.63 | 1.431 | –4.13 |
| 0.346 | 0.7829 | 0.7561 | 3.55 | 0.7953 | –1.56 |
| 0.252 | 0.4454 | 0.4611 | –3.40 | 0.4909 | –9.27 |
| 0.166 | 0.2371 | 0.2404 | –1.37 | 0.2601 | –8.83 |
| TYPE B32 | Calibration Curve of Best Fit $Q = 3.9974\ H_a^{1.5367}$ | | | | |
| 2.467 | 15.854 | 16.011 | 0.98 | 15.810 | 0.28 |
| 2.125 | 12.547 | 12.730 | –1.44 | 12.598 | –0.40 |
| 1.876 | 10.411 | 10.511 | –0.95 | 10.421 | –0.10 |
| 1.398 | 6.941 | 6.689 | 3.76 | 6.661 | 4.21 |
| 1.045 | 4.578 | 4.277 | 7.03 | 4.277 | 7.03 |
| 0.741 | 2.453 | 2.522 | –2.73 | 2.535 | –3.22 |
| 0.599 | 1.797 | 1.819 | –1.19 | 1.834 | –2.00 |
| 0.509 | 1.378 | 1.416 | –2.70 | 1.431 | –3.71 |
| 0.346 | 0.7782 | 0.7825 | –0.55 | 0.7953 | –2.15 |
| 0.251 | 0.4454 | 0.4778 | –6.78 | 0.4879 | –8.72 |
| 0.174 | 0.2923 | 0.2721 | 7.42 | 0.2794 | 4.63 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE B33 | Calibration Curve of Best Fit $Q = 3.9149\ H_a^{1.5956}$ | | | | |
| 2.466 | 15.852 | 16.527 | –4.08 | 15.801 | 0.33 |
| 2.136 | 12.771 | 13.141 | –2.82 | 12.697 | 0.58 |
| 1.870 | 10.364 | 10.628 | –2.49 | 10.371 | –0.06 |
| 1.378 | 6.663 | 6.530 | 2.04 | 6.516 | 2.25 |
| 1.038 | 4.489 | 4.155 | 8.04 | 4.234 | 6.03 |
| 0.723 | 2.334 | 2.333 | 0.03 | 2.442 | –4.41 |
| 0.609 | 1.777 | 1.774 | 0.15 | 1.880 | –5.50 |
| 0.507 | 1.362 | 1.324 | 2.84 | 1.423 | –4.26 |
| 0.354 | 0.7736 | 0.7466 | 3.61 | 0.8235 | –6.06 |
| 0.248 | 0.4175 | 0.4232 | –1.34 | 0.4791 | –12.86 |
| 0.145 | 0.1703 | 0.1797 | –5.24 | 0.2117 | –19.55 |
| TYPE B34 | Calibration Curve of Best Fit $Q = 3.9398\ H_a^{1.5753}$ | | | | |
| 2.467 | 15.616 | 16.340 | –4.43 | 15.810 | –1.23 |
| 2.134 | 12.718 | 13.003 | –2.19 | 12.679 | 0.31 |
| 1.875 | 10.360 | 10.606 | –2.32 | 10.413 | –0.51 |
| 1.371 | 6.774 | 6.477 | 4.59 | 6.466 | 4.76 |
| 1.028 | 4.406 | 4.115 | 7.07 | 4.172 | 5.62 |
| 0.719 | 2.341 | 2.343 | –0.09 | 2.421 | –3.31 |
| 0.607 | 1.788 | 1.794 | –0.36 | 1.871 | –4.44 |
| 0.505 | 1.359 | 1.343 | 1.19 | 1.414 | –3.89 |
| 0.351 | 0.7753 | 0.7572 | 2.39 | 0.8129 | –4.62 |
| 0.248 | 0.4257 | 0.4381 | –2.83 | 0.4791 | –11.14 |
| 0.146 | 0.1855 | 0.1901 | –2.44 | 0.2139 | –13.28 |
| TYPE B35 | Calibration Curve for Best Fit $Q = 3.9304\ H_a^{1.5711}$ | | | | |
| 2.464 | 15.634 | 16.209 | –3.54 | 15.781 | –0.93 |
| 2.135 | 12.613 | 12.941 | –2.53 | 12.688 | –0.59 |
| 1.876 | 10.367 | 10.561 | –1.84 | 10.421 | –0.52 |
| 1.371 | 6.581 | 6.453 | 1.99 | 6.466 | 1.78 |
| 1.025 | 4.401 | 4.086 | 7.71 | 4.153 | 5.97 |
| 0.719 | 2.354 | 2.341 | 0.57 | 2.421 | –2.77 |
| 0.607 | 1.789 | 1.794 | –0.27 | 1.871 | –4.38 |
| 0.505 | 1.355 | 1.344 | 0.85 | 1.414 | –4.18 |
| 0.355 | 0.7681 | 0.7723 | –0.55 | 0.8270 | –7.12 |
| 0.248 | 0.4548 | 0.4396 | 3.46 | 0.4791 | –5.07 |
| 0.145 | 0.1793 | 0.1892 | –5.22 | 0.2117 | –15.29 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C | Calibration Curve of Best Fit $Q = 3.8873\ H_a^{1.5974}$ | | | | |
| 2.574 | 17.193 | 17.602 | –2.36 | 16.866 | 1.94 |
| 2.218 | 13.422 | 13.877 | –3.27 | 13.447 | –0.18 |
| 1.803 | 9.883 | 9.967 | –0.85 | 9.810 | 0.74 |
| 1.511 | 7.556 | 7.516 | 0.52 | 7.497 | 0.78 |
| 1.220 | 5.473 | 5.341 | 2.48 | 5.414 | 1.09 |
| 0.995 | 3.906 | 3.856 | 1.28 | 3.970 | –1.61 |
| 0.808 | 2.827 | 2.765 | 2.23 | 2.892 | –2.23 |
| 0.582 | 1.676 | 1.637 | 2.36 | 1.755 | –4.50 |
| 0.509 | 1.350 | 1.322 | 2.13 | 1.431 | –5.68 |
| 0.355 | 0.7546 | 0.7433 | 1.52 | 0.8270 | –8.75 |
| 0.254 | 0.4260 | 0.4354 | –2.16 | 0.4968 | –14.25 |
| 0.220 | 0.3421 | 0.3461 | –1.16 | 0.3992 | –14.31 |
| 0.159 | 0.2010 | 0.2060 | –2.46 | 0.2435 | –17.48 |
| TYPE C1 | Calibration Curve of Best Fit $Q = 3.8868\ H_a^{1.5944}$ | | | | |
| 2.573 | 16.801 | 17.539 | –4.21 | 16.856 | –0.33 |
| 2.225 | 13.621 | 13.912 | –2.09 | 13.511 | 0.81 |
| 1.798 | 9.866 | 9.904 | –0.39 | 9.769 | 0.99 |
| 1.511 | 7.558 | 7.506 | 0.69 | 7.497 | 0.81 |
| 1.218 | 5.423 | 5.323 | 1.88 | 5.400 | 0.42 |
| 1.218 | 5.483 | 5.323 | 3.01 | 5.400 | 1.53 |
| 0.995 | 3.921 | 3.856 | 1.70 | 3.970 | –1.21 |
| 0.810 | 2.819 | 2.778 | 1.49 | 2.903 | –2.88 |
| 0.584 | 1.677 | 1.649 | 1.71 | 1.764 | –4.94 |
| 0.512 | 1.346 | 1.337 | 0.69 | 1.444 | –6.79 |
| 0.356 | 0.7501 | 0.7489 | 0.17 | 0.8306 | –9.68 |
| 0.254 | 0.4273 | 0.4372 | –2.26 | 0.4968 | –13.99 |
| 0.221 | 0.3451 | 0.3502 | –1.46 | 0.4020 | –14.16 |
| 0.159 | 0.2057 | 0.2072 | –0.71 | 0.2435 | –15.54 |
| TYPE C2 | Calibration Curve of Best Fit $Q = 3.8793\ H_a^{1.5925}$ | | | | |
| 2.560 | 16.673 | 17.333 | –3.81 | 16.726 | –0.32 |
| 2.225 | 13.584 | 13.864 | –2.02 | 13.511 | 0.54 |
| 1.802 | 9.832 | 9.909 | –0.78 | 9.802 | 0.31 |
| 1.511 | 7.568 | 7.486 | 1.11 | 7.497 | 0.95 |
| 1.216 | 5.435 | 5.297 | 2.61 | 5.387 | 0.90 |
| 0.995 | 3.921 | 3.848 | 1.88 | 3.970 | –1.22 |
| 0.810 | 2.833 | 2.773 | 2.15 | 2.903 | –2.39 |
| 0.581 | 1.687 | 1.634 | 3.26 | 1.750 | –3.62 |
| 0.511 | 1.350 | 1.332 | 1.37 | 1.440 | –6.23 |
| 0.356 | 0.7463 | 0.7489 | –0.35 | 0.8306 | –10.14 |
| 0.256 | 0.4255 | 0.4430 | –3.95 | 0.5028 | –15.38 |
| 0.221 | 0.3497 | 0.3505 | –0.23 | 0.4020 | –13.01 |
| 0.159 | 0.2055 | 0.2075 | –0.95 | 0.2435 | –15.61 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |

Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$

| | | | | | |
|---|---|---|---|---|---|
| TYPE C3 | Calibration Curve of Best Fit $Q = 3.8732\ H_a^{1.5882}$ | | | | |
| 2.600 | 16.955 | 17.666 | –4.02 | 17.126 | –1.00 |
| 2.106 | 12.339 | 12.641 | –2.39 | 12.427 | –0.71 |
| 1.766 | 9.449 | 9.557 | –1.13 | 9.506 | –0.60 |
| 1.490 | 7.417 | 7.297 | 1.65 | 7.339 | 1.06 |
| 1.155 | 4.970 | 4.869 | 2.07 | 4.981 | –0.22 |
| 1.004 | 3.944 | 3.898 | 1.18 | 4.024 | –2.00 |
| 0.808 | 2.765 | 2.761 | 0.16 | 2.892 | –4.38 |
| 0.797 | 2.766 | 2.701 | 2.40 | 2.832 | –2.32 |
| 0.651 | 2.024 | 1.959 | 3.33 | 2.081 | –2.75 |
| 0.483 | 1.226 | 1.219 | 0.54 | 1.321 | –7.23 |
| 0.310 | 0.6073 | 0.6029 | 0.73 | 0.6728 | –9.74 |
| 0.240 | 0.4053 | 0.4015 | 0.94 | 0.4558 | –11.07 |
| 0.172 | 0.2238 | 0.2366 | –5.39 | 0.2745 | –18.47 |
| $H_{a1}$ | $Q = 3.9353\ H_{a1}^{1.5937}$ | | | | |
| 2.557 | 16.955 | 17.570 | –3.50 | 16.697 | 1.55 |
| 2.072 | 12.339 | 12.566 | –1.81 | 12.123 | 1.78 |
| 1.743 | 9.449 | 9.540 | –0.95 | 9.318 | 1.41 |
| 1.476 | 7.417 | 7.319 | 1.34 | 7.235 | 2.52 |
| 1.141 | 4.970 | 4.856 | 2.35 | 4.889 | 1.65 |
| 0.993 | 3.944 | 3.891 | 1.35 | 3.957 | –0.34 |
| 0.800 | 2.765 | 2.758 | 0.27 | 2.848 | –2.92 |
| 0.798 | 2.766 | 2.747 | 0.71 | 2.837 | –2.51 |
| 0.650 | 2.024 | 1.981 | 2.19 | 2.076 | –2.52 |
| 0.477 | 1.226 | 1.210 | 1.35 | 1.296 | –5.44 |
| 0.307 | 0.6073 | 0.5993 | 1.34 | 0.6630 | –8.40 |
| 0.239 | 0.4053 | 0.4021 | 0.80 | 0.4529 | –10.51 |
| 0.171 | 0.2238 | 0.2358 | –5.10 | 0.2721 | –17.74 |
| $H_{a2}$ | $Q = 3.9705\ H_{a2}^{1.5928}$ | | | | |
| 2.550 | 16.955 | 17.635 | –3.86 | 16.627 | 1.97 |
| 2.058 | 12.339 | 12.534 | –1.56 | 11.998 | 2.84 |
| 1.748 | 9.449 | 9.664 | –2.23 | 9.359 | 0.97 |
| 1.468 | 7.417 | 7.318 | 1.35 | 7.175 | 3.37 |
| 1.138 | 4.970 | 4.878 | 1.88 | 4.870 | 2.06 |
| 0.989 | 3.944 | 3.901 | 1.10 | 3.933 | 0.27 |
| 0.798 | 2.765 | 2.772 | –0.24 | 2.837 | –2.55 |
| 0.780 | 2.766 | 2.673 | 3.49 | 2.740 | 0.94 |
| 0.637 | 2.024 | 1.936 | 4.55 | 2.014 | 0.52 |
| 0.477 | 1.226 | 1.221 | 0.38 | 1.296 | –5.44 |
| 0.307 | 0.6073 | 0.6053 | 0.33 | 0.6630 | –8.40 |
| 0.238 | 0.4053 | 0.4035 | 0.44 | 0.4500 | –9.93 |
| 0.170 | 0.2238 | 0.2361 | –5.21 | 0.2697 | –17.00 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C4 Calibration Curve of Best Fit $Q = 3.8767\ H_a^{1.5874}$ | | | | | |
| 2.603 | 16.955 | 17.701 | –4.21 | 17.156 | –1.17 |
| 2.100 | 12.339 | 12.588 | –1.98 | 12.373 | –0.28 |
| 1.766 | 9.449 | 9.562 | –1.18 | 9.506 | –0.60 |
| 1.491 | 7.417 | 7.309 | 1.48 | 7.347 | 0.95 |
| 1.151 | 4.970 | 4.846 | 2.55 | 4.955 | 0.31 |
| 0.998 | 3.913 | 3.864 | 1.26 | 3.988 | –1.88 |
| 0.810 | 2.765 | 2.775 | –0.34 | 2.903 | –4.74 |
| 0.796 | 2.766 | 2.699 | 2.50 | 2.827 | –2.13 |
| 0.650 | 2.024 | 1.957 | 3.45 | 2.075 | –2.52 |
| 0.483 | 1.228 | 1.221 | 0.60 | 1.321 | –7.03 |
| 0.309 | 0.6081 | 0.6009 | 1.19 | 0.6695 | –9.18 |
| 0.240 | 0.4053 | 0.4024 | 0.73 | 0.4558 | –11.07 |
| 0.172 | 0.2238 | 0.2371 | –5.61 | 0.2745 | –18.47 |
| $H_{a1}$ $Q = 3.9448\ H_{a1}^{1.5934}$ | | | | | |
| 2.559 | 16.955 | 17.630 | –3.83 | 16.716 | 1.43 |
| 2.069 | 12.339 | 12.565 | –1.80 | 12.096 | 2.01 |
| 1.740 | 9.449 | 9.535 | –0.90 | 9.293 | 1.67 |
| 1.478 | 7.417 | 7.352 | 0.89 | 7.249 | 2.31 |
| 1.140 | 4.970 | 4.861 | 2.25 | 4.883 | 1.78 |
| 0.986 | 3.913 | 3.857 | 1.45 | 3.915 | –0.05 |
| 0.800 | 2.765 | 2.764 | 0.02 | 2.848 | –2.92 |
| 0.789 | 2.766 | 2.704 | 2.30 | 2.789 | –0.81 |
| 0.649 | 2.024 | 1.981 | 2.18 | 2.072 | –2.30 |
| 0.478 | 1.228 | 1.217 | 0.96 | 1.301 | –5.54 |
| 0.306 | 0.6081 | 0.5978 | 1.72 | 0.6597 | –7.82 |
| 0.239 | 0.4053 | 0.4032 | 0.51 | 0.4529 | –10.51 |
| 0.171 | 0.2238 | 0.2365 | –5.38 | 0.2721 | –17.74 |
| $H_{a2}$ $Q = 3.9218\ H_a^{1.5845}$ | | | | | |
| 2.550 | 16.955 | 17.284 | –1.90 | 16.627 | 1.97 |
| 2.066 | 12.339 | 12.383 | –0.35 | 12.069 | 2.23 |
| 1.743 | 9.449 | 9.458 | –0.10 | 9.318 | 1.41 |
| 1.471 | 7.41 | 7.229 | 2.60 | 7.197 | 3.05 |
| 1.235 | 4.970 | 5.479 | –9.30 | 5.515 | –9.89 |
| 0.988 | 3.913 | 3.847 | 1.70 | 3.927 | –0.36 |
| 0.801 | 2.765 | 2.759 | 0.21 | 2.854 | –3.10 |
| 0.775 | 2.766 | 2.619 | 5.63 | 2.714 | 1.93 |
| 0.639 | 2.024 | 1.929 | 4.93 | 2.023 | 0.04 |
| 0.477 | 1.228 | 1.214 | 1.22 | 1.296 | –5.24 |
| 0.306 | 0.6081 | 0.6006 | 1.24 | 0.6597 | –7.82 |
| 0.238 | 0.4053 | 0.4033 | 0.49 | 0.4500 | –9.93 |
| 0.170 | 0.2238 | 0.2367 | –5.44 | 0.2697 | –17.00 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |

Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$

TYPE C5 Calibration Curve of Best Fit $Q = 3.8998\ H_a^{1.5865}$

| | | | | | |
|---|---|---|---|---|---|
| 2.591 | 16.955 | 17.661 | –4.00 | 17.036 | –0.47 |
| 2.100 | 12.339 | 12.654 | –2.49 | 12.373 | –0.28 |
| 1.766 | 9.449 | 9.614 | –1.71 | 9.506 | –0.60 |
| 1.496 | 7.417 | 7.389 | 0.38 | 7.384 | 0.44 |
| 1.152 | 4.970 | 4.881 | 1.81 | 4.961 | 0.17 |
| 0.995 | 3.880 | 3.869 | 0.29 | 3.970 | –2.26 |
| 0.808 | 2.783 | 2.781 | 0.08 | 2.892 | –3.76 |
| 0.793 | 2.766 | 2.699 | 2.48 | 2.810 | –1.57 |
| 0.653 | 2.202 | 1.983 | 11.04 | 2.091 | 5.33 |
| 0.483 | 1.228 | 1.229 | –0.12 | 1.321 | –7.09 |
| 0.309 | 0.6069 | 0.6051 | 0.29 | 0.6695 | –9.36 |
| 0.240 | 0.4053 | 0.4053 | 0.01 | 0.4558 | –11.07 |
| 0.172 | 0.2238 | 0.2389 | –6.32 | 0.2745 | –18.47 |

$H_{a1}$ $Q = 3.9633\ H_{a1}^{1.5914}$

| | | | | | |
|---|---|---|---|---|---|
| 2.562 | 16.955 | 17.712 | –4.27 | 16.746 | 1.25 |
| 2.072 | 12.339 | 12.635 | –2.34 | 12.123 | 1.78 |
| 1.743 | 9.449 | 9.595 | –1.52 | 9.318 | 1.41 |
| 1.477 | 7.417 | 7.372 | 0.60 | 7.242 | 2.41 |
| 1.141 | 4.970 | 4.889 | 1.65 | 4.889 | 1.65 |
| 0.986 | 3.880 | 3.875 | 0.12 | 3.915 | –0.90 |
| 0.800 | 2.783 | 2.779 | 0.16 | 2.848 | –2.29 |
| 0.789 | 2.766 | 2.718 | 1.77 | 2.789 | –0.81 |
| 0.649 | 2.202 | 1.992 | 10.57 | 2.072 | 6.32 |
| 0.478 | 1.228 | 1.224 | 0.28 | 1.301 | –5.61 |
| 0.307 | 0.6069 | 0.6052 | 0.28 | 0.6630 | –8.46 |
| 0.239 | 0.4053 | 0.4063 | –0.24 | 0.4529 | –10.51 |
| 0.171 | 0.2238 | 0.2385 | –6.15 | 0.2721 | –17.74 |

$H_{a2}$ $Q = 3.9968\ H_{a2}^{1.5865}$

| | | | | | |
|---|---|---|---|---|---|
| 2.574 | 16.955 | 17.912 | –5.34 | 16.866 | 0.53 |
| 2.078 | 12.339 | 12.754 | –3.26 | 12.176 | 1.34 |
| 1.748 | 9.449 | 9.694 | –2.53 | 9.359 | 0.97 |
| 1.468 | 7.417 | 7.349 | 0.92 | 7.175 | 3.37 |
| 1.131 | 4.970 | 4.859 | 2.29 | 4.824 | 3.02 |
| 0.985 | 3.880 | 3.902 | –0.57 | 3.909 | –0.74 |
| 0.795 | 2.783 | 2.777 | 0.20 | 2.821 | –1.35 |
| 0.762 | 2.766 | 2.597 | 6.52 | 2.645 | 4.59 |
| 0.638 | 2.202 | 1.959 | 12.42 | 2.018 | 9.12 |
| 0.477 | 1.228 | 1.235 | –0.59 | 1.296 | –5.30 |
| 0.306 | 0.6069 | 0.6107 | –0.62 | 0.6597 | –8.00 |
| 0.238 | 0.4053 | 0.4099 | –1.12 | 0.4500 | –9.93 |
| 0.170 | 0.2238 | 0.2403 | –6.88 | 0.2697 | –17.00 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C7 | Calibration Curve of Best Fit $Q = 3.8066\ H_a^{1.5958}$ | | | | |
| 2.674 | 17.683 | 18.289 | –3.32 | 17.873 | –1.06 |
| 2.187 | 13.040 | 13.270 | –1.73 | 13.162 | –0.92 |
| 1.691 | 8.892 | 8.803 | 1.02 | 8.898 | –0.07 |
| 1.302 | 5.833 | 5.800 | 0.57 | 5.977 | –2.41 |
| 0.935 | 3.509 | 3.419 | 2.62 | 3.611 | –2.83 |
| 0.742 | 2.399 | 2.364 | 1.46 | 2.540 | –5.55 |
| 0.593 | 1.679 | 1.653 | 1.55 | 1.806 | –7.02 |
| 0.438 | 1.035 | 1.020 | 1.52 | 1.139 | –9.10 |
| 0.299 | 0.5530 | 0.5544 | –0.25 | 0.6368 | –13.17 |
| 0.175 | 0.2334 | 0.2358 | –1.03 | 0.2818 | –17.18 |
| 0.129 | 0.1418 | 0.1449 | –2.17 | 0.1772 | –19.96 |
| $H_{a1}$ | $Q = 3.9247\ H_{a1}^{1.6146}$ | | | | |
| 2.605 | 17.683 | 18.415 | –3.97 | 17.176 | 2.95 |
| 2.074 | 13.040 | 12.745 | 2.32 | 12.141 | 7.41 |
| 1.650 | 8.892 | 8.810 | 0.94 | 8.572 | 3.74 |
| 1.281 | 5.833 | 5.854 | –0.36 | 5.831 | 0.03 |
| 0.924 | 3.509 | 3.454 | 1.58 | 3.547 | –1.06 |
| 0.734 | 2.399 | 2.382 | 0.71 | 2.498 | –3.98 |
| 0.589 | 1.679 | 1.670 | 0.56 | 1.787 | –6.05 |
| 0.442 | 1.035 | 1.050 | –1.45 | 1.154 | –10.35 |
| 0.295 | 0.5530 | 0.5467 | 1.14 | 0.6239 | –11.37 |
| 0.174 | 0.2334 | 0.2331 | 0.12 | 0.2794 | –16.45 |
| 0.129 | 0.1418 | 0.1438 | –1.39 | 0.1772 | –19.96 |
| $H_{a2}$ | $Q = 3.9312\ H_{a2}^{1.6021}$ | | | | |
| 2.660 | 12.683 | 18.846 | –6.17 | 17.731 | –0.27 |
| 2.119 | 13.040 | 13.092 | –0.40 | 12.544 | 3.96 |
| 1.603 | 8.892 | 8.372 | 6.21 | 8.203 | 8.40 |
| 1.275 | 5.833 | 5.802 | 0.54 | 5.790 | 0.75 |
| 0.920 | 3.509 | 3.440 | 2.02 | 3.523 | –0.40 |
| 0.732 | 2.399 | 2.385 | 0.59 | 2.488 | –3.58 |
| 0.593 | 1.679 | 1.702 | –1.35 | 1.806 | –7.02 |
| 0.432 | 1.035 | 1.025 | 1.02 | 1.115 | –7.17 |
| 0.294 | 0.5530 | 0.5531 | –0.01 | 0.6207 | –10.91 |
| 0.172 | 0.2334 | 0.2343 | –0.38 | 0.2745 | –14.97 |
| 0.127 | 0.1418 | 0.1441 | 2.76 | 0.1730 | –14.39 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C8 Calibration Curve of Best Fit $Q = 3.7902\ H_a^{1.5879}$ | | | | | |
| 2.690 | 17.684 | 18.242 | –3.06 | 18.036 | –1.95 |
| 2.195 | 13.029 | 13.208 | –1.35 | 13.235 | –1.56 |
| 1.705 | 8.832 | 8.843 | –0.13 | 9.010 | –1.98 |
| 1.307 | 5.873 | 5.798 | 1.29 | 6.012 | –2.31 |
| 0.935 | 3.510 | 3.407 | 3.04 | 3.611 | –2.80 |
| 0.743 | 2.404 | 2.365 | 1.66 | 2.545 | –5.54 |
| 0.593 | 1.674 | 1.653 | 1.27 | 1.806 | –7.29 |
| 0.438 | 1.036 | 1.022 | 1.39 | 1.139 | –9.01 |
| 0.300 | 0.5524 | 0.5602 | –1.40 | 0.6401 | –13.70 |
| 0.175 | 0.2342 | 0.2381 | –1.62 | 0.2818 | –16.90 |
| 0.130 | 0.1472 | 0.1485 | –0.87 | 0.1793 | –17.88 |
| $H_{a1}$ $Q = 3.9107\ H_{a1}^{1.6065}$ | | | | | |
| 2.580 | 17.684 | 17.928 | –1.36 | 16.926 | 4.48 |
| 2.124 | 13.029 | 13.117 | –0.67 | 12.589 | 3.50 |
| 1.659 | 8.832 | 8.819 | 0.14 | 8.643 | 2.19 |
| 1.280 | 5.873 | 4.814 | 1.01 | 5.824 | 0.84 |
| 0.928 | 3.510 | 3.468 | 1.20 | 3.570 | –1.68 |
| 0.735 | 2.404 | 2.385 | 0.81 | 2.504 | –3.97 |
| 0.586 | 1.674 | 1.657 | 1.01 | 1.773 | –5.60 |
| 0.442 | 1.036 | 1.053 | –1.66 | 1.154 | –10.26 |
| 0.295 | 0.5524 | 0.5502 | 0.40 | 0.6239 | –11.46 |
| 0.174 | 0.2342 | 0.2356 | –0.60 | 0.2794 | –16.17 |
| 0.130 | 0.1472 | 0.1475 | –0.21 | 0.1793 | –17.88 |
| $H_{a2}$ $Q = 3.9069^{1.5916}$ | | | | | |
| 2.654 | 17.684 | 18.472 | –4.27 | 17.670 | 0.08 |
| 2.142 | 13.029 | 13.133 | –0.79 | 12.752 | 2.17 |
| 1.660 | 8.832 | 8.753 | 0.90 | 8.651 | 2.09 |
| 1.287 | 5.873 | 5.838 | 0.61 | 5.873 | 0.005 |
| 0.921 | 3.510 | 3.427 | 2.41 | 3.529 | –0.54 |
| 0.726 | 2.404 | 2.347 | 2.43 | 2.457 | –2.16 |
| 0.581 | 1.674 | 1.646 | 1.69 | 1.750 | –4.36 |
| 0.431 | 1.036 | 1.023 | 1.23 | 1.111 | –6.76 |
| 0.293 | 0.5524 | 0.5537 | –0.24 | 0.6175 | –10.54 |
| 0.174 | 0.2342 | 0.2416 | –3.06 | 0.2794 | –16.17 |
| 0.128 | 0.1472 | 0.1482 | –0.68 | 0.1751 | –15.92 |

## Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C9 | Calibration Curve of Best Fit $Q = 3.7673\ H_a^{1.5849}$ | | | | |
| 2.685 | 17.267 | 18.025 | –4.20 | 17.985 | –3.99 |
| 2.192 | 12.944 | 13.069 | –0.95 | 13.207 | –1.99 |
| 1.705 | 8.820 | 8.776 | 0.51 | 9.010 | –2.11 |
| 1.318 | 5.881 | 5.836 | 0.78 | 6.089 | –3.42 |
| 0.940 | 3.496 | 3.415 | 2.37 | 3.640 | –3.96 |
| 0.745 | 2.412 | 2.363 | 2.09 | 2.556 | –5.62 |
| 0.593 | 1.66 | 1.646 | 1.23 | 1.806 | –7.74 |
| 0.438 | 1.049 | 1.018 | 3.00 | 1.139 | –7.90 |
| 0.300 | 0.5553 | 0.5589 | –0.64 | 0.6401 | –13.25 |
| 0.175 | 0.2335 | 0.2379 | –1.83 | 0.2818 | –17.14 |
| 0.130 | 0.1454 | 0.1485 | –2.09 | 0.1793 | –18.89 |
| $H_{a1}$ | $Q = 3.9163\ H_{a1}^{1.6069}$ | | | | |
| 2.569 | 17.267 | 17.837 | –3.20 | 16.816 | 2.68 |
| 2.111 | 12.944 | 13.011 | –0.51 | 12.472 | 3.79 |
| 1.658 | 8.820 | 8.825 | –0.06 | 8.635 | 2.14 |
| 1.274 | 5.881 | 5.779 | 1.77 | 5.783 | 1.71 |
| 0.920 | 3.496 | 3.425 | 2.08 | 3.523 | –0.77 |
| 0.735 | 2.412 | 2.388 | 1.01 | 2.504 | –3.66 |
| 0.583 | 1.666 | 1.646 | 1.23 | 1.760 | –5.32 |
| 0.442 | 1.049 | 1.055 | –0.56 | 1.154 | –9.16 |
| 0.295 | 0.5553 | 0.5507 | 0.83 | 0.6239 | –11.00 |
| 0.174 | 0.2335 | 0.2358 | –0.97 | 0.2794 | –16.42 |
| 0.130 | 0.1454 | 0.1476 | –1.49 | 0.1793 | –18.89 |
| $H_{a2}$ | $Q = 3.8899\ H_{a2}^{1.5953}$ | | | | |
| 2.592 | 17.267 | 17.775 | –2.86 | 17.046 | 1.30 |
| 2.180 | 12.944 | 13.486 | –4.02 | 13.098 | –1.17 |
| 1.629 | 8.820 | 8.473 | 4.10 | 8.406 | 4.92 |
| 1.287 | 5.881 | 5.818 | 1.09 | 5.873 | 0.15 |
| 0.925 | 3.496 | 3.435 | 1.79 | 3.552 | –1.58 |
| 0.738 | 2.412 | 2.396 | 0.68 | 2.519 | –4.25 |
| 0.588 | 1.666 | 1.667 | –0.09 | 1.783 | –6.55 |
| 0.432 | 1.049 | 1.020 | 2.86 | 1.115 | –5.94 |
| 0.295 | 0.5553 | 0.5548 | 0.09 | 0.6239 | –11.00 |
| 0.173 | 0.2335 | 0.2368 | –1.40 | 0.2769 | –15.68 |
| 0.129 | 0.1454 | 0.1483 | –1.94 | 0.1772 | –17.93 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C10 | Calibration Curve of Best Fit $Q = 3.9498\ H_a^{1.5396}$ | | | | |
| 2.526 | 16.465 | 16.450 | 0.09 | 16.389 | 0.46 |
| 2.103 | 12.493 | 12.406 | 0.70 | 12.400 | 0.75 |
| 1.716 | 9.252 | 9.071 | 2.00 | 9.099 | 1.68 |
| 1.343 | 6.351 | 6.220 | 2.11 | 6.266 | 1.36 |
| 1.014 | 4.099 | 4.035 | 1.58 | 4.086 | 0.33 |
| 0.753 | 2.522 | 2.552 | –1.18 | 2.597 | –2.90 |
| 0.634 | 1.924 | 1.958 | –1.75 | 1.999 | –3.76 |
| 0.453 | 1.136 | 1.167 | –2.66 | 1.199 | –5.22 |
| 0.342 | 0.7312 | 0.7571 | –3.42 | 0.7814 | –6.42 |
| 0.271 | 0.5160 | 0.5291 | –2.48 | 0.5483 | –5.90 |
| 0.182 | 0.2653 | 0.2867 | –7.45 | 0.2991 | –11.32 |
| 0.136 | 0.2083 | 0.1831 | 13.79 | 0.1920 | 8.49 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ ft | Measured Q cfs | Calibration Curve of Best Fit Q – cfs | Deviation of Measured Q from Best Fit Curve Q – % | Standard Calibration Curve Q – cfs | Deviation of Measured Q from Standard Calibration Curve Q –% |
|---|---|---|---|---|---|
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C11 | Calibration Curve of Best Fit $Q = 3.9649\ H_a^{1.5605}$ | | | | |
| 2.517 | 16.562 | 16.742 | –1.08 | 16.301 | 1.60 |
| 1.978 | 11.420 | 11.495 | –0.65 | 11.296 | 1.10 |
| 1.569 | 8.081 | 8.008 | 0.92 | 7.940 | 1.78 |
| 1.288 | 5.945 | 5.885 | 1.02 | 5.880 | 1.11 |
| 1.047 | 4.325 | 4.260 | 1.54 | 4.290 | 0.83 |
| 0.871 | 3.227 | 3.196 | 0.96 | 3.242 | –0.45 |
| 0.638 | 1.967 | 1.966 | 0.03 | 2.018 | –2.54 |
| 0.503 | 1.348 | 1.357 | –0.65 | 1.406 | –4.09 |
| 0.438 | 1.080 | 1.093 | –1.22 | 1.139 | –5.15 |
| 0.358 | 0.7832 | 0.7981 | –1.87 | 0.8377 | –6.50 |
| 0.245 | 0.4361 | 0.4416 | –1.24 | 0.4703 | –7.27 |
| 0.151 | 0.2122 | 0.2075 | 2.26 | 0.2251 | –5.75 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C12 | Calibration Curve of Best Fit $Q = 4.0327\ H_a^{1.5442}$ | | | | |
| 2.635 | 18.008 | 18.004 | 0.02 | 17.478 | 3.03 |
| 2.085 | 12.497 | 12.542 | –0.36 | 12.239 | 2.11 |
| 1.638 | 8.744 | 8.641 | 1.20 | 8.477 | 3.15 |
| 1.240 | 5.706 | 5.622 | 1.50 | 5.549 | 2.82 |
| 0.997 | 4.018 | 4.014 | 0.10 | 3.982 | 0.91 |
| 0.794 | 2.812 | 2.824 | –0.43 | 2.816 | –0.13 |
| 0.598 | 1.804 | 1.823 | –1.04 | 1.829 | –1.36 |
| 0.431 | 1.082 | 1.099 | –1.58 | 1.111 | –2.61 |
| 0.356 | 0.8050 | 0.8184 | –1.63 | 0.8306 | –3.08 |
| 0.278 | 0.5475 | 0.5586 | –2.07 | 0.5700 | –4.04 |
| 0.208 | 0.3708 | 0.3569 | 3.95 | 0.3666 | 1.21 |
| 0.154 | 0.2255 | 0.2244 | 0.50 | 0.2320 | –2.80 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |

Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$

TYPE C13 Calibration Curve of Best Fit $Q = 3.9003\ H_a^{1.5475}$

| Measured Head $H_a$ (ft) | Measured Q (cfs) | Calibration Curve of Best Fit (Q – cfs) | Deviation of Measured Q from Best Fit Curve (Q – %) | Standard Calibration Curve (Q – cfs) | Deviation of Measured Q from Standard Calibration Curve (Q –%) |
|---|---|---|---|---|---|
| 2.580 | 16.800 | 16.908 | –0.64 | 16.926 | –0.74 |
| 2.119 | 12.469 | 12.468 | 0.01 | 12.544 | –0.60 |
| 1.693 | 8.902 | 8.809 | 1.05 | 8.914 | –0.14 |
| 1.313 | 5.974 | 5.944 | 0.50 | 6.054 | –1.33 |
| 0.951 | 3.653 | 3.609 | 1.23 | 3.706 | –1.42 |
| 0.687 | 2.218 | 2.182 | 1.67 | 2.259 | –1.81 |
| 0.558 | 1.561 | 1.581 | –1.28 | 1.646 | –5.17 |
| 0.454 | 1.134 | 1.149 | –1.32 | 1.203 | –5.70 |
| 0.338 | 0.7226 | 0.7279 | –0.74 | 0.7675 | –5.85 |
| 0.252 | 0.4594 | 0.4621 | –0.60 | 0.4909 | –6.43 |
| 0.202 | 0.3109 | 0.3282 | –5.28 | 0.3506 | –11.33 |
| 0.128 | 0.1713 | 0.1620 | 5.76 | 0.1751 | –2.15 |

Parshall Flume Calibrations – Approach Study – 12" Flume

| Measured Head $H_a$ | Measured Q | Calibration Curve of Best Fit | Deviation of Measured Q from Best Fit Curve | Standard Calibration Curve | Deviation of Measured Q from Standard Calibration Curve |
|---|---|---|---|---|---|
| ft | cfs | Q – cfs | Q – % | Q – cfs | Q –% |
| Standard Calibration Curve $Q = 4\ W\ H_a^{1.522W^{0.026}}$ | | | | | |
| TYPE C6 | Calibration Curve of Best Fit $Q = 4.1173\ H_a^{1.5620}$ | | | | |
| 2.324 | 14.868 | 15.370 | –3.27 | 14.437 | 2.99 |
| 1.892 | 11.023 | 11.147 | –1.11 | 10.557 | 4.42 |
| 1.656 | 9.056 | 9.053 | 0.03 | 8.619 | 5.07 |
| 1.326 | 6.518 | 6.398 | 1.88 | 6.146 | 6.06 |
| 1.058 | 4.664 | 4.496 | 3.73 | 4.358 | 7.01 |
| 0.826 | 3.080 | 3.054 | 0.84 | 2.990 | 3.00 |
| 0.595 | 1.880 | 1.830 | 2.74 | 1.815 | 3.58 |
| 0.425 | 1.076 | 1.082 | –0.54 | 1.088 | –1.07 |
| 0.364 | 0.8277 | 0.8493 | –2.54 | 0.8591 | –3.66 |
| 0.301 | 0.6201 | 0.6312 | –1.75 | 0.6433 | –3.61 |
| 0.243 | 0.4456 | 0.4518 | –1.37 | 0.4645 | –4.06 |
| 0.164 | 0.2482 | 0.2445 | 1.53 | 0.2553 | –2.78 |
| $H_{a1}$ FT | $Q = 6.4227\ H_{a1}^{1.5669}$ | | | | |
| 1.816 | 14.868 | 16.358 | –9.11 | 9.918 | 49.91 |
| 1.465 | 11.023 | 11.683 | –5.65 | 7.153 | 54.11 |
| 1.247 | 9.056 | 9.077 | –0.23 | 5.597 | 61.80 |
| 0.981 | 6.518 | 6.233 | 4.58 | 3.885 | 67.78 |
| 0.771 | 4.664 | 4.273 | 9.15 | 2.693 | 73.22 |
| 0.606 | 3.080 | 2.930 | 5.12 | 1.866 | 65.03 |
| 0.434 | 1.880 | 1.737 | 8.26 | 1.123 | 67.43 |
| 0.316 | 1.076 | 1.056 | 1.87 | 0.6928 | 55.32 |
| 0.270 | 0.8277 | 0.8255 | 0.27 | 0.5452 | 51.80 |
| 0.228 | 0.6201 | 0.6334 | –2.10 | 0.4215 | 47.10 |
| 0.191 | 0.4456 | 0.4799 | –7.15 | 0.3220 | 38.41 |
| 0.128 | 0.2482 | 0.2563 | –3.17 | 0.1751 | 41.76 |
| $H_{a2}$ FT | $Q = 5.4410\ H_{a2}^{1.5292}$ | | | | |
| 1.960 | 14.868 | 15.226 | –2.35 | 11.140 | 33.47 |
| 1.573 | 11.023 | 10.877 | 1.34 | 7.970 | 38.30 |
| 1.391 | 9.056 | 9.013 | 0.48 | 6.610 | 37.00 |
| 1.142 | 6.518 | 6.666 | –2.22 | 4.896 | 33.13 |
| 0.911 | 4.664 | 4.718 | –1.15 | 3.471 | 34.37 |
| 0.686 | 3.080 | 3.058 | 0.73 | 2.254 | 36.65 |
| 0.482 | 1.880 | 1.782 | 5.48 | 1.317 | 42.73 |
| 0.353 | 1.076 | 1.107 | –2.80 | 0.8199 | 31.23 |
| 0.280 | 0.8277 | 0.7767 | 6.56 | 0.5763 | 43.63 |
| 0.239 | 0.6201 | 0.6097 | 1.70 | 0.4529 | 36.92 |
| 0.201 | 0.4456 | 0.4679 | –4.76 | 0.3480 | 28.06 |
| 0.135 | 0.2482 | 0.2546 | –2.50 | 0.1899 | 30.73 |