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# A Field Guide To Streamflow Measurement By Gauging And Metering

by
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Habitat Protection Directorate
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# A FIELD GUIDE TO STREAMFLOW MEASUREMENT
# BY GAUGING AND METERING

TECHNICAL BULLETIN SERIES PAC/T-76-2


BY

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FISHERIES & MARINE SERVICE

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# PREFACE

This report is designed to provide guidelines in the selection and operation of stream gauging and metering equipment currently used by The Fisheries & Marine Service in the Pacific Region. Standard instrumentation, operational methods of streamflow measurement, data interpretation, and essential equipment maintenance are described.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

## LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

# A FIELD GUIDE TO STREAMFLOW MEASUREMENT BY GAUGING AND METERING

## 1. INTRODUCTION

### 1.1 Purpose of Streamflow Measurement

Stream gauging and metering are used to determine the discharge rate of a stream over a period of time. The estimates of volume of flow are applied in hydrologic studies to determine available water resources for municipal water supplies, irrigation projects and flood control. In the case of the Fisheries and Marine Service, records of discharge are indispensable during the design of fishways, counting fences, and spawning channels; minimum flow requirements for adult migration and spawning, incubation of fish eggs, fry migration, and rearing of juveniles; and the design of related hydraulic structures.

When a record of streamflow is required, a relationship between the height of water surface and the rate of discharge at a specific point is established. This relationship can readily be shown on a discharge table or by a stage-discharge curve (see Appendix A, Figure A-2). The discharge at any moment can be estimated by observing the water surface height at the reference point, and then reading the corresponding discharge from the discharge table or stage-discharge curve. The data for preparing a discharge table or a stage discharge curve are obtained by measuring the water surface height and the rate of discharge at various stages of stream flow. The types of gauging instruments commonly in use are described in Section 2, INSTRUMENTATION.

# 2. INSTRUMENTATION

## 2.1 Staff Gauge

Various types of gauges are in use for indicating or recording the height of the water surface of a stream. The staff gauge, shown in Figure 1, is the simplest to use.

The gauge consists of a staff which has a vertical scale marked on its surface. Graduations on the scale may be in decimal units of a foot or in metres. When placed in a fixed position in a stream bed or secured to some available stable structure, the height of the water surface can be read directly from the scale. Operational use of the staff gauge is described in Section 3.1.

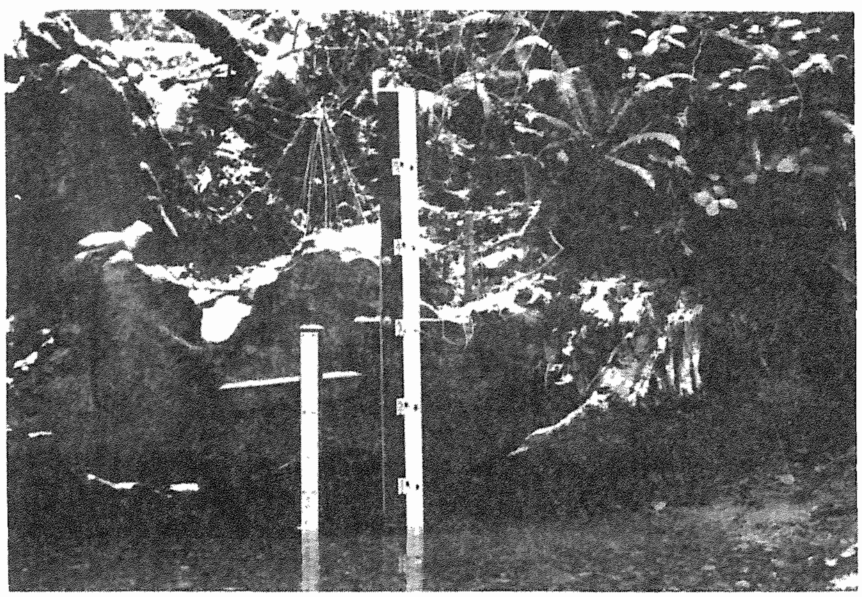

FIGURE 1

A 3-FT. AND 5-FT. STAFF GAUGE INSTALLATION AT CARNATION CREEK, B. C.

## 2.2 Weight-and-Chain Gauge

This type of gauge (see Figure 2), consists of a graduated scale (a) normally 9 ft in length (composed of 3, 3-ft gauge plates), but may be longer depending on the expected rise and fall of the stream; a brass chain (b) that passes over a pulley (c) and carries a weight (d) at its free end. A marker (e) affixed to the chain provides a direct reading from the scale to indicate the height of the water surface above the stream bottom. Observation is made by lowering the weight until it just touches the water surface, the marker reading is then recorded.

To provide protection against icing and vandalism, the gauge may be enclosed in a wooden box about 6 $in^2$ as shown in Figure 2. The lid can be hinged and locked. A Bench Mark should be set nearby so that the gauge can be re-established if, for any reason, the gauge is disturbed. Operational use of the weight and chain gauge is described in Section 3.2.

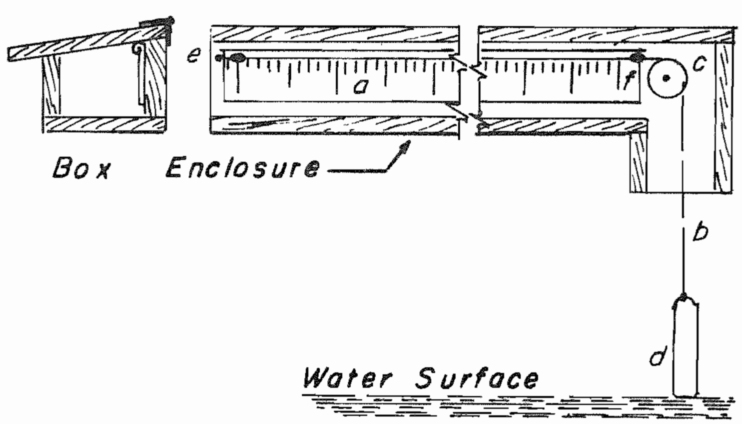


FIGURE 2

WEIGHT AND CHAIN GAUGE IN BOX ENCLOSURE

## 2.3 Automatic Stage Recorder

When it is necessary to obtain a continuous record of height fluctuations of the water surface, an automatic stage recorder should be installed. This gauge mechanism consists of a hollow metal float attached to a light chain, cable or perforated metal tape that passes over a spurred pulley. The change in position of the float, which rests continuously on the water surface, is transferred through the chain, wheel, and gearing and is converted to an inked pen trace on an internal chart. This method of recording water level on a chart mounted on a revolving drum, or on a strip chart moved at a pre-determined rate, is controlled by a clock movement. The marking stylus moves laterally across the chart in direct proportion to changes in water level, resulting in a graphic record of water level against time. Continuous recording is the type most commonly used by Fisheries Service personnel in the Pacific Region.

In other models of recorders the time and heights are printed on a strip of paper at regular intervals, usually at 15, 30 or 60 min. periods, or a punch tape output is available. The tape is 2 1/8 in. wide and is designed to accommodate four decades of BCD (Binary Coded Decimal) punched across the tape, 16 bits in parallel. Punch time intervals available are 5, 15, 30 and 60 min. One roll of tape (410 ft) lasts 171 days at the 5-min. interval, and proportionally longer for the 30- and 60-min. intervals. The tape can be translated into magnetic tape or punched card form for computer processing and analysis. Alternatively, it can be read visually or by a manual tape reader.

The automatic stage recorder may be located directly in the stream (as in Figure 3), or in a well adjacent to the stream (see Appendix B for different types of installation). In the latter installation, protection is afforded from wind and floating debris; but an intake pipe or channel must be provided between the stream and the well, to allow the water levels in stream and well to equalize (see Appendix B, Figures B-1 and B-2). Operational use of the automatic stage recorder is described in Section 3.3.

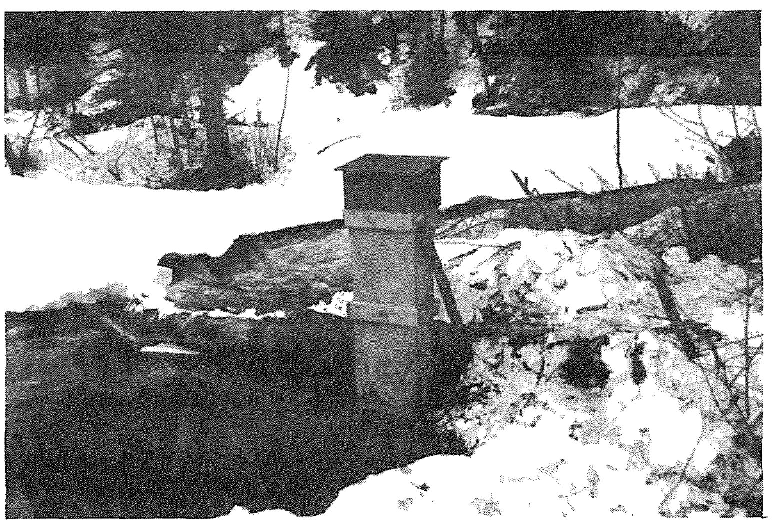

FIGURE 3

AUTOMATIC STAGE RECORDER
USING A STEVENS "F" TYPE WATER
LEVEL RECORDER IN SLIM CREEK, B.C.

## 2.4 Current Meters

Several types of current meters are available, all of which use the same basic operating principle. A rotational device attached to the instrument is immersed in the stream so that the pressure exerted by streamflow will cause the device to make a number of revolutions during an interval of time.

The Price type meter (Figure 4), capable of measuring velocities within the range of 0.08 ft/sec to 11.0 ft/sec, is commonly used. In deep water the current meter is suspended by cable from a bridge or cable car; for shallow water, the instrument is mounted on a hand-held rod (Figure 5) and observations are made by wading.

For measuring flow velocity in very shallow streams or flumes, a Pygmy type meter should be used (Figure 6). The Pygmy type meter is a small scale version of the standard meter and measures velocities as slow as 0.05 ft/sec. For measuring flow velocity in hydraulic models, test flumes or pipes, meters such as the Model C-1 (Figure 7), manufactured by A. Ott are recommended.

The Price type meter (Figure 4) consists of a rotating wheel, to which is attached 6 conical cups. This assembly turns on a vertical shaft supported on a pivot point. At the upper end of the shaft a contact chamber contains a mechanism which completes an electric contact for each wheel revolution. The electrical signal is transmitted to an automatic register, an electric buzzer, or a telephone receiver that is held to the ear by the observer. To keep the meter oriented in the same direction as the current, a 4-vaned rudder is provided. A torpedo shaped weight located below the water holds the instrument stationary in the current. To determine the velocity of flow using the Price type meter, the registered or audible count of revolutions and the duration of observation are recorded, and by reference to corresponding values on the manufacturer's Rating Table, the velocity can be read off directly (see Figures 8(a) and 8(b).

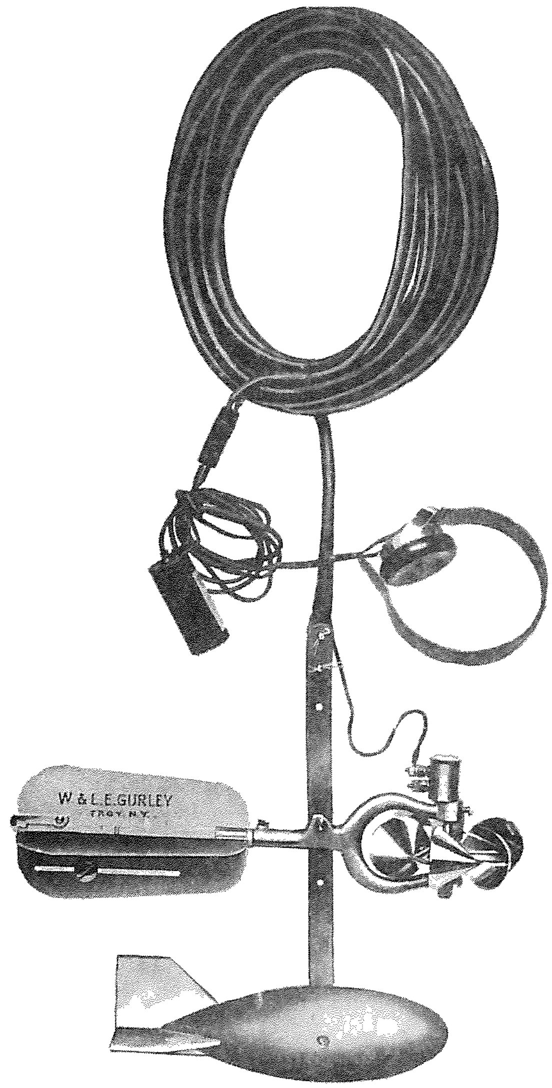


FIGURE 4

PRICE TYPE CURRENT METER
MODEL 622 GURLEY WITH
SUSPENSION CABLE AND EARPHONE
(Compliment of W. & L.E. Gurley)

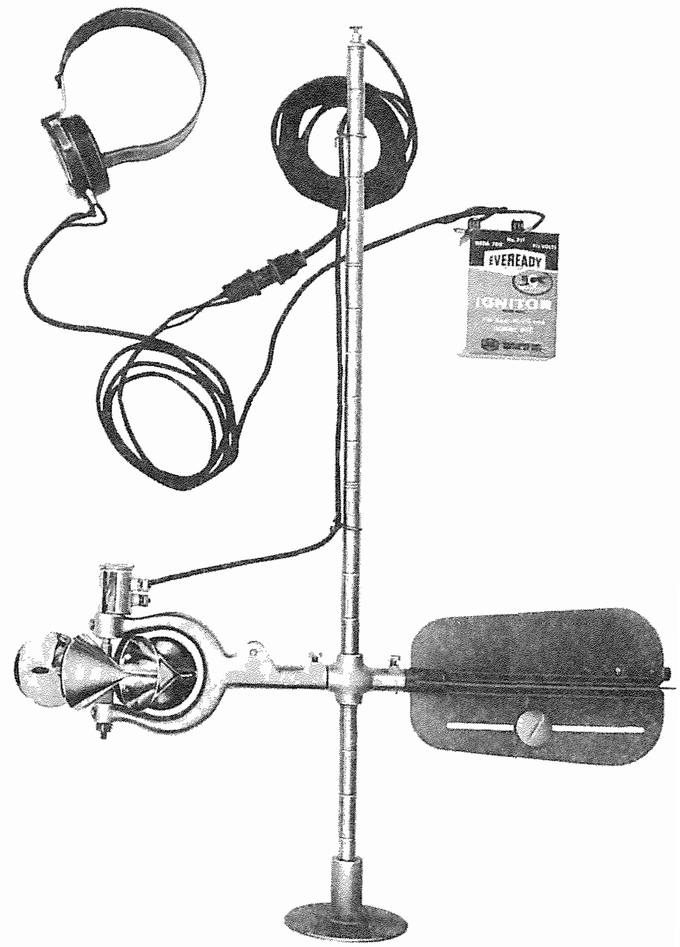


FIGURE 5

MODEL 622 GURLEY WITH
WADING ROD & EARPHONE

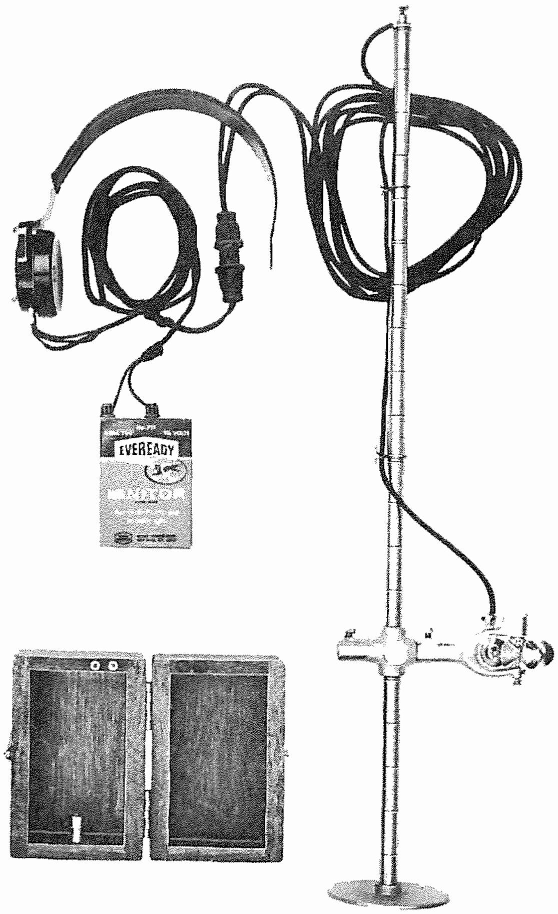


FIGURE 6

"PYGMY" TYPE METER WITH
WADING ROD & EARPHONE

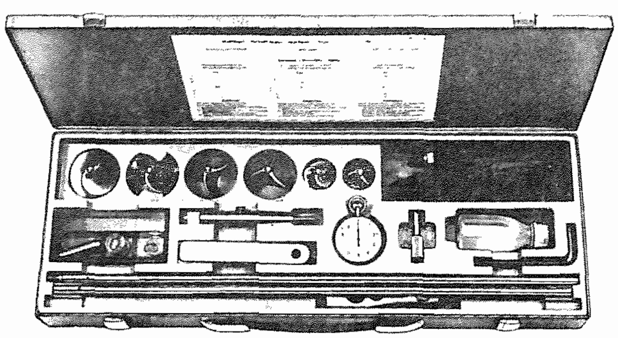

FIGURE 7

MODEL C-1 OTT METER
IN CARRYING CASE

## RATING TABLE FOR No. 622 CURRENT METER

This table applies when measurements are made with meter suspended by cable. When measurements are made with meter suspended by rod, reduce the tabular velocities by 2%.

| Time in Seconds | VELOCITY IN FEET PER SECOND | | | | | | | | | | | | | | | | Time in Seconds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 Revs. | 2 Revs. | 3 Revs. | 5 Revs. | 10 Revs. | 20 Revs | 30 Revs. | 40 Revs. | 50 Revs. | 60 Revs. | 70 Revs. | 80 Revs. | 90 Revs. | 100 Revs. | 150 Revs. | 200 Revs. | |
| 40 | 0.09 | 0.15 | 0.21 | 0.31 | 0.58 | 1.13 | 1.68 | 2.23 | 2.78 | 3.34 | 3.90 | 4.45 | 5.01 | 5.56 | 8.34 | 11.12 | 40 |
| 41 | 0.09 | 0.15 | 0.20 | 0.30 | 0.57 | 1.10 | 1.64 | 2.18 | 2.71 | 3.26 | 3.81 | 4.34 | 4.89 | 5.43 | 8.14 | 10.85 | 41 |
| 42 | 0.09 | 0.14 | 0.20 | 0.30 | 0.56 | 1.07 | 1.60 | 2.13 | 2.65 | 3.18 | 3.72 | 4.24 | 4.77 | 5.30 | 7.95 | 10.59 | 42 |
| 43 | 0.09 | 0.14 | 0.20 | 0.29 | 0.54 | 1.05 | 1.56 | 2.08 | 2.59 | 3.11 | 3.63 | 4.14 | 4.66 | 5.18 | 7.77 | 10.34 | 43 |
| 44 | 0.09 | 0.14 | 0.19 | 0.28 | 0.53 | 1.03 | 1.53 | 2.03 | 2.53 | 3.04 | 3.55 | 4.04 | 4.55 | 5.06 | 7.59 | 10.10 | 44 |
| 45 | 0.09 | 0.14 | 0.19 | 0.28 | 0.52 | 1.01 | 1.50 | 1.99 | 2.48 | 2.97 | 3.47 | 3.95 | 4.45 | 4.95 | 7.42 | 9.87 | 45 |
| 46 | 0.09 | 0.14 | 0.19 | 0.28 | 0.51 | 0.99 | 1.47 | 1.95 | 2.43 | 2.90 | 3.39 | 3.87 | 4.35 | 4.84 | 7.26 | 9.65 | 46 |
| 47 | 0.08 | 0.14 | 0.18 | 0.27 | 0.50 | 0.97 | 1.44 | 1.91 | 2.38 | 2.84 | 3.32 | 3.79 | 4.26 | 4.74 | 7.11 | 9.45 | 47 |
| 48 | 0.08 | 0.14 | 0.18 | 0.26 | 0.49 | 0.95 | 1.41 | 1.87 | 2.33 | 2.78 | 3.25 | 3.71 | 4.17 | 4.64 | 6.96 | 9.25 | 48 |
| 49 | 0.08 | 0.13 | 0.18 | 0.26 | 0.48 | 0.93 | 1.38 | 1.83 | 2.28 | 2.72 | 3.18 | 3.63 | 4.09 | 4.54 | 6.81 | 9.06 | 49 |
| 50 | 0.08 | 0.13 | 0.17 | 0.26 | 0.47 | 0.91 | 1.35 | 1.79 | 2.23 | 2.67 | 3.12 | 3.56 | 4.01 | 4.45 | 6.67 | 8.89 | 50 |
| 51 | | 0.13 | 0.17 | 0.25 | 0.46 | 0.90 | 1.32 | 1.75 | 2.19 | 2.62 | 3.06 | 3.49 | 3.93 | 4.36 | 6.54 | 8.72 | 51 |
| 52 | | 0.13 | 0.17 | 0.25 | 0.46 | 0.88 | 1.29 | 1.72 | 2.15 | 2.57 | 3.00 | 3.42 | 3.85 | 4.28 | 6.42 | 8.56 | 52 |
| 53 | | 0.13 | 0.16 | 0.24 | 0.45 | 0.86 | 1.27 | 1.69 | 2.11 | 2.52 | 2.94 | 3.36 | 3.78 | 4.20 | 6.30 | 8.40 | 53 |
| 54 | | 0.13 | 0.16 | 0.24 | 0.44 | 0.85 | 1.25 | 1.66 | 2.07 | 2.47 | 2.88 | 3.30 | 3.71 | 4.12 | 6.18 | 8.24 | 54 |
| 55 | | 0.13 | 0.16 | 0.24 | 0.43 | 0.83 | 1.23 | 1.63 | 2.03 | 2.43 | 2.83 | 3.24 | 3.64 | 4.05 | 6.07 | 8.09 | 55 |
| 56 | | 0.12 | 0.16 | 0.23 | 0.43 | 0.82 | 1.21 | 1.60 | 1.99 | 2.39 | 2.78 | 3.18 | 3.58 | 3.98 | 5.96 | 7.95 | 56 |
| 57 | | 0.12 | 0.16 | 0.23 | 0.42 | 0.80 | 1.19 | 1.57 | 1.96 | 2.35 | 2.73 | 3.12 | 3.52 | 3.91 | 5.86 | 7.81 | 57 |
| 58 | | 0.12 | 0.15 | 0.22 | 0.41 | 0.79 | 1.17 | 1.54 | 1.93 | 2.31 | 2.68 | 3.07 | 3.46 | 3.84 | 5.76 | 7.68 | 58 |
| 59 | | 0.12 | 0.15 | 0.22 | 0.41 | 0.78 | 1.15 | 1.51 | 1.90 | 2.27 | 2.63 | 3.02 | 3.40 | 3.77 | 5.66 | 7.55 | 59 |
| 60 | | 0.12 | 0.15 | 0.22 | 0.40 | 0.77 | 1.13 | 1.48 | 1.87 | 2.23 | 2.59 | 2.97 | 3.34 | 3.71 | 5.56 | 7.42 | 60 |
| 61 | | 0.12 | 0.15 | 0.22 | 0.39 | 0.75 | 1.11 | 1.46 | 1.84 | 2.19 | 2.55 | 2.92 | 3.29 | 3.65 | 5.47 | 7.30 | 61 |
| 62 | | 0.11 | 0.15 | 0.21 | 0.39 | 0.74 | 1.09 | 1.44 | 1.81 | 2.16 | 2.51 | 2.87 | 3.24 | 3.59 | 5.38 | 7.18 | 62 |
| 63 | | 0.11 | 0.14 | 0.21 | 0.38 | 0.73 | 1.07 | 1.42 | 1.78 | 2.13 | 2.47 | 2.82 | 3.19 | 3.53 | 5.30 | 7.07 | 63 |
| 64 | | 0.11 | 0.14 | 0.21 | 0.38 | 0.72 | 1.05 | 1.40 | 1.75 | 2.10 | 2.43 | 2.77 | 3.14 | 3.48 | 5.22 | 6.96 | 64 |
| 65 | | 0.11 | 0.14 | 0.20 | 0.37 | 0.71 | 1.03 | 1.38 | 1.72 | 2.07 | 2.39 | 2.73 | 3.09 | 3.43 | 5.14 | 6.85 | 65 |
| 66 | | 0.11 | 0.14 | 0.20 | 0.37 | 0.70 | 1.02 | 1.36 | 1.69 | 2.04 | 2.35 | 2.69 | 3.04 | 3.38 | 5.06 | 6.75 | 66 |
| 67 | | 0.11 | 0.14 | 0.20 | 0.36 | 0.69 | 1.01 | 1.34 | 1.66 | 2.01 | 2.32 | 2.65 | 2.99 | 3.33 | 4.98 | 6.65 | 67 |
| 68 | | 0.11 | 0.14 | 0.20 | 0.36 | 0.68 | 1.00 | 1.32 | 1.64 | 1.98 | 2.29 | 2.61 | 2.95 | 3.28 | 4.91 | 6.55 | 68 |
| 69 | | 0.11 | 0.13 | 0.19 | 0.35 | 0.67 | 0.99 | 1.30 | 1.62 | 1.95 | 2.26 | 2.57 | 2.91 | 3.23 | 4.84 | 6.45 | 69 |
| 70 | | 0.11 | 0.13 | 0.19 | 0.35 | 0.66 | 0.98 | 1.28 | 1.60 | 1.92 | 2.23 | 2.53 | 2.87 | 3.18 | 4.77 | 6.36 | 70 |

(a)

## METRIC RATING TABLE FOR No. 622 CURRENT METER

VELOCITY IN METERS PER SECOND

| Time in Secs | 1 Rev | 2 Rev | 3 Rev | 5 Rev | 10 Rev | 20 Rev | 30 Rev | 40 Rev | 50 Rev | 60 Rev | 70 Rev | 80 Rev | 90 Rev | 100 Rev | 150 Rev | 200 Rev | Time in Secs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 0 027 | 0 046 | 0 064 | 0 094 | 0 177 | 0 344 | 0 5.2 | 0 680 | 0 84" | 1 018 | 1 189 | 1 356 | 1 527 | 1 695 | 2 542 | 3 389 | 40 |
| 41 | 0 027 | 0 046 | 0 061 | 0 091 | 0 174 | 0 335 | 0 500 | 0 664 | 0 826 | 0 994 | 1 161 | 1 323 | 1 490 | 1 655 | 2 481 | 3 307 | 41 |
| 42 | 0.027 | 0 043 | 0 061 | 0 091 | 0 171 | 0 326 | 0 488 | 0 649 | 0 808 | 0 969 | 1 134 | 1 292 | 1 454 | 1 615 | 2 423 | 3 228 | 42 |
| 43 | 0 027 | 0 043 | 0 061 | 0 088 | 0 165 | 0.320 | 0 475 | 0 634 | 0 789 | 0 948 | 1 106 | 1 262 | 1 420 | 1 579 | 2 368 | 3 152 | 43 |
| 44 | 0 027 | 0 043 | 0 058 | 0 085 | 0 162 | 0 314 | 0 466 | 0 619 | 0 771 | 0 927 | 1 082 | 1 231 | 1 387 | 1 542 | 2 313 | 3 078 | 44 |
| 45 | 0 027 | 0 043 | 0 058 | 0 085 | 0 158 | 0 308 | 0 457 | 0 607 | 0 756 | 0 905 | 1 058 | 1 204 | 1 356 | 1 509 | 2 262 | 3 008 | 45 |
| 46 | 0 027 | 0 043 | 0 058 | 0 085 | 0 155 | 0.302 | 0 448 | 0 594 | 0 741 | 0 884 | 1 033 | 1 190 | 1 325 | 1 475 | 2.213 | 2 941 | 46 |
| 47 | 0 024 | 0 043 | 0 055 | 0 082 | 0 152 | 0 296 | 0 439 | 0 582 | 0 725 | 0 866 | 1 012 | 1 155 | 1 298 | 1 445 | 2 167 | 2 880 | 47 |
| 48 | 0 024 | 0 043 | 0 055 | 0 079 | 0 149 | 0.290 | 0 430 | 0 570 | 0 710 | 0 847 | 0 991 | 1 131 | 1 271 | 1 414 | 2 121 | 2 819 | 48 |
| 49 | 0 024 | 0 040 | 0 055 | 0 079 | 0 146 | 0 283 | 0 421 | 0 558 | 0 695 | 0 829 | 0 969 | 1 106 | 1 247 | 1 384 | 2 076 | 2 761 | 49 |
| 50 | 0.024 | 0 040 | 0 052 | 0 079 | 0 143 | 0 277 | 0 411 | 0 546 | 0 680 | 0 814 | 0 951 | 1 085 | 1 222 | 1 356 | 2 033 | 2 710 | 50 |
| 51 | | 0 040 | 0 052 | 0 076 | 0 140 | 0 274 | 0 402 | 0.533 | 0 668 | 0 799 | 0 933 | 1 064 | 1 198 | 1 329 | 1 993 | 2 658 | 51 |
| 52 | | 0 040 | 0 052 | 0 076 | 0 140 | 0 268 | 0 393 | 0.524 | 0 655 | 0 783 | 0 914 | 1 042 | 1 173 | 1 305 | 1 957 | 2 609 | 52 |
| 53 | | 0 040 | 0.049 | 0 073 | 0 137 | 0 262 | 0 387 | 0.515 | 0 643 | 0 768 | 0 896 | 1 024 | 1 152 | 1 280 | 1 920 | 2 560 | 53 |
| 54 | | 0 040 | 0 049 | 0 073 | 0 134 | 0 259 | 0 381 | 0.506 | 0 631 | 0 753 | 0 878 | 1 006 | 1 131 | 1 256 | 1 884 | 2 512 | 54 |
| 55 | | 0 040 | 0.049 | 0 073 | 0.131 | 0 253 | 0 375 | 0.497 | 0.619 | 0 741 | 0 863 | 0 988 | 1 109 | 1 234 | 1 850 | 2 466 | 55 |
| 56 | | 0.037 | 0.049 | 0.070 | 0 131 | 0.250 | 0 369 | 0 488 | 0 607 | 0 728 | 0 947 | 0 969 | 1 091 | 1 213 | 1 817 | 2 423 | 56 |
| 57 | | 0 037 | 0.049 | 0.070 | 0 128 | 0 244 | 0 363 | 0.479 | 0 597 | 0 716 | 0 832 | 0 951 | 1 073 | 1 192 | 1 786 | 2 360 | 57 |
| 58 | | 0.037 | 0.046 | 0.067 | 0.125 | 0.241 | 0 357 | 0.469 | 0 568 | 0 704 | 0 817 | 0 936 | 1 055 | 1 170 | 1 756 | 2.341 | 58 |
| 59 | | 0 037 | 0.046 | 0 067 | 0 125 | 0.238 | 0 351 | 0 460 | 0 579 | 0 692 | 0 802 | 0 920 | 1 036 | 1 149 | 1 725 | 2 301 | 59 |
| 60 | | 0.037 | 0.046 | 0.067 | 0.122 | 0.235 | 0 344 | 0.451 | 0.570 | 0 680 | 0 789 | 0 905 | 1 018 | 1 131 | 1 693 | 2 252 | 60 |
| 61 | | 0.037 | 0.046 | 0.067 | 0.119 | 0.229 | 0 338 | 0.445 | 0.561 | 0 668 | 0.777 | 0 890 | 1 003 | 1.113 | 1.667 | 2 225 | 61 |
| 62 | | 0.034 | 0.046 | 0.064 | 0.119 | 0.226 | 0 332 | 0.439 | 0.552 | 0.658 | 0 765 | 0.875 | 0 988 | 1.094 | 1.640 | 2 188 | 62 |
| 63 | | 0.034 | 0.043 | 0 064 | 0.116 | 0 223 | 0 326 | 0.433 | 0.543 | 0 649 | 0 753 | 0 860 | 0 972 | 1 076 | 1 615 | 2 155 | 63 |
| 64 | | 0.034 | 0.043 | 0.064 | 0 116 | 0.219 | 0 320 | 0.427 | 0 533 | 0 640 | 0 741 | 0 844 | 0 957 | 1 061 | 1.591 | 2 121 | 64 |
| 65 | | 0.034 | 0.043 | 0 061 | 0 113 | 0.216 | 0 314 | 0.421 | 0.524 | 0 631 | 0 728 | 0.832 | 0.942 | 1 045 | 1 567 | 2 088 | 65 |
| 66 | | 0.034 | 0 043 | 0 061 | 0.113 | 0.213 | 0 311 | 0.415 | 0 515 | 0 622 | 0 716 | 0 820 | 0.927 | 1.030 | 1.542 | 2 057 | 66 |
| 67 | | 0.034 | 0.043 | 0.061 | 0 110 | 0.210 | 0 308 | 0 408 | 0.506 | 0 613 | 0.707 | 0 808 | 0.911 | 1.015 | 1.518 | 2 027 | 67 |
| 68 | | 0.034 | 0.043 | 0.061 | 0.110 | 0.207 | 0 305 | 0.402 | 0.500 | 0 604 | 0 698 | 0 796 | 0.899 | 1.000 | 1 497 | 1 996 | 68 |
| 69 | | 0.034 | 0.040 | 0.058 | 0 107 | 0 204 | 0 302 | 0 396 | 0 494 | 0 594 | 0 689 | 0 783 | 0 887 | 0.985 | 1 475 | 1 966 | 69 |
| 70 | | 0.034 | 0.040 | 0.058 | 0 107 | 0 201 | 0 299 | 0 390 | 0 488 | 0 585 | 0 680 | 0.771 | 0 875 | 0 969 | 1 454 | 1 939 | 70 |

This table applies when measurements are made with meter suspended by cable When measurements are made with meter suspended by rod, reduce the tabular velocities by 2 per cent

(b)

FIGURE 8

RATING TABLE FOR MODEL 622 GURLEY CURRENT METER
(a) IN FT/SEC AND (b) IN M/SEC

## 3. MEASURING HEIGHT OF WATER SURFACE

### 3.1 Staff Gauge

The gauge should be securely anchored to a bridge abutment tree or other physically stable object and should be set vertically. In Figure 1, two staff gauges are secured by wooden batons wedged against a streamside stump. The gauge should be set so that the graduated scale has its zero mark well below the lowest level to which the water is expected to drop during the gauging period, and its top above the high-water level.

Variations of water level are read directly from the scale at frequent intervals by an observer on-site, or at less frequent intervals by a visiting observer; therefore, accessibility is a prime requisite when determining station location.

### 3.2 Weight and Chain Gauge

This type of gauge may be used from a bridge or other overhead structure, and may be protected from damage by enclosure in a wooden housing. The gauge is designed to measure water level variations up to 9 feet; however, if the water level varies more than 9 feet, the height is measured by placing an additional temporary marker (f), (see Figure 2), on the chain coincident with the gauge "0", when the original marker is positioned at exactly 9 feet on the gauge. Nine feet is then added to the reading indicated by the second temporary marker. Only one marker should be permanently attached to the gauge at one time. The length of the chain must be sufficient to permit the marker to be on the scale when the water reaches its lowest level. The chain should be carefully stretched to a constant length and coils and kinks removed before it is installed. A ring should be attached to the chain on the opposite end to the weight, so that the chain will be stopped by the chain guide and will not fall into the stream if the chain and weight are accidentally dropped.

### 3.3 Automatic Stage Recorder

Manual gauges such as the staff gauge and weight/chain gauges must be read frequently to define a hydrograph when water levels change rapidly. For unmanned, continuous recording an automatic stage recorder should be used. The type of recorder depicted in Figure 3 is commonly used by personnel of the Fisheries and Marine Service, Pacific Region. This float-type of recorder is generally mounted in a well to protect the float from floating debris. The connecting intake pipe or channel should be located to prevent as much sediment as possible from entering the float chamber. It is important that the instrument and its housing remain vertical, therefore, support bracing (as in Figure 3) may be necessary.

The enclosed recording device used to tabulate the height of the water surface is usually driven by a pulley, float, tape and counterweight. The time may be recorded by a device operated by a weight, spring or battery-operated clock.

# 4. MEASURING DISCHARGE

## 4.1 Velocity-Area Method

When this method is used a suitable cross-section of the stream is divided into a convenient number of segments, each bounded by imaginary vertical lines from the water surface to the stream bed; the area of each segment and the mean velocity of the water flowing through it are determined by taking current meter measurements. The discharge for each segment is computed by multiplying the area of the segment by the corresponding mean velocity, and these individual discharges are added to derive the required discharge. Velocities in a stream are usually measured using a current meter (see Figures 4 and 5). When the velocity-area method is used, the stream stage should be observed at the beginning and the end of the current meter measurements, to determine the area of the cross-section. Stream stage readings at intermediate times during velocity measurements should also be observed if rapid variations occur in the water level.

## 4.2 Weir Formulae Method

To use this method of measuring discharge, a weir is placed at a convenient section in the stream, and the discharge at various stages is calculated from the known length of the crest, and the known coefficient determined by the type of weir employed. After the discharge table or stage-discharge (see Appendix A and Section 5.3) has been prepared, the head or water height over the crest of the weir is the only quantity that needs to be measured to determine the discharge at any moment. Further discussion on the design, construction and use of weirs may be found in hydrology texts and the Fisheries and Marine Service report on weirs. A typical weir is illustrated in Figure 9.

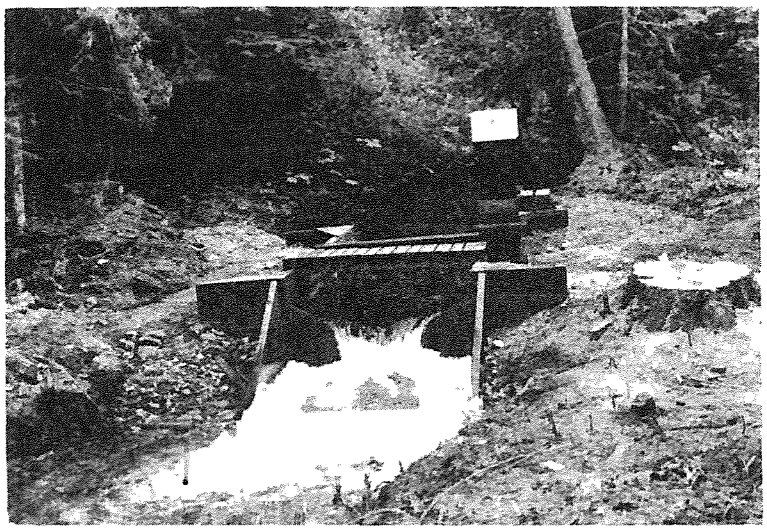

FIGURE 9

PRE-RATED 120$^{\circ}$ V-NOTCH WEIR
ON GENESEE RIVER, B. C.

## 4.3 Location of Station Site

The first step in measuring streamflow by the velocity-area method is to establish a gauging station, which is simply a specific cross-section of the stream at which measurement of water depth and velocity are to be taken. If possible, the gauging station should be so located that the discharge corresponding to any particular height of water surface will be unvarying, i.e., stable river bottom. A discharge table or stage-discharge curve (see Appendix A and Section 5.3) prepared from a series of measurements at various depths, will enable the determination of the discharge at this particular site at any future time.

A relatively permanent relationship between water depth and discharge can be established when the station is influenced by a suitable and stable "control". The control may be an obstruction, such as a rock ledge or a dam extending across the stream and downstream of the station. Such a "control" is shown in Figure 10. The control functions as a weir ensuring that the discharge will always be the same for a given water level by minimizing variations of the river bed at the station. The station is located upstream from the "control" to avoid sharp variations in the water surface which often occur at obstructions in streams at varying flows, i.e., ripples, waves, eddies and hydraulic jumps.

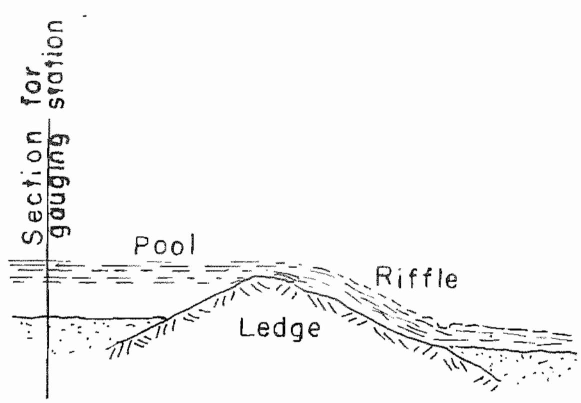


FIGURE 10

TYPICAL POOL/LEDGE "CONTROL" DOWN-STREAM OF THE GAUGING STATION

Where a stream has a soft, shifting bed, it may be necessary to establish the gauging station at the most suitable section available, and then regularly re-survey the river bed and prepare new discharge tables or stage-discharge curves at frequent intervals. Records produced in these latter conditions will be reliable, only if regular monitoring of river bed variation is maintained.

The gauging station should be in a relatively straight and smooth reach of the stream. The water level at the station should not be affected by backwater from any tributaries flowing into the stream below the station. The preferable stream velocity at the station at ordinary stages of flow should be between 1 ft/sec to 10 ft/sec. The station should be readily accessible.

## 4.4 Division of Stream Cross-Section and Determination of Segment Areas

Figure 11 shows a reach of a stream in which a gauging station is to be established.

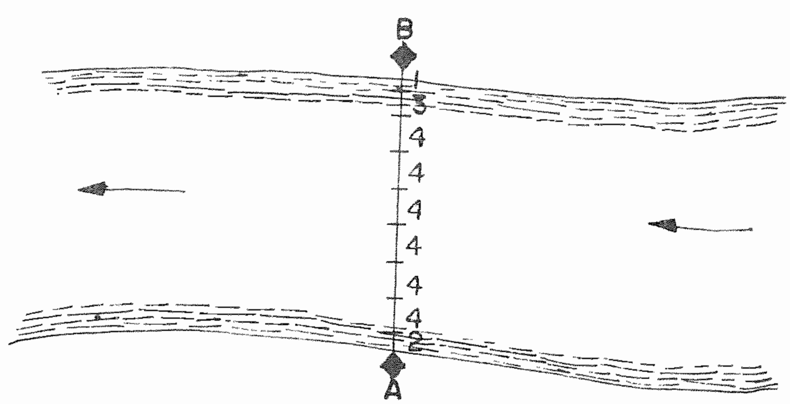


FIGURE 11

PLAN OF A TYPICAL RIVER REACH

The cross-section AB at the station may be marked in any way that is most convenient, but the recommended procedure is to stretch a wire or rope across the stream. The cross-section is then divided into any desired number of segments and the points of (imaginary vertical lines from water surface to stream bed) are marked on the wire by means of tape or tags. Distances along the wire from the selected reference point to the various division points are measured, measurements of the water depth at each division point are taken, and the cross-sectional area of each segment is calculated by multiplying its width by its mean depth. A typical cross-section and segmentation of a stream is shown in Figure 12.

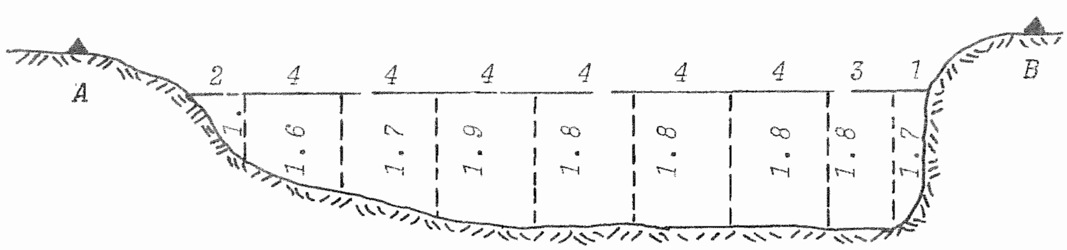


FIGURE 12

SEGMENTED CROSS-SECTION PROFILE

4.5 Variation of Velocity in a Stream Section

The velocity of flow in a stream usually increases with increasing distance from the banks and the stream bed. In general, the maximum velocity occurs in that part of the cross-section where the depth is greatest and at a point slightly below the surface. Typical variations of velocity with the depth along a vertical line are depicted in Figure 13.

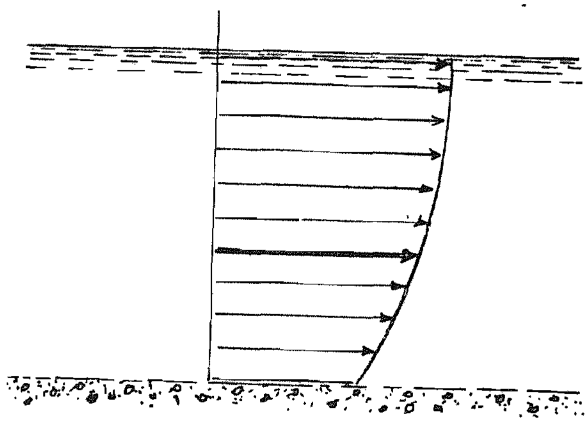

FIGURE 13

GRAPHICAL REPRESENTATION OF A VERTICAL VELOCITY CURVE

The arrow lengths indicate the relative magnitude of the velocities at the various depths from the water surface to the stream bed. The depth from the surface to the point at which the mean velocity occurs ranges from 0.5 to 0.65 of the total depth. The smaller value applies to broad, shallow streams, and the larger, to deep streams. An average value of 0.6 of the total depth is commonly used for measuring the mean velocity.

## 4.6 Methods of Determining Stream Velocity Using a Current Meter

### 4.6.1 General Operating Guidelines for Current Meter

To make a velocity measurement at any point, the current meter should be spin-tested before measuring commences and at frequent times throughout the measuring period. This is done to avoid false readings due to silt or debris lodged in the revolving cone-shaped cups. When measuring velocities below 1 ft/sec the meter should spin freely in the air for at least 90 sec. When measuring high velocities in silty water, the meter should be spin-tested for at least 1 min. In both tests, the meter should come to a very gradual stop.

To obtain an accurate value of the average velocity at any point, it is necessary to hold the meter at the point for an appreciable length of time. Generally, the time required for an observation is at least 40-50 sec. but if the velocity is small, 100 sec. is better. Accuracy is increased by measuring the time required for the wheel to make a certain number of revolutions, compared to the technique of counting the number of revolutions made in a definite interval of time. Usually the number of revolutions may be any multiple of ten, providing the observation time is not less than 40 sec. When velocities are less than 0.5 ft/sec, any number of revolutions can be used if the time of observation is more than 40 sec. By means of a Rating Table for the meter, the velocity corresponding to the number of revolutions per second can be found (see Figures 8(a) and (b)).

The velocity observations are taken on the verticals bounding each segment in succession, until the entire cross-section has been covered. The one-point method in which a single velocity is measured along each segment vertical, is quicker; but the two-point method gives more reliable results and is the method most often used. The average of the velocity at the two points is taken as the mean velocity for the segment vertical.

It should be noted that stream velocity may vary not only with respect to the position in the cross-section but also to time, because the water moves in surges or pulsations which can cause the meter cups to speed up or slow down. Under ordinary circumstances the surges are not great, but their presence should be recognized.

### 4.6.2 Metering by a Suspension Cable

When using the current meter on a suspension cable from a bridge or a cable car (see Figure 14), the total depth of water along each segment vertical must be measured so that the meter cups can be held at the correct underwater level. The following method may be used to determine water depth. A graduated tape is attached to the meter's suspension cable, and then the meter is lowered until the bottom of the weight (see Figure 4) just touches the surface of the water. A reading of the tape is then taken at some fixed point convenient for the observer. Next, the meter is lowered until the weight rests gently on the stream bed; a second tape reading is taken at the same reference point. The difference between the two tape readings is equal to the total depth of the water, and the reading of the tape that will locate the meter's rotating cups at the proper depth can be computed. This method of measuring depth can be used only where the velocity of the stream is low and the immersed meter is not swung far downstream by the current.

If the velocity is very high, a heavy weight is required to ensure that the meter hangs vertically below the point of suspension. In this case, a mechanical aid such as a Stevens (see Figure 15) or Canfield metering reel may be employed.

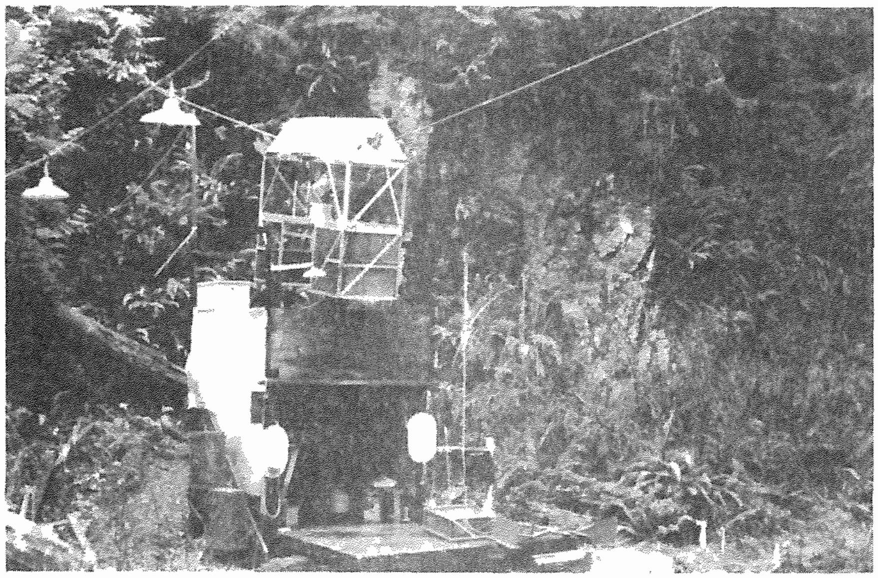

FIGURE 14

CABLE CAR INSTALLATION FOR METERING AT CARNATION CREEK, B.C.

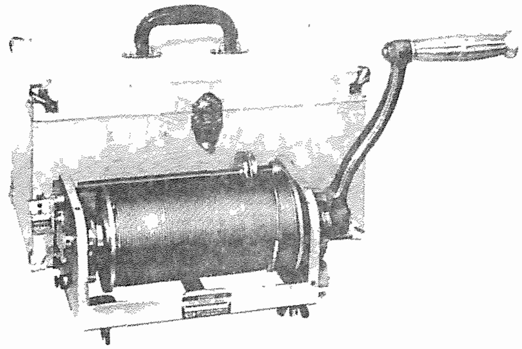

FIGURE 15

STEVENS METERING REEL

Two methods of measuring average velocity using a suspended current meter are commonly employed: Integration method and Point method. In the Integration Method, the meter is moved up and down at a uniform speed through each segment in the cross-section, and the velocity recorded by the meter is assumed to be the mean velocity in the segment. To make an observation along a segment's vertical line, the meter cups are just submerged beneath the surface and the count is started. The meter is then slowly lowered at a uniform rate to the stream bed. The direction of movement is then instantly reversed, and the meter is raised to the surface at the same rate. The total number of revolutions of the meter cups and the time needed to complete the operation are recorded.

If the rates of lowering and raising the meter have been exactly uniform, and the stream velocity has remained constant, the number of revolutions registered during descent will equal the number registered during ascent. As the two values are seldom equal, the mean rate is derived by dividing the total number of revolutions registered during both descent and ascent by the total time taken to lower and raise the meter. This calculated mean velocity will not be strictly accurate, because the meter cannot be lowered close to the bottom. In addition, some observers consider that moving the meter causes it to tip slightly out of its horizontal position, thus causing a slight error in the reading. However, if the observation is made carefully, the result should be reasonably satisfactory.

Where the integration method is employed to determine the mean velocity in an entire cross-section, the meter must be passed at a slow, uniform rate over all parts of the cross-section in a single operation. A more accurate method is to first move the meter slowly from one side of the stream to the other, holding it submerged with the suspending cable or rod in a vertical orientation; at the same time moving it up and down to sample the current throughout the cross-section. A second observation is taken by moving the meter in a reversed direction and path back to the starting point. The number of revolutions and time in seconds for each observation are recorded. If the results of the two observations are reasonably close, the mean is taken; if the difference approaches 10%, the need for a third observation should be considered. When a third observation is necessary and the result obtained nearly agrees with one of the other two results, the mean of the two results most nearly alike is used, and the most divergent result is discarded. Where any two of the three results are not in close agreement, the mean of all three results should be used. Section 4.7 describes the manner in which a typical set of field notes should be recorded (see also, Figure 18).

The integration method is considered less reliable than the point method (described in the following paragraphs), because the meter cannot be moved across the cross-section in a path which properly represents the average of the velocities existing in various parts of the stream. It may be used, however, to obtain an approximate value of the mean velocity, and it is the quicker of the two methods.

In the Point Method for determining velocities with the current meters, the first step is to establish the vertical lines separating segments along which the meter is to be held. This applies whether velocity measurements are to be made at one or two points in a segment's vertical line. Thus, for the cross-section shown in Figure 12, the velocity may be measured on each of the vertical lines represented by short dashes. The positions of these lines in the stream may be marked by stretching a wire or rope across the stream just above the water surface and attaching tags to the wire or rope. If a bridge is available at the gauging station, the positions of the lines may be marked on the bridge, preferably on the upstream side. When a single velocity measurement is to be made on each vertical line, the meter should be placed at a point whose depth below the water surface is 0.6 times the total depth at that particular vertical line. Where velocity measurements are to be made at two points on the same vertical line, the points are located at depths of 0.2 and 0.8 times the total depth.

In the integration or point method, during current meter operations using cable suspension in high velocity streams, the meter can be prevented from swinging too far downstream by the use of an upstream stay line support. Measurements of depth made by the usual procedure are too large if the depth and velocity are such as to cause the meter, sounding weight and line to drift downstream from the vertical. The downstream drift of the weight, meter and line will place the sounding weight downstream from the vertical when it reaches the river bed, causing the sounding line to be curved from the water surface.

The length of the line is as such, greater than the vertical depth of the water. The excess in length of the curved line over the vertical depth is indicated by the vertical angle made by the line at or above the water surface, and the excess in apparent depth caused by the inclination of the line above the water is a function of the same angle.

The error that may occur in such a measurement is indicated in Figure 16.

The index on the metering reel is read when the sounding weight is at the surface (b) and then read again at the bottom (e). The distance (c e) represents the amount of line let out during the process of lowering the weight from the surface to the bottom. The distance (a e) may be called the observed depth. The error in the observed depth consists of two parts: (1) the distance (c d) above the water and, (2) the difference between the wet line depth (d e) and the vertical depth.

The correction above the water surface (c d) is called the Air Correction and depends upon the vertical angle of the line and the height (a b) of the suspension mechanism above the water surface. This correction may be obtained by calculating the product of the exsecant of the vertical angle and the height (a b) above the water surface or may be obtained directly from the Air Correction table, (Figure 17).

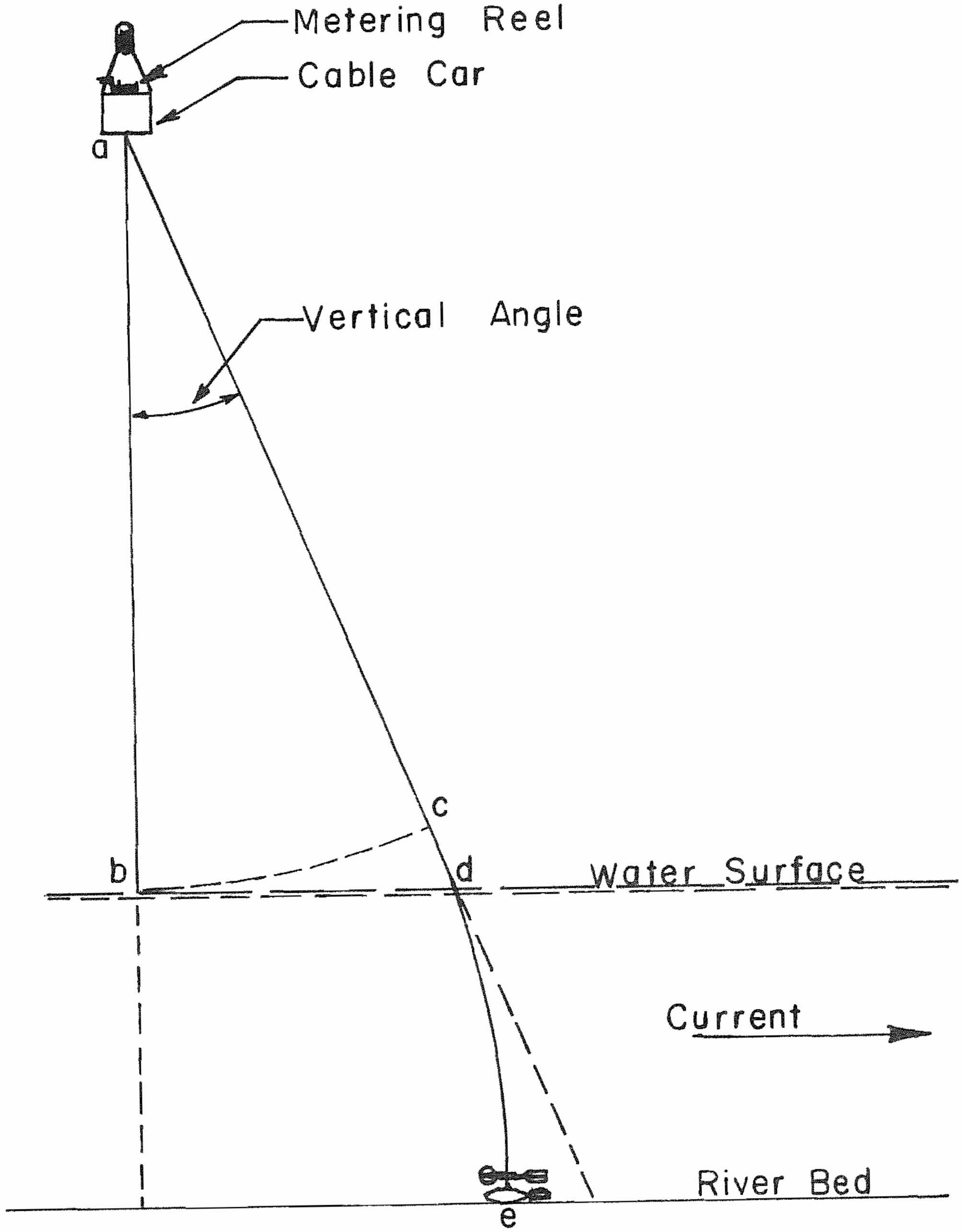


FIGURE 16

POSITION OF A SOUNDING WEIGHT WITH METER ATTACHMENT IN DEEP SWIFT WATER.

The correction for excess in length of line below the water surface may be obtained by using the Water Correction table, (Figure 17).

It should be noted that the Water Correction table has been calculated for a river reach with a regular velocity distribution as in Figure 13, and for a properly designed sounding weight with a standard cable so as to offer little resistance to the current.

The correction from the Water Correction table, (Figure 17) cannot be ascertained until the air correction has been deducted from the observed depth and the wet-line depth obtained by means of the Air Correction table.

For example, metering from a cable car as shown in (Figure 16), the Air and Water Correction table (Figure 17) are used as follows:

Recorded Data:

Vertical distance above water surface (a b) = 22'

Observed depth ......................(a e) = 32'

Vertical angle ...................... = $14^{\circ}$

Calculations:

Air correction for 22' and $14^{\circ}$ = 0.62

Therefore, Wet-line length = 32'-(22'+0.62) = 9.38

Water correction for 9.38' and $14^{\circ}$ = 0.09

Therefore, Vertical depth of water is 9.38-0.09' = 9.29'

AIR CORRECTION TABLE.

| vertical length | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° | 26° | 28° | 30° | 32° | 34° | 36° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2' | nil | 0.01 | 0.02 | 0.03 | 0.04 | 0.6 | 0.08 | 0.10 | 0.13 | 0.15 | 0.19 | 0.22 | 0.26 | 0.31 | 0.35 | 0.41 | 0.47 |
| 4' | nil | 0.03 | 0.04 | 0.06 | 0.09 | 0.13 | 0.16 | 0.20 | 0.26 | 0.31 | 0.38 | 0.45 | 0.53 | 0.62 | 0.71 | 0.82 | 0.94 |
| 6' | nil | 0.04 | 0.06 | 0.09 | 0.13 | 0.19 | 0.24 | 0.31 | 0.38 | 0.47 | 0.57 | 0.62 | 0.79 | 0.93 | 1.07 | 1.23 | 1.42 |
| 8' | nil | 0.05 | 0.08 | 0.12 | 0.18 | 0.25 | 0.32 | 0.41 | 0.51 | 0.63 | 0.75 | 0.90 | 1.06 | 1.24 | 1.43 | 1.65 | 1.89 |
| 10' | 0.02 | 0.06 | 0.10 | 0.15 | 0.22 | 0.31 | 0.40 | 0.51 | 0.64 | 0.79 | 0.95 | 1.13 | 1.33 | 1.55 | 1.79 | 2.06 | 2.36 |
| 12' | 0.03 | 0.07 | 0.12 | 0.19 | 0.27 | 0.37 | 0.48 | 0.62 | 0.77 | 0.94 | 1.14 | 1.35 | 1.59 | 1.86 | 2.15 | 2.47 | 2.83 |
| 14' | 0.03 | 0.08 | 0.14 | 0.22 | 0.31 | 0.43 | 0.56 | 0.72 | 0.90 | 1.10 | 1.32 | 1.58 | 1.86 | 2.17 | 2.51 | 2.89 | 3.30 |
| 16' | 0.04 | 0.09 | 0.16 | 0.25 | 0.36 | 0.48 | 0.64 | 0.82 | 1.03 | 1.26 | 1.51 | 1.80 | 2.12 | 2.48 | 2.87 | 3.30 | 3.78 |
| 18' | 0.04 | 0.10 | 0.18 | 0.28 | 0.40 | 0.55 | 0.73 | 0.93 | 1.16 | 1.41 | 1.70 | 2.03 | 2.39 | 2.78 | 3.23 | 3.71 | 4.25 |
| 20' | 0.05 | 0.11 | 0.20 | 0.31 | 0.45 | 0.61 | 0.81 | 1.03 | 1.28 | 1.57 | 1.89 | 2.25 | 2.65 | 3.09 | 3.58 | 4.12 | 4.72 |
| 22' | 0.05 | 0.12 | 0.22 | 0.34 | 0.49 | 0.62 | 0.89 | 1.13 | 1.41 | 1.73 | 2.08 | 2.48 | 2.92 | 3.40 | 3.94 | 4.54 | 5.19 |

WATER CORRECTION TABLE

| wet-line length | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° | 26° | 28° | 30° | 32° | 34° | 36° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2' | | | 0.01 | 0.01 | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.09 | 0.10 | 0.12 | 0.14 |
| 4' | | | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.11 | 0.14 | 0.15 | 0.19 | 0.21 | 0.25 | 0.28 |
| 6' | | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.07 | 0.10 | 0.12 | 0.15 | 0.18 | 0.21 | 0.25 | 0.28 | 0.33 | 0.37 | 0.42 |
| 8' | | 0.01 | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.13 | 0.16 | 0.20 | 0.23 | 0.28 | 0.31 | 0.38 | 0.43 | 0.50 | 0.56 |
| 10' | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.10 | 0.13 | 0.16 | 0.20 | 0.25 | 0.30 | 0.35 | 0.41 | 0.47 | 0.54 | 0.62 | 0.70 |
| 12' | 0.01 | 0.02 | 0.04 | 0.06 | 0.09 | 0.12 | 0.15 | 0.20 | 0.24 | 0.30 | 0.36 | 0.42 | 0.49 | 0.57 | 0.67 | 0.74 | 0.84 |
| 14' | 0.01 | 0.02 | 0.04 | 0.07 | 0.10 | 0.14 | 0.18 | 0.23 | 0.29 | 0.35 | 0.41 | 0.49 | 0.56 | 0.66 | 0.76 | 0.87 | 0.98 |
| 16' | 0.01 | 0.03 | 0.05 | 0.08 | 0.12 | 0.16 | 0.20 | 0.26 | 0.33 | 0.40 | 0.47 | 0.56 | 0.63 | 0.76 | 0.87 | 0.99 | 1.12 |
| 18' | 0.01 | 0.03 | 0.06 | 0.09 | 0.13 | 0.18 | 0.23 | 0.30 | 0.37 | 0.45 | 0.53 | 0.63 | 0.70 | 0.85 | 0.98 | 1.12 | 1.26 |
| 20' | 0.01 | 0.03 | 0.06 | 0.10 | 0.14 | 0.20 | 0.26 | 0.33 | 0.41 | 0.50 | 0.59 | 0.70 | 0.77 | 0.94 | 1.09 | 1.24 | 1.40 |
| 22' | 0.01 | 0.04 | 0.07 | 0.11 | 0.16 | 0.22 | 0.28 | 0.36 | 0.45 | 0.55 | 0.65 | 0.77 | 0.84 | 1.04 | 1.20 | 1.36 | 1.54 |
| 24' | 0.01 | 0.04 | 0.08 | 0.12 | 0.17 | 0.24 | 0.31 | 0.39 | 0.49 | 0.60 | 0.71 | 0.84 | 0.91 | 1.13 | 1.31 | 1.49 | 1.68 |
| 100' | 0.08 | 0.16 | 0.32 | 0.50 | 0.72 | 0.98 | 1.28 | 1.64 | 2.04 | 2.48 | 2.96 | 3.50 | 4.08 | 4.72 | 5.44 | 6.20 | 6.98 |

FIGURE 17

AIR AND WATER CORRECTION TABLES

### 4.6.3 Metering by Wading

The section of stream to be metered should be located in a stable, uniform portion of the stream, preferably in a straight reach with a length at least five times the width. A tag line indicating vertical bounding segments is then set up at right angles to the flow, and the chainage to edges of the stream is recorded. The number of segments into which a stream should be divided will depend upon the width of the stream. The section should be divided into a minimum of 20 segments or such that each segment accounts for not more than 10-15% of the total flow. The chainage to the verticals which determine the size of the segments is recorded. For small streams the verticals should not be less than one foot apart. The irregularity of the bottom of the stream may dictate the number and position of the verticals. The operator should stand immediately downstream of the tag line and at least 18 in. from the meter rod which, in turn, is positioned at each vertical. He should stand facing either the left or right bank and hold the meter rod in his upstream hand. The rod should be held in a vertical position with the meter parallel to the direction of stream flow. Before a velocity determination is made, the meter should be allowed to operate at the correct depth for several seconds until the revolutions become steady. In some situations, the velocity will not be zero at the stream's edge. An estimate of this velocity should be made (i.e., as a percentage of the velocity at the first segment vertical). The meter may not give a correct result close to a vertical wall or steep bank due to turbulence effects. During metering the meter should be positioned as follows:

a) For depths less than 0.5 ft, measure the velocity 0.5d from the water surface (where d = total depth).

b) For depths greater than 0.5 ft but less than 1.5 ft, measure the velocity 0.6d from the surface.

c) For depths of 1.5 ft and greater, measure the velocity 0.2d, and 0.8d from the surface.

If it is apparent that velocities measured at 0.2d and 0.8d (for depths of 1.5 to 2.0 ft) are affected by river bottom or surface irregularities, then the velocities should be measured at 0.6d from the surface.

## 4.7 Current Meter Field Notes

A typical set of current meter notes is illustrated in Figure 18. The field data is entered under "observations". In the first column are the horizontal distances from the initial reference point on the streambank to the various vertical lines in the cross-section at which velocity measurements are made. These distances are expressed as stations. Thus, the point at a distance of 10 ft is called Sta. 0 + 10; the point at a distance of 15 ft is called Sta. 0 + 15, a point at a distance of 110 ft would be called 1 + 10. Values in the second column are the total depths (often determined by using the current meter rod as a sounding device) at each segment's vertical line.

In the Figure 12 example, the stream was so shallow that the mean velocity for each vertical was determined by a single observation at a depth of 0.6 times the total depth. The number of revolutions of the meter wheel and corresponding time, in seconds, are recorded in the pertinent columns. Each observation had a duration of at least 40 sec.

Goldstream RIVER GAUGING STATION CURRENT METER NOTES

Date July 10 19 74 Party J.S. Arseneault
Total area 49.45 sq. ft. Mean velocity 1.62 Discharge 77.49
Recorder tape Begin 5.10 End 5.10 Mean 5.10 Method / Wt Wading
Gauge height Begin 5.10 End 5.10 Mean 5.10 Stream Rising Falling Steady
Measurement rated Excellent 2% Good 5% Fair 8% Poor over 8% Based on
Cross section Control Flow Good Weather Clear, sunny and warm
Ice conditions, misc. Nil
Recorder Stevens A-35

| OBSERVATIONS | | | | | | | COMPUTATIONS | | |
|---|---|---|---|---|---|---|---|---|---|
| Distance From Initial Point | Depth | Depth Of Observation | Revolutions | Time In Seconds | VELOCITY At Point | VELOCITY Mean In Vertical | Area | Width | Discharge |
| 0 + 00 | 0.2 | 0 | 0 | 0 | 0 | | | | |
| | | | | | | 0.75 | 1.30 | 2.0 | 0.98 |
| 0 + 02 | 1.1 | 0.66 | 30 | 45 | 1.50 | | | | |
| | | | | | | 1.71 | 5.40 | 4.0 | 9.23 |
| 0 + 06 | 1.6 | 0.96 | 40 | 47 | 1.91 | | | | |
| | | | | | | 1.85 | 6.60 | 4.0 | 12.21 |
| 0 + 10 | 1.7 | 1.02 | 40 | 50 | 1.79 | | | | |
| | | | | | | 1.77 | 7.20 | 4.0 | 12.74 |
| 0 + 14 | 1.9 | 1.14 | 40 | 52 | 1.75 | | | | |
| | | | | | | 1.72 | 7.40 | 4.0 | 12.73 |
| 0 + 18 | 1.8 | 1.08 | 40 | 53 | 1.69 | | | | |
| | | | | | | 1.66 | 7.20 | 4.0 | 11.95 |
| 0 + 22 | 1.8 | 1.08 | 40 | 55 | 1.63 | | | | |
| | | | | | | 1.52 | 7.20 | 4.0 | 10.94 |
| 0 + 26 | 1.8 | 1.08 | 30 | 48 | 1.41 | | | | |
| | | | | | | 1.33 | 5.40 | 3.0 | 7.19 |
| 0 + 29 | 1.8 | 1.08 | 30 | 54 | 1.25 | | | | |
| | | | | | | 0.63 | 1.75 | 1.0 | 1.10 |
| 0 + 30 | 1.7 | 1.02 | 0 | 0 | 0 | | | | |
| | | | | | | | | | 79.07 |
| | | Wading | Rod | less 2% | | | | | 1.58 |
| | | Total area x Mean Velocity = | | | | 80.10 | | | |
| Note: Not an actual METERING | | | | | | | | | |
| TOTAL | | | | | 1.62 | | 49.45 | 30.0 | 77.49 |

FIGURE 18

SAMPLE OF CURRENT METER FIELD NOTES

General information relevant to the observations, include the date, time and place where undertaken; the observer's name; the number and type of meter used; the gauge readings, and information of visible stream and meteorological conditions is entered in the upper area of the table.

## 5. COMPUTATION OF RECORDED DATA

### 5.1 Computation of Discharge - Integration Method

When the Integration Method is used to determine the mean velocity in the entire cross-section at one operation, the discharge of the stream may be found directly by multiplying the mean velocity by the entire cross-sectional area. The area may be obtained by taking gaugings at various points as indicated in Figure 12, computing the areas of each part into which the section is thus divided, and adding these partial areas.

### 5.2 Discharge for Part of a Section

Where current meter measurements have been made along several segment verticals, the discharge is computed for each segment. Figure 19 represents a portion of stream cross-section between two segment vertical lines at which the depths and mean velocities have been measured.

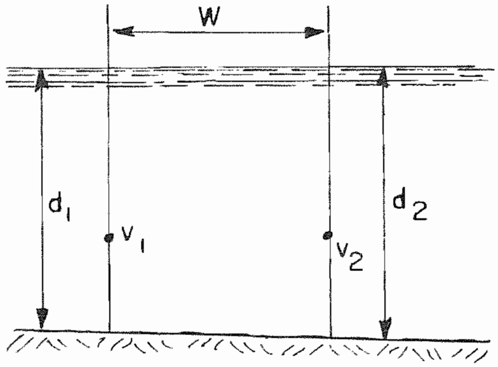


FIGURE 19

SEGMENT BOUNDED BY TWO VERTICALS

W denotes the horizontal distance in feet between the segment verticals. $d_1$ and $d_2$ represent depths in feet of the water obtained by sounding at the segment verticals, and $V_1$ and $V_2$ denote the respective mean velocities in feet per second at the segment verticals. The area in square feet of the segment under consideration:

$$\text{Area} = \frac{d_1 + d_2}{2} \times W$$

the mean velocity $V = \frac{V_1 + V_2}{2}$

and the discharge $Q = W \times \left(\frac{d_1 + d_2}{2}\right) \times \left(\frac{V_1 + V_2}{2}\right)$, in $ft^3/sec$.

The above formula may be applied successively to each trapezoidal-shaped part of the cross-section. Near each bank of the stream, the section may be treated as a right-angle triangle, which is really a trapezoid with one of the parallel bases equal to zero. Thus, the preceding formula may be applied by assuming that $d_1$ and $V_1$, or $d_2$ and $V_2$, are zero.

## 5.3 Compilation of the Discharge Table and Stage-Discharge Curve

The rise and fall of the water surface in a stream reflects a corresponding increase or decrease in discharge. This stage-discharge relationship can be presented on a discharge table and the resulting data graphed on a stage-discharge curve. Where observations were made under "control" (see Section 4.3) conditions, the stage-discharge relationship remains relatively permanent; under "non-control" conditions, frequent re-measuring of the stream and re-compilation of the table and curve may be necessary.

The parameters required to compile a table and curve are as follows:

- depth of water (ft) at each observation point;
- area of each section (segment) in which observations were made;
- mean velocity (ft/sec) of the entire section (segment);
- discharge of each section (segment), calculated by multiplying the mean velocity by the area.

The calculations required to compile a hypothetical discharge table and associated stage-discharge curve are presented in Appendix A.

# 6. CARE AND MAINTENANCE OF CURRENT METER

## 6.1 Rating and Calibration

To ensure accuracy during meter observations, the meter must be rated (calibrated). The meter is rated by holding it in a current of known velocity or by moving it through still water at a recorded uniform speed and noting the time and number of revolutions for a given distance.

The manufacturer supplies a rating table with each current meter (see Figures 8(a) and (b)). Should the instrument require major repairs or re-calibration, the meter should be sent to the Hydraulics Laboratory of the Canada Centre for Inland Waters, P.O. Box 5050, Burlington, Ontario.

## 6.2 Cleaning and Lubrication for Daily Use

Meters should be cleaned and oiled at the end of each day's use. Meters should be oiled frequently with a light machine oil during daily use.

It is sometimes necessary to clean the meter during the measuring of sewage flow, or streams containing heavy silt loads or industrial waste. This may be done in a pail of clean water. In winter, warm water should be available to thaw out the meter if it freezes by being held in the air.

The meter cup bearing consists of a tool-steel pivot turning in a highly polished tungsten carbide hub. By regular drying and oiling, these rotating parts can be kept free from rust. The hub bearing may be cleaned with a small pointed stick. Upon receipt of a new meter or a re-calibrated one, the bearing parts should be examined, and, if necessary, cleaned, dried and oiled. When storing the meter for any length of time, the bearing should be covered with grease. The light oils normally used, will eventually evaporate and leave gummy residues which can accelerate rusting. The grease should be removed from the bearing before the meter is used.

## 6.3 Lubrication and Maintenance Involving Dismantling

### 6.3.1 Shaft Lubrication

To lubricate the shaft remove the cap from the cummutator box (see Figure 20); oil the top of the shaft, steady bearing, worm, gear, and small worm gear bearing. When electric signals are used, it may be necessary to keep the commutator box filled with oil to reduce sparking, to prevent pitting of the eccentric and fins on the worm gear, and to prevent burning of the contact wires.

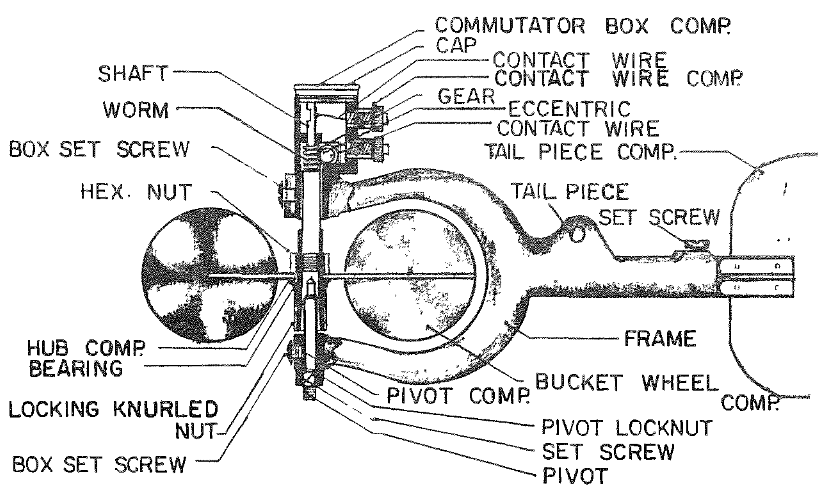


FIGURE 20

DETAILS OF A STANDARD MODEL 622 GURLEY METER WITH LABELLED PARTS REFERRED TO IN SECTION 6.3.

6.3.2 Pivot Lubrication

To lubricate the pivot loosen the lower set screw and withdraw the pivot from the frame. Wipe off excess grease or gummy oil from the pivot and clean the bearing (Figure 20) with a sharpened stick. Hold meter with commutator box down. Oil bearing, replace pivot and tighten set screw.

6.3.3 Current Meter Dis-assembly

To dis-assemble the current meter (see Figure 20) remove the cap from the commutator box, and loosen the box set screws in the frame a one-half turn. Withdraw the pivot and lock nut and commutator box. Care must be taken in the removal of the commutator box to ensure gear is not injured. Unscrew the shaft by lifting the bucket wheel until the hole in the shaft projects above the frame; insert the adjusting pin (or nail) in the hole and turn counter-clockwise. The bucket wheel can now be withdrawn from the frame. The hub and bearing can be separated from the bucket wheel by unscrewing the hex nut but this is necessary only when replacing a hub and bearing. Loosen the tailpiece set screw and withdraw the tailpiece from the frame. Lift up the curved end of the vane catch to release the stop pin, then swing the catch 180°. Separate the vanes by pulling each one in the direction indicated by the arrow engraved directly on the vane.

6.3.4 Pivot Adjustment

The proper amount of play in the pivot bearing is obtained in the following manner: first, the set screw in the pivot adjusting nut is released and, with the contact chamber cap tightly in place, the meter is turned over so that the top of the shaft rests against the cap (see Figure 20). The pivot is inserted into the pivot bearing until there is no vertical play. The screw for holding the pivot is tightened and the pivot adjusting nut is advanced until it rests against the yoke. The set screw is released slightly and the pivot adjusting nut is further advanced a quarter of a turn and the keeper set screw is firmly tightened. Upon completion of this adjustment the set screw in the yoke is tightened. The adjustment provides an end play of about 0.008 in. The meter is rated with this amount of play and it is essential that the adjustment be made when installing a new pivot or when the point becomes worn.

6.3.5 Contact Wire Adjustment

The contact wire should be bent to make a light contact with the rim or eccentric. Too heavy a pressure will cause drag and wear out the shaft and contact wire. Assemble the meter, headphone and battery and listen to the clicks as the bucket wheel revolves at a moderate rate. The clicks should be sharp with no dragging sound. Adjustment of the contact wire will give the proper signal. With proper adjustment of the pivot and contact, the bucket wheel should spin freely.

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# APPENDIXES

# APPENDIX A

## CALCULATIONS FOR A HYPOTHETICAL DISCHARGE TABLE AND STAGE-DISCHARGE CURVE

The cross-section of a hypothetical canal with five stages of water is shown in Figure A-1. For illustration, the height of the different stages are assumed to vary by intervals of exactly two feet. The bottom width of the canal is 10 ft, and the slope of the bank is 45$^{\circ}$, or 1 horizontal to 1 vertical.

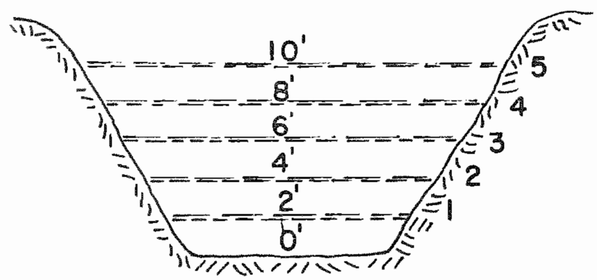


FIGURE A-1
CROSS-SECTION OF A CANAL

The areas of the cross-section of the water at the successive stages are as follows:

For a depth of 2 ft: $A = (\frac{10 + 14}{2}) \times 2 = 24 \text{ ft}^2$

For a depth of 4 ft: $A = (\frac{10 + 18}{2}) \times 4 = 56 \text{ ft}^2$

For a depth of 6 ft: $A = (\frac{10 + 22}{2}) \times 6 = 96 \text{ ft}^2$

For a depth of 8 ft: $A = (\frac{10 + 26}{2}) \times 8 = 144 \text{ ft}^2$

For a depth of 10 ft: $A = (\frac{10 + 30}{2}) \times 10 = 200 \text{ ft}^2$

The areas are tabulated in the third column of the Discharge Table (see page A-2).

The mean velocity for the entire section when measured directly, as by the integration method, is entered in the fourth column. The discharge, calculated by multiplying the area by the mean velocity, is entered in the fifth column.

The mean velocity may be measured indirectly by dividing the total discharge by the total area of the cross-section. The total discharge may be determined by dividing the cross-section into divisions and summing the discharge of each division.

DISCHARGE TABLE

| Number of Observations | Depth of Water(ft) | Sectional Area ($ft^2$) | Mean Velocity (ft/sec) | Discharge ($ft^3$/sec) |
|---|---|---|---|---|
| 1 | 2 | 24 | 1.00 | 24.0 |
| 2 | 4 | 56 | 1.46 | 81.8 |
| 3 | 6 | 96 | 1.81 | 174.0 |
| 4 | 8 | 144 | 2.09 | 301.0 |
| 5 | 10 | 200 | 2.34 | 468.0 |

The data entered in the discharge table for a stream cross-section, can be plotted as illustrated in Figure A-2. The stage-discharge curve drawn through the plotted points can be used to interpolate the discharge for any stage within the limit of the observations.

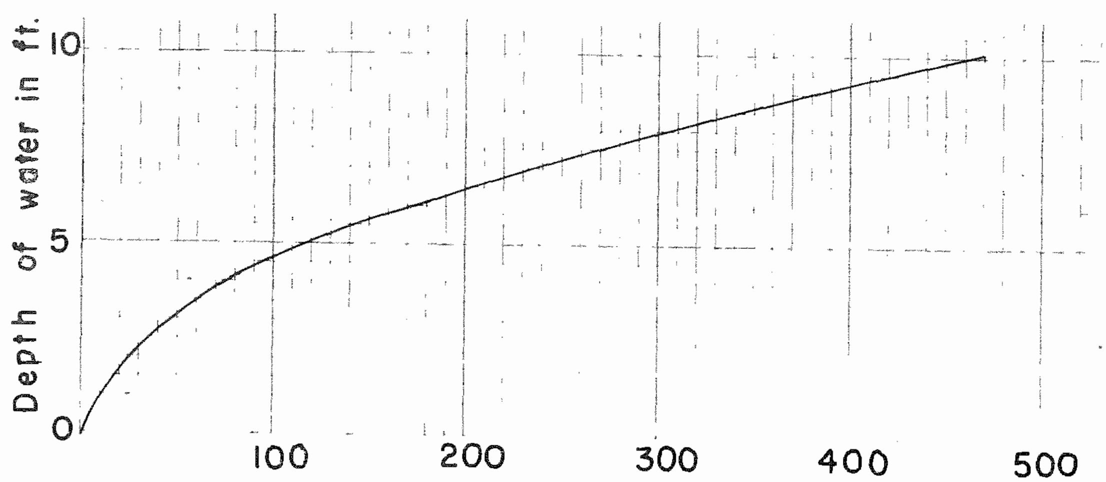


FIGURE A-2

STAGE-DISCHARGE CURVE
(data obtained from Discharge Table above)

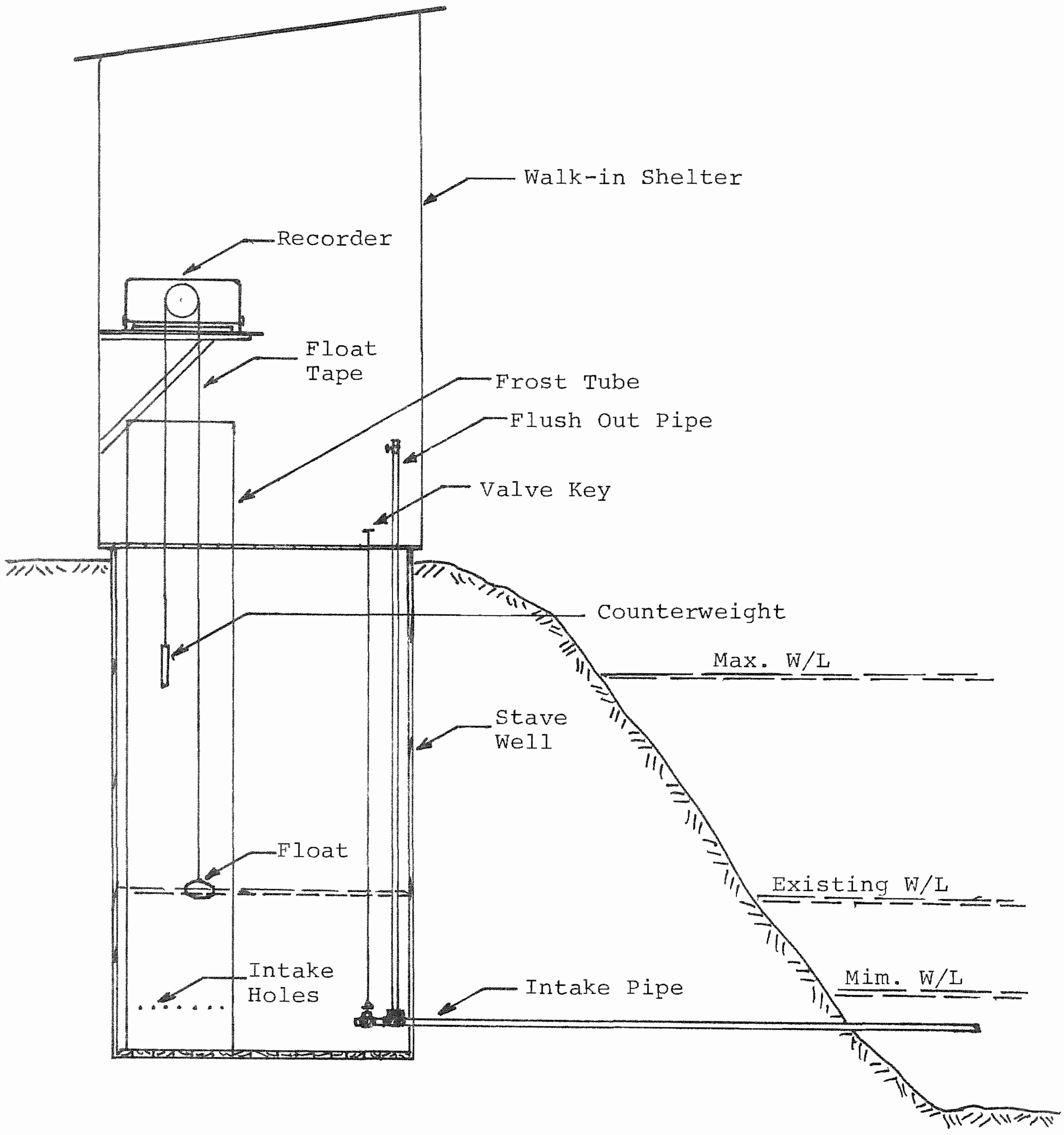


FIGURE B-1

BANK INSTALLATION SHOWING WATER LEVEL RECORDER IN WALK-IN SHELTER OVER WELL WITH FROST TUBE AND INTAKE PIPE TO STREAM

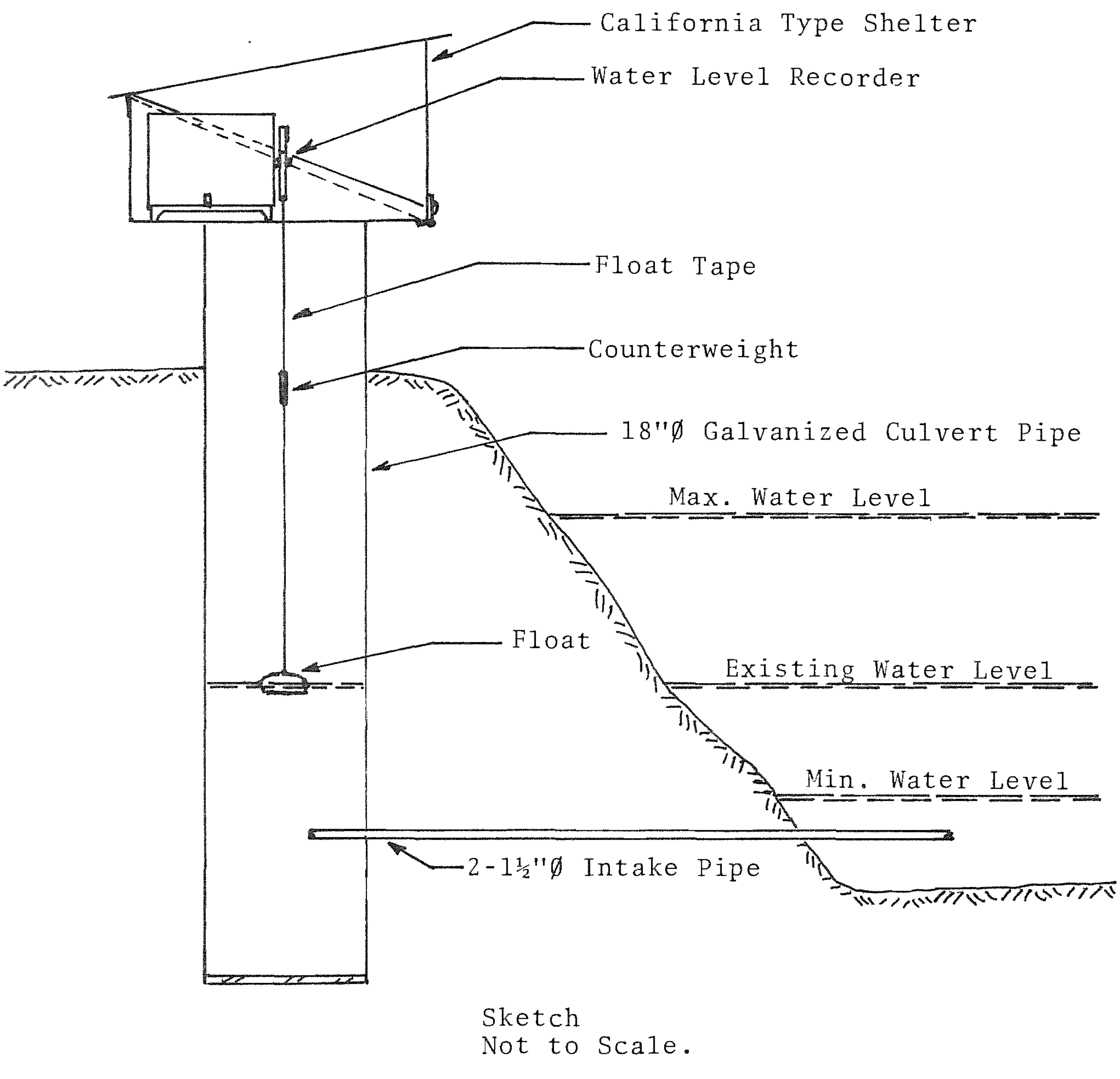


FIGURE B-2

BANK INSTALLATION USING AN 18" DIA. GALVANIZED CULVERT PIPE AS A WELL, WITH INTAKE PIPE TO STREAM