

Training module # SWDP - 27

*How to make data entry for
flow measurement data*

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with
HALCROW, TAHAL, CES, ORG & JPS

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1. Module context

While designing a training course, the relationship between this module and the others, would be maintained by keeping them close together in the syllabus and place them in a logical sequence. The actual selection of the topics and the depth of training would, of course, depend on the training needs of the participants, i.e. their knowledge level and skills performance upon the start of the course.

2. Module profile

| | | |
|---------------------------------------|---|--|
| Title | : | How to make data entry for flow measurement data |
| Target group | : | Data Processing Centre Assistants, Assistant Hydrologists, Hydrologists, Data Processing Centre Managers |
| Duration | : | Two sessions of 60 minutes each |
| Objectives | : | After the training the participants will be able to: <ul style="list-style-type: none">• Make entries for flow measurement data• Compute summary stage-discharge data |
| Key concepts | : | <ul style="list-style-type: none">• Cross sectional data• Basic flow measurement data• Summary stage-discharge data |
| Training methods | : | Lecture, software |
| Training tools required | : | OHS, computers |
| Handouts | : | As provided in this module |
| Further reading and references | : | |

3. Session plan

| No | Activities | Time | Tools |
|----|---|--------|--|
| 1 | <p>General</p> <ul style="list-style-type: none"> • Introduction • Stage-discharge scatter plot • Typical gauging section (a) • Typical gauging section (b) • Typical gauging section (c) • Velocity distribution in a flow section • Sampling velocity at multiple points in the flow section | 10 min | OHS 1 OHS 2 OHS 3 OHS 4 OHS 5 OHS 6 OHS 7 |
| 2 | <p>Entry of cross-sectional data</p> <ul style="list-style-type: none"> • Entry screen for cross sectional data • Example plot of cross section profile | 10 min | OHS 8 OHS 9 |
| 3 | <p>Entry of flow measurements</p> <ul style="list-style-type: none"> • General • Velocity measurements by area-velocity method <p>3.1 Entry of gauge data and reference information</p> <ul style="list-style-type: none"> • Data entry form <p>3.2 Entry of current metering observations</p> <ul style="list-style-type: none"> • Data entry form for current meter gaugings • Airline and wetline correction – Definition sketch • Airline and wetline correction – Formulations • Airline and wetline correction – Illustration (a) • Airline and wetline correction – Illustration (b) • Airline and wetline correction – Illustration (c) • Airline and wetline correction – Illustration (d) • Airline and wetline correction – Illustration (e) • Oblique flow • Current meter rating graph • Current meter rating table • Velocity distribution profile • Flow distribution diagram <p>3.3 Entry of float observations</p> <ul style="list-style-type: none"> • Entry form for velocity observations using floats • Float observations – Definition sketch <p>3.4 Entry of slope observations</p> <ul style="list-style-type: none"> • General <p>Entry form for slope observations</p> <p>3.5 Entry of summary stage-discharge data</p> <ul style="list-style-type: none"> • Entry form for summary stage-discharge data (1) • Entry form for summary stage-discharge data (2) • Scatter plot of stage-discharge data | 40 min | OHS 10 OHS 11 OHS 12 OHS 13 OHS 14 OHS 15 OHS 16 OHS 17 OHS 18 OHS 19 OHS 20 OHS 21 OHS 22 OHS 23 OHS 24 OHS 25 OHS 26 OHS 27 OHS 28 OHS 29 OHS 30 OHS 31 OHS 32 |
| 4 | <p>Exercise on entry of flow measurements data for two observations</p> | 60 min | |

4. Overhead/flipchart master

5. Handout

Add copy of Main text in chapter 8, for all participants.

6. Additional handout

These handouts are distributed during delivery and contain test questions, answers to questions, special worksheets, optional information, and other matters you would not like to be seen in the regular handouts.

It is a good practice to pre-punch these additional handouts, so the participants can easily insert them in the main handout folder.

7. Main text

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| 2. | Entry of cross-sectional data | 1 |
| 3. | Scrutiny of manuscript of flow measurement data | 3 |
| 4. | Entry of flow measurement data | 3 |

How to make data entry for flow measurement data

1. General

- **Flow measurements and the associated measurement of river level at a gauging station provide the means of establishing a relationship between stage and discharge, the rating curve, for any river gauging station.** Discharge is usually determined by the velocity-area method using a current meter to measure velocity at a number of points across a cross section and the associated cross sectional area of flowing water. Where a current meter is not available, velocity may be determined more approximately using the float method. Alternatively in flood flows, the slope-area method may be used to compute discharge using a measurement of the slope of the water surface profile.
- **SWDES provides suitable forms for entry of details of individual current meter measurements, from which discharge and geometric properties of the cross section are computed. SWDES also provides a form for entry of data from a float measurement of discharge and from slope-area determinations.**

A summary form for the results of gaugings is also provided both for the transfer of information from individual gaugings and also for the entry of historical gauging summary data for which a full record of the gauging is no longer available.

- **SWDES provides facilities for the entry of cross-sectional data at a river gauging station.** The gauging section is normally surveyed twice per year, before and after the monsoon but may be surveyed more frequently if changes are suspected. It should be noted however, that the main control of the stage discharge relationship is a section or channel control downstream from the station, whose position may vary with discharge and may be imprecisely known. Cross sections of fixed section controls are also regularly surveyed.

2. Entry of cross-sectional data

Cross-section data comprise of the pairs of distance and elevation of several points on the cross-sectional profile of the river gauging section. The distances are taken with respect to an origin on the gauging section and elevation is reported with respect to the mean sea level as the datum. The date of survey is always associated with the cross-sectional data. The layout of the form for entry of cross-sectional data is as shown in Fig. 2.1:

Standard location information on station code, station name, local river/basin and sub-division are displayed at the top of the form. The date of the cross-sectional survey must be entered. The tabular layout for the entry of cross-section data comprises five columns:

- **Column 1:** is the serial number
- **Column 2:** is the horizontal distance of the point from the common origin (also called the reduced distance)
- **Column 3:** is the elevation with respect to the mean sea level for U/S gauge line (if available)
- **Column 4:** is the elevation with respect to the mean sea level for Central gauge line
- **Column 5:** is the elevation with respect to the mean sea level for D/S gauge line (if available)

SW-DES [Ver 1.02] - Work Area : SAMPLE_SWDES - [X-Section Master : Form]

File Edit View Insert Format Records Tools Window Help

View Data Edit Data Add Rec Del Rec cmdGraph1 Save Close

Editing Session...

| | |
|------------|-------------|
| Mahemdabad | 1994-Dec-01 |
| Mahemdabad | 1995-Dec-01 |
| Mahemdabad | 1995-Jun-01 |
| Mahemdabad | 1996-Dec-01 |
| Mahemdabad | 1996-Jun-01 |
| Mahemdabad | 1997-Jun-01 |
| Megharaj | 1994-Dec-01 |
| Megharaj | 1995-Dec-01 |
| Megharaj | 1995-Jun-01 |
| Megharaj | 1996-Dec-01 |
| Megharaj | 1996-Jun-01 |
| Megharaj | 1997-Jun-01 |

Sort
Code
Date

| SNo. | Reduced Dist. (m) | Elevation (m) | | |
|------|-------------------|---------------|--------|-----|
| | | UGL | CGL | DGL |
| 1 | 0.00 | | 40.000 | |
| 2 | 0.10 | | 32.720 | |
| 3 | 3.00 | | 32.160 | |
| 4 | 4.00 | | 30.180 | |
| 5 | 30.00 | | 28.420 | |
| 6 | 40.00 | | 27.080 | |
| 7 | 50.00 | | 26.860 | |
| 8 | 60.00 | | 26.140 | |
| 9 | 70.00 | | 25.830 | |
| 10 | 80.00 | | 25.500 | |
| 11 | 90.00 | | 26.050 | |
| 12 | 100.00 | | 26.250 | |
| 13 | 110.00 | | 26.430 | |
| 14 | 120.00 | | 24.610 | |
| 15 | 130.00 | | 25.950 | |
| 16 | 140.00 | | 25.770 | |
| 17 | 150.00 | | 25.210 | |

Station Code: Mahemdabad
Date: 01/06/97
Gauge Line Reference: []

UGL CGL DGL
Base Value: []
Standard Bank Side: []

Add Sort Add Cell Del. Cell
Graph Report multicolumn Report

Fig. 2.1: Data entry form for cross sectional data

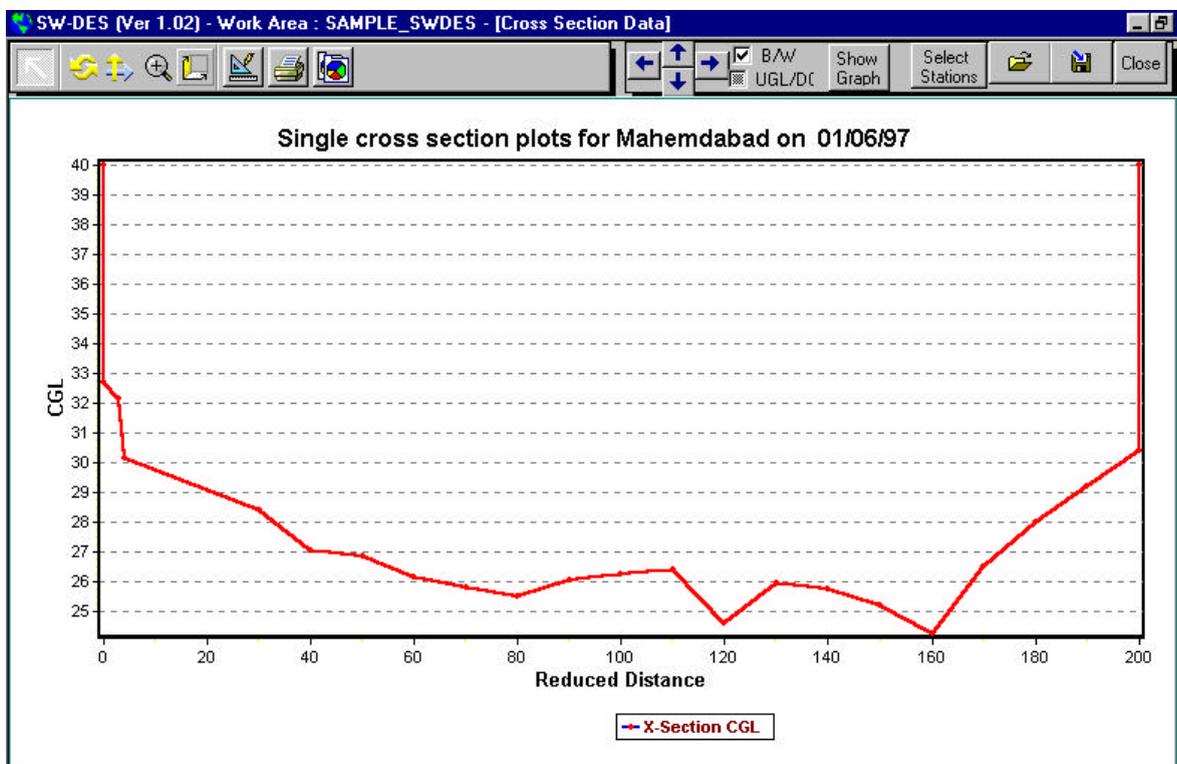


Fig. 2.2: Plot of cross sectional profile

Any number of pairs of cross-section data can be entered for each data set. At the time of data entry all the reduced distances entered are checked if they are in increasing or decreasing order of the magnitude. Suitable options for making cross-section plots are available for obtaining cross-section profiles (see Fig. 2.2)

3. Scrutiny of manuscript of flow measurement data

Discharge measurements at a station are entered to a standard form in the field and discharge is computed by the observer. Manuscript flow measurement observations received at the sub-divisional office from gauging stations must be immediately inspected to ensure that locational and date/time details are complete and correct. Rectification of such faults is much more difficult at a later stage when forms from several stations are present.

Inspection of numerical values is also essential to eliminate absurd values arising from faulty observation or the recording of data in the manuscript. Any ambiguities are referred back to the observer for clarification. If values remain doubtful, they should be left out of further analysis.

4. Entry of flow measurement data

Since flow measurements and associated summary data comprise different data types, entry is made using one of five forms as follows:

- (a) entry of gauge data and reference information
- (b) entry of current metering observations
- (c) entry of float observations
- (d) entry of slope observations
- (e) entry of summary stage-discharge data

In addition a form is available for the entry of summary suspended sediment data.

4.1 Entry of gauge data and reference information

This form is the first page of stage discharge data entry and is used to specify the location, method of observation and conditions under which the observation was made. It also provides a field for entry of stage observations. The form layout is shown in Fig. 4.1.

At the top of the form, fields are provided for location and date/time information for the beginning and end of the observation. The gauging is also allocated an observation number so that any stage-discharge data is uniquely identified by the station code, date and observation number. Any attempt to duplicate the entry for a set which is already available is automatically brought to the notice of the user.

Next, fields for entry of information concerning the method of observation are provided and entry to these fields is accomplished by selecting from listed items as follows:

- **Mode of crossing**
 - ❖ by wading
 - ❖ by boat without engine
 - ❖ by boat having engine
 - ❖ by bridge
 - ❖ by bank operated cableway
 - ❖ by cableway and trolley.

- **Method of velocity observation**
 - ❖ using floats
 - ❖ using current meter
 - ❖ using slope-area method.
- **Location of discharge site**
 - ❖ permanent site
 - ❖ temporary site (at certain distance u/s or d/s of permanent site).
- **Sounding taken with**
 - ❖ Wading rods
 - ❖ sounding pole
 - ❖ metallic reel
 - ❖ eco-sounder.

Fields are then available for information concerning the conditions of water and weather under which the observation was made and which might influence either the stage discharge relationship or the accuracy of the measurement. The entry for numeric fields like river and atmospheric temperature and wind velocity is made by the user. The user is prompted if the data is not within an expected range. The specified expected range for water temperature is 10 to 35°C, for atmospheric temperature it is 5 to 45° C and wind velocity is 0 to 60 kms./hr. However, the system does not stop further entry of data if the user decides to accept a value beyond these limits. Fields are provided as follows:

- **Condition of water**
 - ❖ clear water
 - ❖ slightly silty water
 - ❖ silty water
 - ❖ heavily silty water
 - ❖ other (specify).
- **Condition of weather**
 - ❖ clear sky
 - ❖ slightly cloudy
 - ❖ cloudy
 - ❖ overcast
 - ❖ other (specify)
- **River water temperature (°C)**
- **Atmospheric temperature (°C)**
- **Wind direction with respect to direction of flow**

The wind direction with respect to the direction of flow in clock wise direction can be entered. The unit used is degrees and can be entered at the multiples of 22.5 degrees.
- **Strength of wind**
 - ❖ Calm
 - ❖ slight
 - ❖ strong
 - ❖ very strong.
- **Wind velocity (kms/hr)**

The screenshot shows the SW-DES software interface. The title bar reads "SW-DES (Ver 1.02) - Work Area : SAMPLE_SWDES - [FLW-Master]". The menu bar includes File, Edit, View, Insert, Format, Records, Tools, Window, and Help. The toolbar contains buttons for Add Recs, Delete Recs, Report, and Close. The form is divided into several sections:

- Station Information:** Station Name: 9A_Pondugala, Station Code: AK000E_7, User Level: 1, Sub-Division: L K SD No 2, Vijaywada.
- Observation Details:** Year: 1995, Month: October, Day: 13, O.No: 1, Time From: 08:00:00, Time To: 10:00:00.
- General & Gauge Information:** Mode of Crossing: Boat with DBE, Method of Velocity Observation: Current Meter, Location of Discharge Site: Permanent Site, Sounding Taken with: Sounding pole, Sounding Weight used: 30lb (13.6Kg).
- Current Meter Measurements:** Condition of Water: Slightly silty water, Wind Direction wrt Current: 22.5, Weather Condition: Slightly Cloudy, Strength of Wind: Slight, River Water Temp. (°C): 28, Velocity of Wind (kms./hr): 10.0, Atmospheric Temp. (°C): 29.
- Remarks:** This is not a real remark.
- Gauge Readings:**

| | Permanent Site | Temporary Site | Coincident Gauge Observation for Fall |
|-------------------------|----------------|----------------|---------------------------------------|
| Gauge reading at Start | 2.250 m | | |
| Gauge reading at End | 2.100 m | | |
| Mean Gauge Reading | 2.175 m | | |
| R L of Zero Gauge | 42.334 m | | |
| Water Level w.r.t m.s.l | 44.509 m | | |
- Rate of change of Water Level:** -1.800 m/day.

Fig. 4.1: Layout of form for entry of gauge data and reference information for stage-discharge measurements

Finally, various fields for entering stage observations are available. The gauge at start and end of the observations is entered for the permanent site as well as a temporary site and mean gauge levels are computed automatically. Where the station is known to be affected by backwater effects and a second set of gauges is available downstream for estimating fall then its station code and coincident gauge readings at main and twin station are also entered.

Provision is made for creating a summary from entries made on this page. Also, buttons are provided to go to other sub-forms to make further entries.

4.2 Entry of current metering observations

Total discharge in a gauging is estimated as the sum of sectional discharges across the section. (Sections are sometimes referred to as segments). Sectional discharges are computed as the multiple of mean velocity and sectional area, which is in turn based on measurement of widths and depths. Fig. 4.2 gives an illustration of a typical current meter observation and computation of discharge using the mid section method. Additional measurements are made where required to make corrections in depth and velocity. the field observer is required to compute the discharge in the field from raw measurements but the data processor enters only the raw observations and computation of discharge is repeated automatically by the software. The form for such current meter data entries is shown in Fig. 4.3.

At the top of the form details of the current meter used are entered. The data processor must choose from a previously entered list of meters for which calibration details are held in the

database. Having chosen the meter, the appropriate calibration between meter revolutions and water velocity is automatically applied to compute point velocity from the number of measured revolutions in given time. The processor is also required to enter the results of a spin test to demonstrate the condition of the meter.

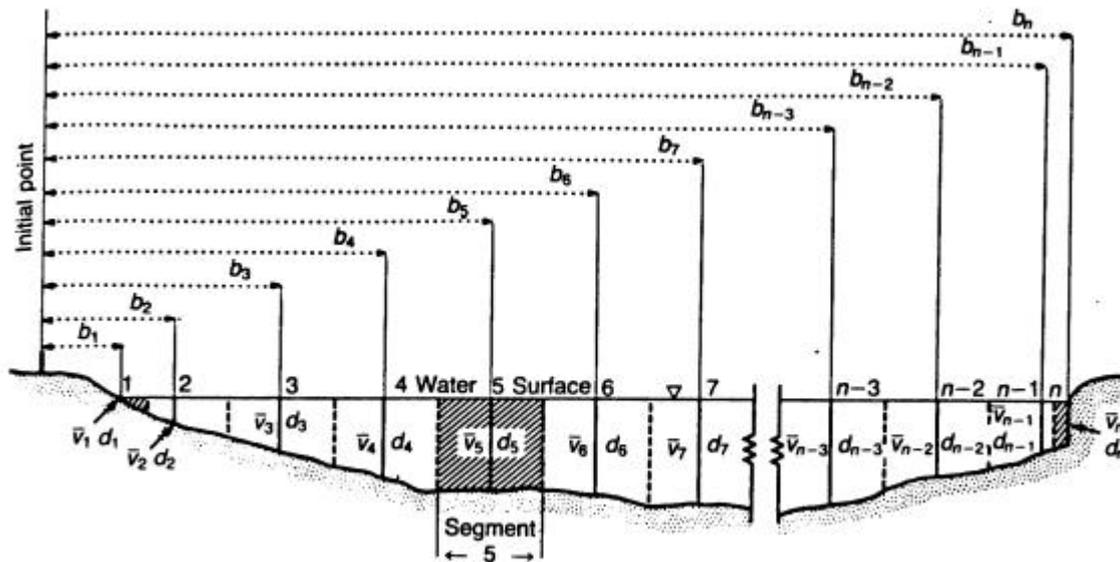


Fig. 4.2: The mid-section method of computing current meter measurements. 1, 2, 3, ..., n, number of vertical; $b_1, b_2, b_3, \dots, b_n$, distance from initial point; $d_1, d_2, d_3, \dots, d_n$, depth of flow at verticals; $v_1, v_2, v_3, \dots, v_n$ average velocity in verticals.

Next, data related to velocity observations is made including the method of suspending the meter, the weight used with the meter and the number of flow compartments is entered. Options for selection for the first two fields are as follows:

- **Method of suspending meter**

- ❖ wading rod
- ❖ gauging reel

- **Fish-weight used with meter**

- ❖ 15 lb (6.8 kg)
- ❖ 30 lb (13.6 kg)
- ❖ 50 lb (22.7 kg)
- ❖ 100 lb (45.4 kg)
- ❖ 200 lb (90.7 kg)
- ❖ 300 lb (136.1 kg)
- ❖ other (specify)

- **No. of Compartments**

The flow of water at the gauging section may take place in more than one compartment. This is normally the case when the observations are taken from a bridge where each bridge opening is a compartment. Where braided river sites are unavoidably used for gauging, each river thread is a compartment. In this field, the total number of compartments into which the flow is divided is entered. This is an integer field and the expected maximum number of compartments is 15. Beyond this figure the user gets a prompt if the entry is correct. Most commonly the number of compartments is 1.

SW-DES [Ver 1.02] - Work Area : SAMPLE_SWDES - [FLW-Master]

File Edit View Insert Format Records Tools Window Help

+ Add Recs X Delete Recs < > Report < > Close

Station Name **9A_Pondugala** Station Code **AK000E_7** User Level : 1 Sub-Division **L K SD No 2, Vijaywada**

Year **1995** Month **October** Day **13** O.No **1** Time From **08:00:00** to **10:00:00** Local River / Basin

General & Gauge Information Current Meter Measurements Flow by Slope Area Method

Meter No **33811** Method of Suspending Meter **Gauging Re** Weight used with meter **30lb (13)** No of compartments **1**

Meter Type **PROPELLOR T** Meter Make **OMEGA** Date of Mfr. **10/06/1991** No of rating eq. **2** Threshold vel. **0.0901** Max. vel. **4.5000** Spin before Meas. **70**

Validity start date **10/06/1995** Validity end date **25/12/1998** Equation 1: **0.0185** + **0.6820**x Limit 1 of x (rev./s) **3.7200** Spin after Meas. **70**

Equation 2: **0.0827** + **0.6648**x

Rated spin (rev.) **55**

| Cmp. No | No of Sc | RD of Sc | Water Dpth (m) | Vertical Ang. (Deg.) | Airline Depth (m) | Airline Corr. (m) | Wetline Corr. (m) | Cor.wt Dpth (m) | Area - sec (m2) | No of Vel. Obs. | Mean Vel. (m/s) | Angle of Obliq. (Deg.) | Corr. Mean Vel. (m/s) | Drift Dist. (m) | Time - Drift (s) | Final Mean Vel. (m/s) | Disch - sec (m3/s) | Remarks |
|---------|----------|----------|----------------|----------------------|-------------------|-------------------|-------------------|-----------------|-----------------|-----------------|-----------------|------------------------|-----------------------|-----------------|------------------|-----------------------|--------------------|---------|
| 1 | 17 | 1 | 86.0 | SBS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1 | 0.315 | 90 | 0.315 | | | 0.315 | 16.87 | |
| | 2 | | 100.0 | | 3.15 | | | 3.15 | 53.55 | 1 | 0.742 | 90 | 0.742 | | | 0.742 | 100.15 | |
| | 3 | | 120.0 | | 6.75 | | | 6.75 | 135.00 | 1 | 0.856 | 90 | 0.856 | | | 0.856 | 131.83 | |
| | 4 | | 140.0 | | 7.70 | | | 7.70 | 154.00 | 1 | 0.749 | 90 | 0.749 | | | 0.749 | 110.88 | |
| | 5 | | 160.0 | | 7.40 | | | 7.40 | 148.00 | 1 | 0.724 | 90 | 0.724 | | | 0.724 | 97.02 | |
| | 6 | | 180.0 | | 6.70 | | | 6.70 | 134.00 | 1 | 0.564 | 90 | 0.564 | | | 0.564 | 60.36 | |
| | 7 | | 200.0 | | 5.35 | | | 5.35 | 107.00 | 1 | 0.391 | 90 | 0.391 | | | 0.391 | 34.75 | |
| | 8 | | 220.0 | | 4.45 | | | 4.45 | 89.00 | 1 | | | | | | | | |

Computed Top Width **314.000** W.Perimeter **314.864** Total Area **1142.550** Total Dischg **616.036**

In form Top Width W.Perimeter Total Area Total Dischg

Fig. 4.3: Layout of form for entry of current metering observations.

The greater part of the raw data is entered in a tabular manner. The row wise entry in the tabular form is then made by filling all the necessary fields. The column fields are as follows.

- Column 1: Compartment serial No.
- Column 2: No. of sections
- Column 3: R. D. of sections
- Column 4: Observed water depth
- Column 5: Vertical angle
- Column 6: Airline depth
- Column 7 & 8: Airline & wetline corrections
- Column 9: Corrected water depth
- Column 10: Area of section
- Column 11: No. of velocity observations
- Column 12: Details of velocity observations
- Column 13: Velocity observed at depth
- Column 14: Coefficient to be used
- Column 15: No. of revolutions
- Column 16: Time taken
- Column 17: Point velocity
- Column 18: Mean velocity
- Column 19: Angle of current with G.L.
- Column 20: Corrected mean velocity
- Column 21: Drift distance

- **Column 22:** Time for drift
- **Column 23:** Drift correction
- **Column 24:** Final corrected velocity
- **Column 25:** Discharge for section
- **Column 26:** Discharge for section from observer's form
- **Column 27:** Remarks

A brief description of each of these fields is given below:

Column 1: *Compartment serial No.*

As stated above, the flow may be divided in more than one distinct compartment. In this field, the serial number of each compartment is filled automatically. In the beginning, serial No. 1 is filled in the first row and as soon as the number of rows required for each compartment is known, the next serial no. is filled automatically after leaving an adequate number of rows.

Column 2: *No. of sections*

In each compartment the velocity is observed at a number of sections. This field gives the total number of such sections for each compartment. Two more sections, the end sections of each compartment at which velocity and depth may or may not be zero, are always counted.

Column 3: *R. D. of sections*

The R. D. of a section is the "reduced distance", having units of metres, at which the velocity observations are taken, from an initial reference location on the bank. For each compartment, the reduced distances of the first and last sections, i.e. the end sections, are annotated by "(SBS)" and "(OBS)" to mean "Standard Bank Side" and "Other Bank Side" respectively to make entries self explanatory. The R. D. of successive sections is expected to be in increasing order and accordingly the system checks each entered value against the previous one. If the latest entry is less than the previous entry the user is prompted to correct it.

Column 4: *Observed water depth*

At each section the observed depth of water is entered This is used with section width to calculate the sectional area.. This depth is reported in units of metres.

Column 5: *Vertical angle*

If the depth of water is large and the flow in the river swift, the sounding reel tends to drift downstream. The angle made by the sounding reel with the vertical, in units of degrees, is called the vertical angle. When this angle is appreciable it is required to apply air line and wet line corrections for obtaining the corrected water depth.

Column 6: *Airline depth*

Airline depth is the depth of the surface of water form the point of measurement. This is required to compute the airline correction and is given in units of metres.

Column 7 & 8: *Airline & wetline corrections*

The airline and wetline corrections are computed values based on the entered depth, vertical angle and airline depth. Both these fields are automatically completed by the software. Physical significance of these corrections is illustrated in the Fig. 4.4. The necessary corrections are estimated on the basis of factors, given in the form of tables, as a function of the vertical angle. The corrections, in metres, are computed as below:

Airline correction = Airline depth (Sec θ - 1)
and

$$\begin{aligned} \text{Wetline correction} &= \text{Wetline depth} * (\alpha / 100) \\ &= (\text{Observed water depth} - \text{Airline correction}) * (\alpha / 100) \end{aligned}$$

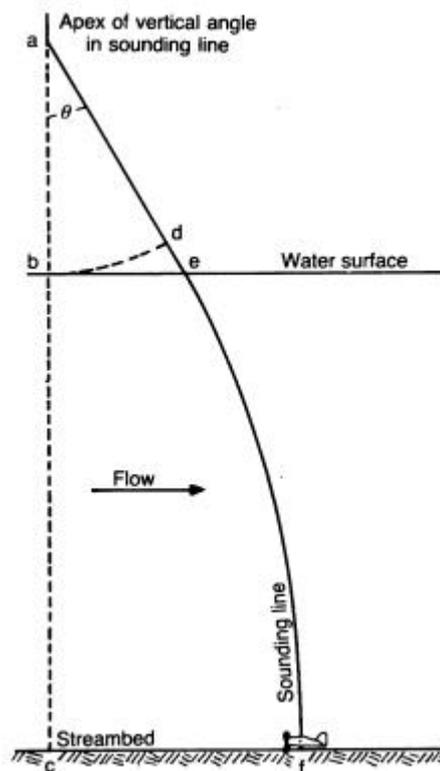


Fig. 4.4: Position taken up by sounding line and weight in deep swift water. Corrections to be made to determine depth, “bc”, are air-line correction, “de”, and wet line correction as percentage of “ef”.

Table 1: Wet-line correction (Correction given in this table are percentages of wet line depth)

| Vertical Angle | Correction (%) | Vertical Angle | Correction (%) |
|----------------|----------------|----------------|----------------|
| 4° (0.07 rad) | 0.06 | 18° (0.31 rad) | 1.64 |
| 6° (0.10 rad) | 0.16 | 20° (0.35 rad) | 2.04 |
| 8° (0.14 rad) | 0.32 | 22° (0.38 rad) | 2.48 |
| 10° (0.17 rad) | 0.50 | 24° (0.42 rad) | 2.96 |
| 12° (0.21 rad) | 0.72 | 26° (0.45 rad) | 3.50 |
| 14° (0.24 rad) | 0.98 | 28° (0.49 rad) | 4.08 |
| 16° (0.28 rad) | 1.28 | 30° (0.52 rad) | 4.72 |

Here, θ is the vertical angle and α is percent of the wetline depth and is tabulated in Table 1 below for different values of θ according to ISO 748-1979 (E), Annex C, Table 2.

For the depths as 0.2d, 0.6d and 0.8d

The default coefficients are 0.25, 0.5 and 0.25 respectively

Column 15: No. of revolutions

The number of revolutions made by the flow meter, as available in the manuscript, are entered at this location.

Column 16: Time taken

Time taken for each observation corresponding to the number of revolutions is entered in this column. The time taken, in seconds, is available in the manuscript.

Column 17: Point velocity

As per the entries of No. of revolution, time taken and the current meter ratings the system automatically computes and fills the velocity observed at each point in the vertical section. The velocity is reported in m/s. This is also the last column of the small pop-up table and as soon as the control comes out of this it gets wrapped into a single cell again.

Column 18: Mean velocity

Depending upon the point velocities and the corresponding coefficients, the system computes the weighted average or the mean velocity. This mean velocity represents the average velocity for the vertical section.

Column 19: Angle of current with G.L.

Sometimes the flow is not normal to the direction of the gauge line (G.L.) or cross section line along which the area of cross section is estimated. In such cases, the observed velocity is also not normal to the cross sectional area and so its normal component is to be estimated. This is accomplished by observing the angle which the current makes with the G.L. This angle, in degrees, is entered in this column.

Column 20: Corrected mean velocity

As stated above whenever the flow is oblique (see Fig. 4.5), the corrected velocity is computed and filled automatically as per the observed velocity and the angle of current with G.L. The computation is made as under:

$$\text{Corrected mean velocity} = \text{Observed mean velocity} * \sin(\beta)$$

where β represents the angle between the current and the G.L.

Column 21: Drift distance

If adequate restraint is not provided, by using an anchor or an engine or anchoring the boat with the cableway, the boat drifts with the flow of water whilst making a velocity observation. This drifting makes the velocity observations inaccurate and so a drift correction is to be applied. At any section, the boat is allowed to drift by a certain distance which is termed as the drift distance. This drift distance is entered, in metres, in this column.

Column 22: Time for drift

As stated above, for estimating the drift correction, the time elapsed during the drift of the boat through the drift distance is noted. This time for drift, in seconds, is entered in this column.

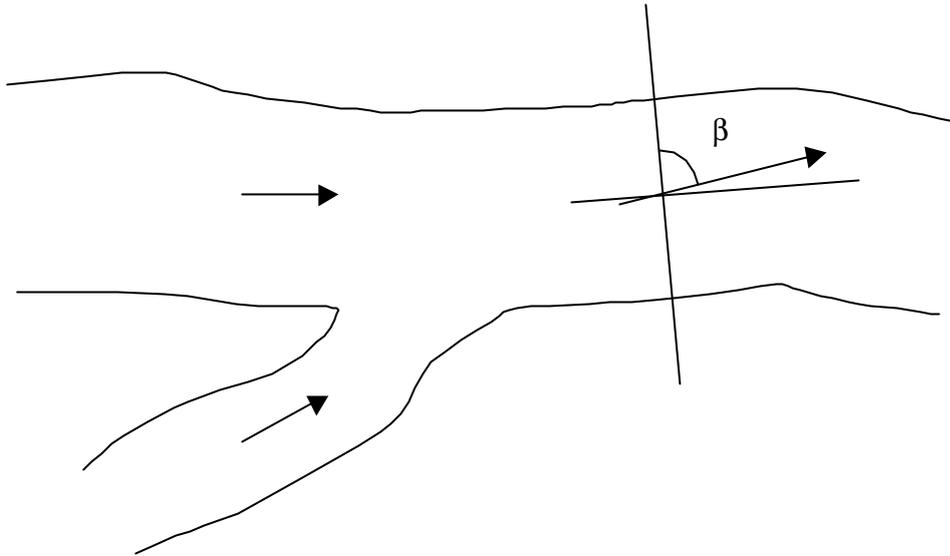


Fig. 4.5: Correction for obliqueness of flow lines with respect to the normal to the gauging section

Column 23: Drift correction

The error in the observed velocity due to drifting of boat is computed automatically by the system and the corresponding drift correction, in m/s, is filled in this column. The drift correction is computed as:

$$\text{Drift correction} = (\text{Drift distance}) / (\text{Time for drift})$$

Column 24: Final corrected velocity

The final corrected velocity is computed and filled automatically by adding the corrected mean velocity, as obtained in column 20, and the drift correction.

Column 25: Discharge for section

The representative discharge for each section is computed by multiplying the area of section (Column 10) and the final corrected velocity (Column 24) and is filled automatically in this column. The unit of this computed discharge is cumec.

Column 26: Discharge for section from observer's form

Section discharge is thus computed by the software from values entered from the manuscript completed by the observer as follows:

- (a) for area of section - R.D. of section, observed water depth, vertical angle and
- (b) for final corrected velocity - no. of velocity observations, depth of velocity observation, coefficients used, angle of current with G.L., drift distance and time for drift.

All other fields are computed independently of the values entered in the manuscript. To see if the discharges for each section as computed and as available in the manuscript match with each other, the manuscript discharge as computed by the observer is entered in this column.

Values in Columns, 25 and 26 are compared with each other and if the difference is more than 1% of the discharge as available in the manuscript then the user is prompted to check

the entries. Where there is a consistent difference, the current meter calibration used by observer and computer should be compared. This checking provides a means of avoiding data entry errors.

Column 27: Remarks

Remarks from the manuscript or required at the time of data entry can be entered with respect to the entries for individual sections.

Computed quantities

After entering the tabular data for all sections of each compartment totals for the entire cross section are computed and filled automatically for the following fields:

- (a) top width,
- (b) wetted perimeter,
- (c) total area and
- (d) total discharge .

These computations are made as given below:

Top width = $\Sigma \{(\text{R.D. of last section} - \text{R.D. of first section}) \text{ for each compartment}\}$

here, the summation is done for all the compartments of the gauging section.

Wetted perimeter = $\Sigma \{(\text{sum of corrected water depth at first and last section}) + [(\text{difference in R.D. of successive sections})^2 + (\text{difference in corrected water depth at successive sections})^2] \}$ for all compartments

here also, the summation is done for all the compartments of the gauging section.

Total area = sum of area of all sections for all compartment
Total discharge = sum of discharges for all sections for each compartment

Deactivating columns related to corrections

In many cases, when the one or more corrections like depth, angle of flow or drift corrections are insignificant then no observations are taken to compute them. In such cases, all the related columns will be left blank in the manuscript. There is an opportunity for closing down such inactive columns if desired by the user. This will make the table less wide for making the entries conveniently. The columns related to depth, angle of flow and drift correction can be closed individually or in combination.

Graph Options

Two types of graphs can be plotted after completing the data entry. These are:

- (a) **graph for velocity distribution across the gauging section** giving point velocities at each vertical section and the profile of mean velocity along the gauging section and
- (b) **graph for mean velocity profile along the gauging section** giving average velocity at each gauging sections along the (see Fig. 4.6)
- (c) **graph for distribution of discharge giving the histogram of discharge flowing through each sectional area in percentage and absolute form** (see Fig. 4.7).

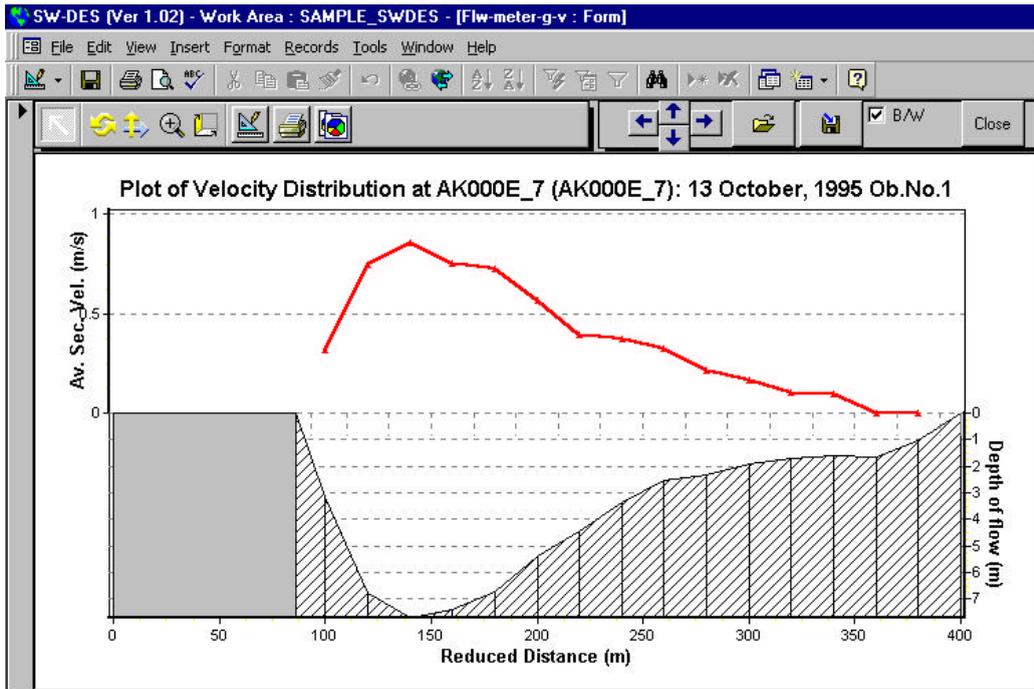


Fig. 4.5: Plot of mean velocity profile along the gauging section

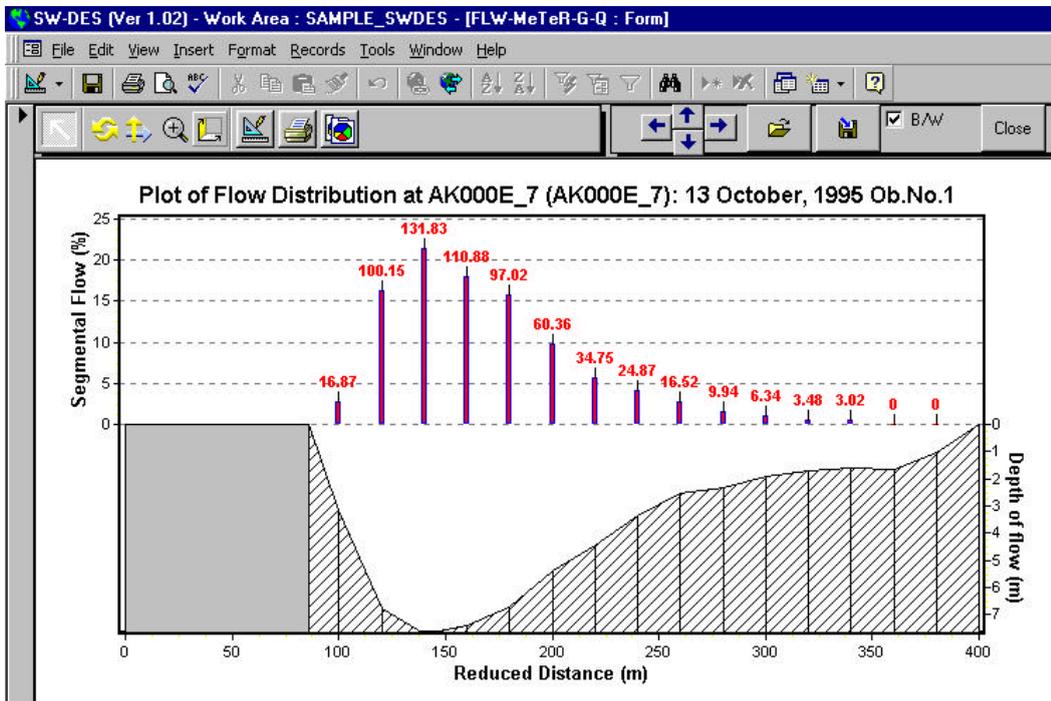


Fig. 4.6: Plot of flow passing through various segmental areas

4.3 Entry of float observations

Float observations are made either when it is very difficult to cross the river by boat or take current metering observations even from a bridge site or when the gauging site is not equipped with a current meter. The layout of this form for entering the float observations is as shown in Fig. 4.7.

Fig. 4.7: Layout of form for entry of velocity observations using floats.

First, information on the following is entered on the top of the form:

- type of float
- length of float run
- coefficient to be used

The list of the type of floats (surface or subsurface float) is provided for the user to make the selection. The length of float run is the distance, in metres, between the two cross sections for which the float is observed for velocity estimation. For different type of floats different coefficients are to be applied to get the mean velocity in the vertical. This coefficient is entered in the field for use in further computations. Fig. 4.8 illustrates the method of velocity measurement using floats.

A number of float observations are taken across the section to allow for the variability of flow in different sections. It is also likely that some observations do not yield good results due to erratic movement of the floats in the water and have to be discarded. Since it is difficult to exactly locate a float across the river, it is advantageous to group more than one float observation to compartments of river sections across it. These individual compartments may or may not have blank sections between them. An elaborate exercise of discharge estimation by float observation involves making cross sectional observation at two sections.

These cross sections are termed U/S and D/S cross sections. Each cross section is divided into a certain number of compartments and the ends of compartments on both the sections are joined on the basis of flow lines. The number of compartments is entered in the beginning.

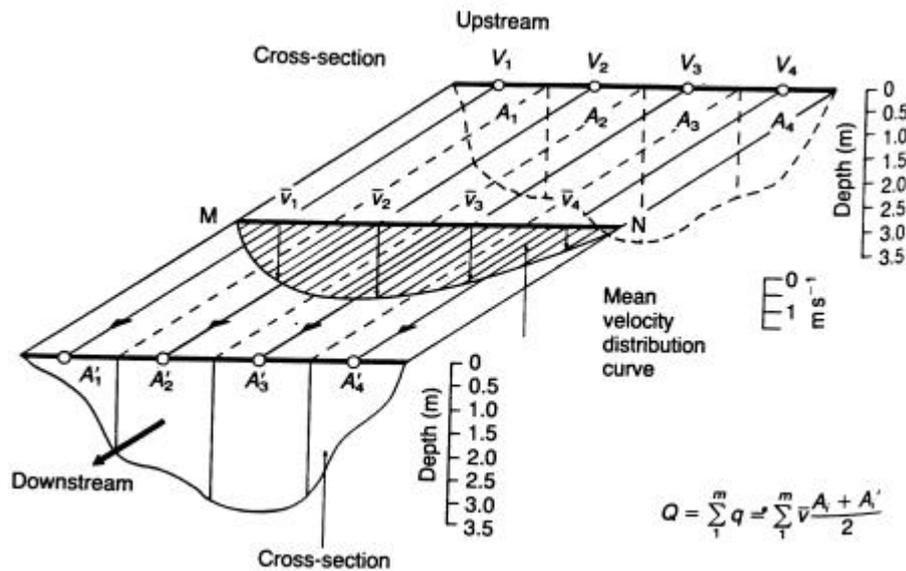


Fig. 4.8: Computation of discharge from float measurement. $v_1, v_2, v_3, \dots, v_n$ are the mean velocities in each of the four panels

Further data entry is carried out in tabular form in two tables. The first table is for entering the cross sectional details and for computing compartmental area. The second table is for entry of float observations for computing velocity and discharges in each compartment.

In the first table, for obtaining compartmental areas, entries for compartment number, the number of sections in each compartment, R.D. of each section and water depth is made. The sectional area for each vertical section is automatically computed and filled in the table. All these entries are exactly similar to those explained for the current metering observations. Data for both upstream and downstream cross sections is entered and the mean compartmental area is computed automatically and filled. Thus, for each compartment the area of flow is available. To ensure correct data entry, it is required to enter the mean area for each compartment as it is available in the manuscript. This is compared with the corresponding computed values and if the difference is more than 1% of the value entered in the manuscript then user is suitably prompted to recheck the entries.

The second table is for entry of float observations. For each compartment, the number of floats observed is entered. For each float, the time taken to travel the distance between the upstream and downstream cross sections is entered. On the basis of this time, the length of the float run and the coefficient for the float, the velocity of each float is computed and filled automatically.

A plot of the velocity of various floats against corresponding compartment can be made to see if certain float observations show any major disagreement with the rest. At this juncture, if desired, one or more float observations can be discarded from further computations by assigning "yes", or "no" to each of them.

On the basis of acceptable float observations to be considered for each compartment, the mean velocity of flow in each compartment is computed automatically by taking an arithmetic mean. The area of each compartment which has already been computed in the first table is multiplied by the corresponding average velocity to get the discharge flowing through each compartment. To ensure correct data entry, it is required to enter the discharge for each compartment as it is available in the manuscript. This is compared with the corresponding computed values and if the difference is more than 1% of the value entered in the manuscript then user is prompted to recheck the entries.

Finally, the top width, wetted perimeter, total area of cross section and total discharge is computed from the tabular entries in exactly the same way as explained for the current metering observations.

4.4 Entry of slope observations

The slope-area method can be used to estimate the flow during high stages when it is very difficult to make velocity observations. For this, the average slope of the water surface profile is observed and velocity of flow is estimated using the Manning's formulae. This velocity is multiplied by the area of cross section to get the total discharge flowing through the cross section. For this, it is required to know the value of the Manning's roughness coefficient and this can either be based on the type of bed and condition of flow or from the earlier observations when the flow was estimated from direct velocity observations. For this reason it is always better to take slope observations even when the discharge is being estimated using velocity-area method. This provides the basis of assigning a value to the roughness coefficient for velocity observations using the slope-area method. The layout of the form is as shown in Fig.4.9.

First the distances of upstream and downstream gauge lines from the central gauge (C.G.) line is entered. Then the level readings of all the three gauges are entered. Where the slope is observed by carrying out levelling then the final levels, with respect to the common datum, at all the three locations can be entered. On the basis of the distances between the three gauge lines and the corresponding levels of water surface, the slope is computed and filled. The slope is computed as given under:

When all the three gauges or U/S and D/S gauges are observed then:

Mean slope = (level at U/S gauge - level at D/S gauge) / (distance between U/S gauge and C.G. + distance between C.G. and D/S gauge)

When only U/S gauge and C.G. is observed then:

Mean slope = (level at U/S gauge - level at C.G.) / (distance between U/S gauge and C.G.)

When only D/S gauge and C.G. is observed then:

Mean slope = (level at C.G. - level at D/S gauge) - / (distance between C.G and D/S gauge)

A value for the Manning's roughness coefficient can be entered in addition to the observations for estimating the mean slope, This entry is made only when a reasonable value based on the flow conditions prevailing during the flow and past variations of the roughness coefficient can be assumed. Otherwise this entry is left blank and later estimated during processing of stage-discharge data on the basis of available records.

SW-DES (Ver 1.02) - Work Area : SAMPLE_SWDES - [FLW-Master]

File Edit View Insert Format Records Tools Window Help

+ Add Recs X Delete Recs Report Close

Station Name: 9A_Pondugala Station Code: AK000E_7 User Level: 1 Sub-Division: L K SD No 2, Vijaywada

Year: 1995 Month: October Day: 13 O.No: 1 Time From: 08:00:00 to 10:00:00

General & Gauge Information Current Meter Measurements Flow by Slope Area Method

| Location of Level Observations | Right Bank Details | | Left Bank Details | |
|--------------------------------|--------------------|---------------|-------------------|---------------|
| | Dist. from CGL | Level Reading | Dist. from CGL | Level Reading |
| U/S Gauge Line | 300.000 | 2.250 | 200.000 | 2.240 |
| Central Gauge Line | 0.000 | | 0.000 | |
| D/S Gauge Line | 200.000 | 2.250 | 200.000 | 2.150 |

Slope: 0.00000 Mean Slope: 0.00022

Bed Characteristics: There is no change in the bed characteristics.

Transfer

Fig. 4.9: Layout of form for entry of slope observations for discharge estimation using slope-area method.

4.5 Entry of summary stage-discharge data

The entry of current metering and float observations of discharge is done mainly to re-compute and check the discharge computations carried out by the observer. It also provides a means of displaying the velocity and discharge profiles in the cross section graphically, and of ensuring that the data are stored on magnetic media in an organised manner.

For further use in stage discharge computations, only summary information is needed. This summary information can either be automatically generated from the detailed data already entered or if the detailed data are not available (as in the case of historical data) then it can be directly entered using a separate form. The form used for making entries for summary stage-discharge data is as shown in Fig. 4.10a and 4.10b.

To access a station for the entry of summary stage-discharge data the station is selected from a list and the displayed form automatically shows its name, local river/ basin and sub-division. The month and year are selected for making entries. As in the case of primary flow measurement data, the summary stage-discharge data are also identified by Station, date and observation number. For no two observations can these three descriptors be identical and this provides integrity of the data. The data required for entry to the form for each stage-discharge observation are explained below:

For each stage-discharge observation, date and time of observation together with the observation number are entered.

SW-DES (Ver 1.02) - Work Area : SAMPLE_SWDES - [Stage Discharge Summary]

File Edit View Insert Format Records Tools Window Help

* New Record + Add Recs Delete Record Report Check Zero of RL Close

Station Name **Mahemdabad** Station Code **Mahemdabad** Zero RL **0.000** Year **1994**

Sub-Division **W.R.I. Subdivision, Af** Local River / Basin Lat. **22°49'30"** Long. **72°45'30"** Month **August**

User Level : 1

| Day | Time | Obs. No | Mean Gauge (m) | WL w.r.t. M.S.L. (m) | Dischrg. (Q) (m ³ /s) | Observed / Computed | Area (A) (sq.m) | Surface Slope (S) (m/m) | Top Width (m) | Wetted Perimeter (m) | Hyd. Radius (m) | Velocity (m/s) | Manning (N) | Gradient (m/day) |
|-----|-------|---------|----------------|----------------------|----------------------------------|---------------------|-----------------|-------------------------|---------------|----------------------|-----------------|----------------|-------------|------------------|
| 1 | 08:00 | 1 | 0.200 | 25.730 | 0.89 | Observed | | | | | | | | |
| 2 | 08:00 | 1 | 1.200 | 26.740 | 0.93 | Observed | | | | | | | | |
| 3 | 08:00 | 1 | 3.100 | 28.620 | 750.00 | Observed | | | | | | | | |
| 4 | 08:00 | 1 | 1.400 | 26.880 | 210.00 | Observed | | | | | | | | |
| 5 | 08:00 | 1 | 1.300 | 26.810 | 190.00 | Observed | | | | | | | | |
| 6 | 08:00 | 1 | 1.500 | 27.020 | 230.00 | Observed | | | | | | | | |
| 7 | 08:00 | 1 | 1.200 | 26.700 | 140.00 | Observed | | | | | | | | |
| 8 | 08:00 | 1 | 1.100 | 26.640 | 250.00 | Observed | | | | | | | | |
| 9 | 08:00 | 1 | 1.500 | 26.970 | 220.00 | Observed | | | | | | | | |
| 10 | 08:00 | 1 | 1.500 | 27.020 | 230.00 | Observed | | | | | | | | |
| 11 | 08:00 | 1 | 0.900 | 26.370 | 115.00 | Observed | | | | | | | | |
| 12 | 08:00 | 1 | 1.400 | 26.950 | 220.00 | Observed | | | | | | | | |
| 13 | 08:00 | 1 | 0.900 | 26.380 | 90.00 | Observed | | | | | | | | |
| 14 | 08:00 | 1 | 0.600 | 26.120 | 85.00 | Observed | | | | | | | | |
| 15 | 08:00 | 1 | 0.900 | 26.410 | 120.00 | Observed | | | | | | | | |
| 16 | 08:00 | 1 | 1.500 | 27.040 | 225.00 | Observed | | | | | | | | |
| 17 | 08:00 | 1 | 1.300 | 26.820 | 200.00 | Observed | | | | | | | | |

Fig. 10a: Form for entry of stage-discharge summary data

SW-DES (Ver 1.02) - Work Area : SAMPLE_SWDES - [Stage Discharge Summary]

File Edit View Insert Format Records Tools Window Help

* New Record + Add Recs Delete Record Report Check Zero of RL Close

Station Name **Khangaon** Station Code **Khangaon** Zero RL **0.000** Year **1995**

Sub-Division **SDDPC, Shirur Sub-div** Local River / Basin **Mula Mutha** Lat. **18°33'00"** Long. **74°13'00"** Month **August**

User Level : 1

| Gradient (m/day) | Fall (m) | Day | Obs. No | Mode of crossing | Method of velocity observation | No. of verticals / Float cmprmt | Vmax (m/sec) | Weather Condition | Wind velocity (kms/hr) | Wind Dir. w.r.t Flow (Deg) | Remarks |
|------------------|----------|-----|---------|------------------|--------------------------------|---------------------------------|--------------|-------------------|------------------------|----------------------------|---------|
| | | 1 | 1 | | | | | | | | |
| | | 1 | 2 | | | | | | | | |
| | | 2 | 1 | | | | | | | | |
| | | 2 | 2 | | | | | | | | |
| | | 3 | 1 | | | | | | | | |
| | | 3 | 2 | | | | | | | | |
| | | 4 | 1 | | | | | | | | |
| | | 4 | 2 | | | | | | | | |
| | | 5 | 1 | | | | | | | | |
| | | 5 | 2 | | | | | | | | |
| | | 6 | 1 | | | | | | | | |
| | | 6 | 2 | | | | | | | | |
| | | 7 | 1 | | | | | | | | |
| | | 7 | 2 | | | | | | | | |
| | | 8 | 1 | | | | | | | | |
| | | 8 | 2 | | | | | | | | |
| | | 9 | 1 | | | | | | | | |

Fig. 10b: Form for entry of stage-discharge summary data

Then mean gauge reading either with respect to the zero of the gauge or to mean sea level, (whichever is available) is entered. Where the reduced level of the gauge zero is available in the database for the station for the period under consideration then the entry in one column is used for automatically computing the other column.

The next few fields are for the results of the flow measurement and total discharge, area, surface slope, top width, wetted perimeter, and cross section area are entered.

On the basis of the entered values next three fields of hydraulic radius, mean velocity and Manning's roughness coefficient are computed automatically.

After that the gradient and fall are to be entered if required. Since, in some historical data the manually computed discharge is also put in the tabular form along with the observed stage-discharge data, provision is made to distinguish the two by stating whether the data are observed or computed. This column is put just after the discharge column and by default all data are considered as observed.

The remaining fields concern the method used and conditions of water and weather during the measurement. These fields are:

- mode of crossing,
- method of velocity observation,
- no. of verticals/float compartments,
- maximum point velocity,
- weather condition,
- wind velocity,
- wind direction and
- remarks.

Where no data are available for one or more of these columns, a facility is provided for closing columns down This helps in easier navigation of control within the table.

As stated above, summary data can also be automatically transferred from records held as primary flow measurement data . Thus, there is no need to enter the same quantities again.

Graph Options

A facility is provided for making scatter plots of the stage and discharge data of an year using an arithmetic scale. Observed discharge may be displayed against water level observations either as:

- (a) with respect to gauge zero (the normal procedure), or
- (b) with respect to mean sea level (as shown in Fig.4.11).

Navigation from within the graph permits plotting data for different years. Such graphs help in detecting data entry errors since erroneous data points will normally plot as outliers.

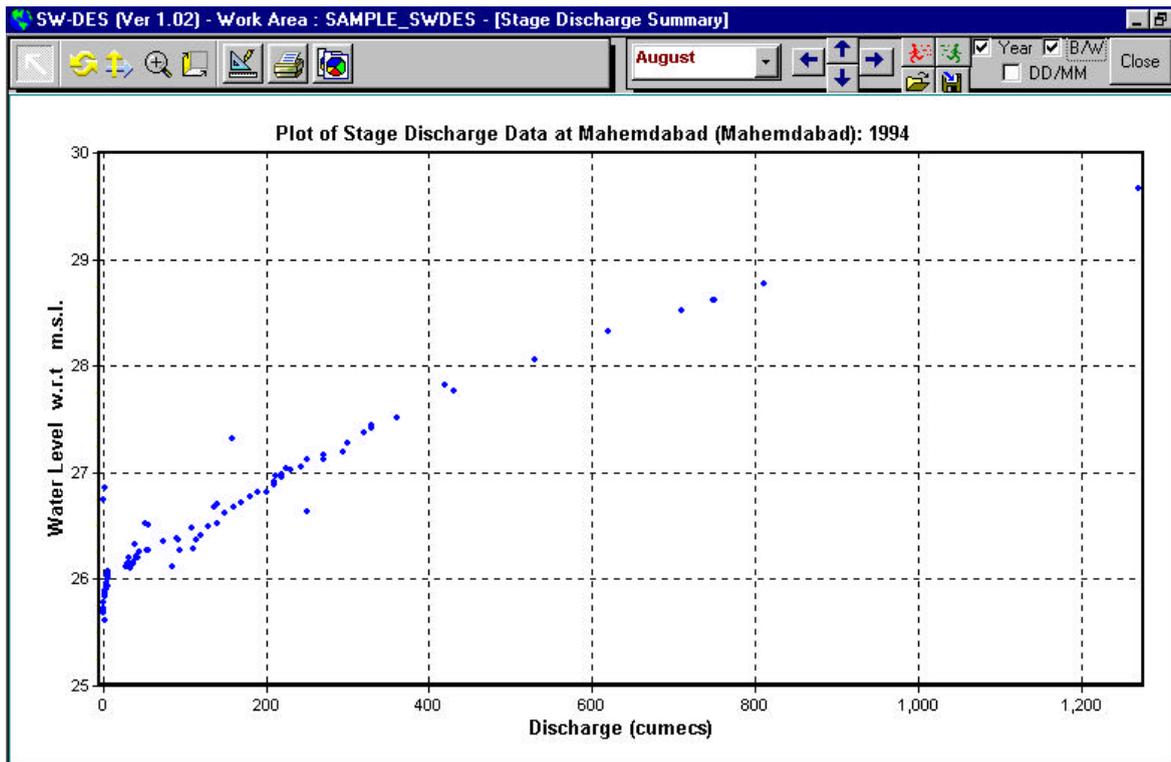


Fig. 4.11: Plot of observed discharge against water level with respect to mean sea level