Government of India & Government of The Netherlands

HYDROLOGY PROJECT
Technical Assistance

DHV CONSULTANTS & DELFT HYDRAULICS with HALCROW, TAHAL, CES, ORG & JPS

# VOLUME 8
# DATA PROCESSING AND ANALYSIS

## OPERATION MANUAL – PART I

## DATA ENTRY AND PRIMARY VALIDATION

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# 1 INTRODUCTION

## 1.1 GENERAL

The prime objective of the Hydrology Project is to develop a sustainable Hydrological Information System for 8 states in Peninsular India, set up by the state Surface Water and Groundwater Departments and by the central agencies (CWC and CGWB) with the following characteristics:

- Demand driven, i.e. output is tuned to the user needs
- Use of standardised equipment and adequate procedures for data collection and processing
- Computerised, comprehensive and easily accessible database
- Proper infrastructure to ensure sustainability.

This Hydrological Information System provides information on the spatial and temporal characteristics of water quantity and quality variables/parameters describing the water resources/water use system in Peninsular India. The information needs to be tuned and regularly be re-tuned to the requirements of the decision/policy makers, designers and researchers to be able to take decisions for long term planning, to design or to study the water resources system at large or its components.

This manual describes the procedures to be used to arrive at a sound operation of the Hydrological Information System as far as hydro-meteorological and surface water quantity and quality data are concerned. A similar manual is available for geo-hydrological data. This manual is divided into three parts:

a) **Design Manual,** which provides information for the design activities to be carried out for the further development of the HIS
b) **Reference Manual,** including references and additional information on certain topics dealt with in the Design Manual
c) **Field/Operation Manual,** which is an instruction book describing in detail the activities to be carried out at various levels in the HIS, in the field and at the data processing and data storage centres.

The manual consists of ten volumes, covering:

1. Hydrological Information System, its structure and data user needs assessment
2. Sampling Principles
3. Hydro-meteorology
4. Hydrometry
5. Sediment transport measurements
6. Water Quality sampling
7. Water Quality analysis
8. Data processing
9. Data transfer, storage and dissemination, and
10. SW-Protocols.

This Volume 8 deals with **data processing** and consists of an Operation Manual and a Reference Manual. The Operation Manual comprises 4 parts, viz:

Part I: Data entry and primary validation
Part II: Secondary validation
Part III: Final processing and analysis
Part IV: Data management

This Part I concerns the first step in data processing, i.e. data entry and primary data validation, which is executed in the Sub-divisions. The procedures described in the manual have to be applied to ensure uniformity in data processing throughout the Project Area and to arrive at high quality data.

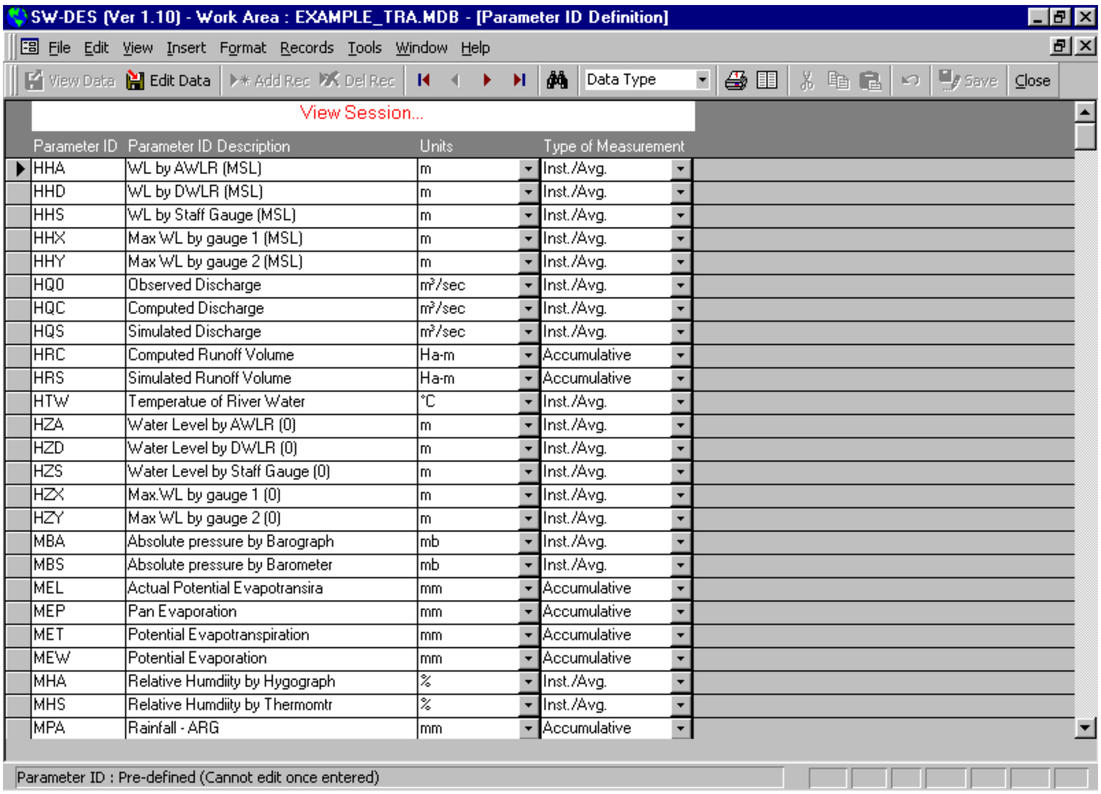
# 2 ENTRY OF MASTER INFORMATION

## 2.1 GENERAL

The software maintains a set of important information on data types, administrative and drainage boundaries and that on the owner agency and various HIS offices at which the data from an observation station is processed. This master information helps in avoiding duplicate spellings for the same item in the database and at the same time the user is not required to waste time every time in keying-in the information. The required item can be entered, whenever required, by clicking it from the available list. There is adequate facility available in the system to extend or modify this type of information. A brief description on the information on data types, administrative boundaries, drainage boundaries and various agencies and its office units is given here.

## 2.2 ENTRY OF DATA TYPES

A number of variables are observed with the help of hydrological and meteorological network at several locations. It is also very important to note certain key characteristics of these variables. Characteristics like description, unit and type of measurement of the variables are also maintained. Defining and maintaining data types is accomplished using ***"Data Type" button*** available on the main switch board. This button initiates the ***"Data Type Definition" form*** as shown in Figure 2.1. The available data types are listed on the form. Characteristics of any data type can be viewed by using the navigating buttons. For creating or deleting a data type, "Add Record" or "Delete Record" button is clicked respectively, after the form has been brought in the edit mode.




| Parameter ID | Parameter ID Description | Units | Type of Measurement |
|---|---|---|---|
| HHA | WL by AWLR (MSL) | m | Inst./Avg. |
| HHD | WL by DWLR (MSL) | m | Inst./Avg. |
| HHS | WL by Staff Gauge (MSL) | m | Inst./Avg. |
| HHX | Max WL by gauge 1 (MSL) | m | Inst./Avg. |
| HHY | Max WL by gauge 2 (MSL) | m | Inst./Avg. |
| HQO | Observed Discharge | $m^3$/sec | Inst./Avg. |
| HQC | Computed Discharge | $m^3$/sec | Inst./Avg. |
| HQS | Simulated Discharge | $m^3$/sec | Inst./Avg. |
| HRC | Computed Runoff Volume | Ha-m | Accumulative |
| HRS | Simulated Runoff Volume | Ha-m | Accumulative |
| HTW | Temperatue of River Water | °C | Inst./Avg. |
| HZA | Water Level by AWLR (0) | m | Inst./Avg. |
| HZD | Water Level by DWLR (0) | m | Inst./Avg. |
| HZS | Water Level by Staff Gauge (0) | m | Inst./Avg. |
| HZX | Max.WL by gauge 1 (0) | m | Inst./Avg. |
| HZY | Max WL by gauge 2 (0) | m | Inst./Avg. |
| MBA | Absolute pressure by Barograph | mb | Inst./Avg. |
| MBS | Absolute pressure by Barometer | mb | Inst./Avg. |
| MEL | Actual Potential Evapotransira | mm | Accumulative |
| MEP | Pan Evaporation | mm | Accumulative |
| MET | Potential Evapotranspiration | mm | Accumulative |
| MEW | Potential Evaporation | mm | Accumulative |
| MHA | Relative Humdity by Hygograph | % | Inst./Avg. |
| MHS | Relative Humdity by Thermomtr | % | Inst./Avg. |
| MPA | Rainfall - ARG | mm | Accumulative |

*Figure 2.1: Layout of data type definition form*

Four fields required for defining a data type are explained below:

- ***Parameter ID*** Parameter identification code is a three character code used to uniquely define any parameter. No two parameters can have the same identification code and this integrity is maintained by the system automatically. This characteristic being the primary field is obviously mandatory to be supplied by the user.

- ***Description*** Full description of the variable is given for explaining its exact meaning. Sometimes, a variable is observed by different methods/instruments and since it is required to keep these data separately, it is desired to codify them differently. In such cases, the codes themselves are a little obscure to understand, the description of the variable helps in knowing its meaning appropriately. A length of 30 characters is reserved for stating the description of the variable.

- ***Units of measurement*** Every parameter is characterised with the units of measurement. This is a very important characteristic of the parameter since the quantitative interpretation of every data in a series depends on the units of measurement used. For a specific data type only one unit applies. A list of commonly used units is provided by the program. The desired units can be entered by clicking from the available list or entering it using keyboard, if not available in the list. A length of 15 characters is reserved for stating the units of measurement.

- ***Type of measurement*** Measurements on various variables are either accumulative, instantaneous or constant in nature and is very important to know it. An ***instantaneous type*** of observation indicates the instantaneous value of the parameter at the time of measurement. On the other hand an ***accumulative type*** of observation gives the accumulated amount of the quantity being measured since the last measurement was made. ***Constant type*** of observation are made for those quantities which change only due to some artificial or man made interventions. In other words, it can be stated that the constant type of measurement remains constant till the next measurement is made. This distinction in the type of observation is of utmost important while compiling one data series into another data series with different time intervals. This field can be entered by clicking the appropriate choice of type of measurement out of all the three listed by the program. These types of measurement are illustrated using schematic sketches in Figure 2.2 given below:

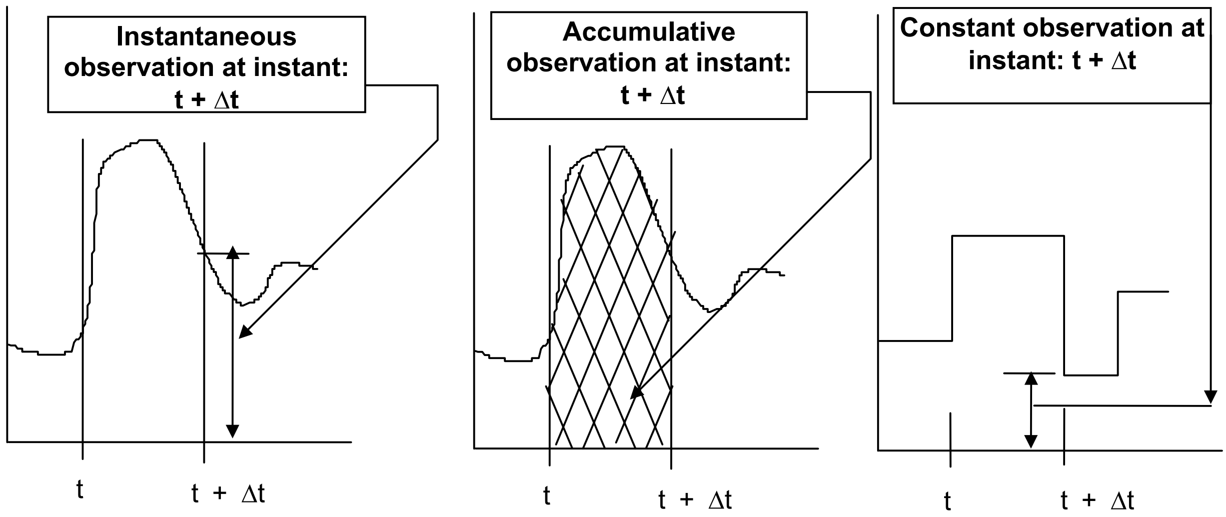



*Figure 2.2: Schematic illustration of various types of measurement*

A standard and ***comprehensive list of data types*** is included in the program. This list can not be modified by any user in any way so as to avoid ambiguity in interpreting the standard data types which will be used in all the agencies This list is given in ***Appendix A*** along with the description about the basis of its codification. Adequate flexibility is however provided for adding new data types, if required. The option for defining new data type or editing an existing one (except for the standard data types) is given only to the Level 1 users. Once a parameter is defined with the help of Parameter ID, its description, units or type of measurements is editable and thus can be changed later, if desired.

## 2.3 ENTRY OF ADMINISTRATIVE BOUNDARIES

Important administrative boundaries are identified so that observation stations can be associated with them and vice versa. Three levels of administrative boundaries can be defined in the program. These are: (a) State, (b) District, and (c) Tehsil/Taluka. The classification and identification of these boundaries is done by the competent administrative authorities and the same is to be followed. There are eight States in the project area and the list of all districts in these states is included in the program.

The hierarchical record of the information on these administrative boundaries is maintained with the help of the ***"State/District/Tehsil" button*** available on the switch board. This button initiates ***"State/District/Tehsil Definitions" form*** as shown in Figure 2.3.

Three levels of administrative boundaries are displayed in the form of separate columns. The relationship between two consecutive administrative boundaries in descending order is of ***"one to many"*** type. Location of the control at any point of time is indicated by a triangle at the left side of every column. When an item from the list of State is selected by clicking it by mouse, the corresponding list of district is displayed in the second column. On selecting a district, the corresponding list of Tehsil/Taluka is displayed in the third column. Entries in any column can be made by going to its last row, marked by *, and entering using the keyboard. However, since names of States in the project area is comparatively fixed, the list is not amenable to any changes.

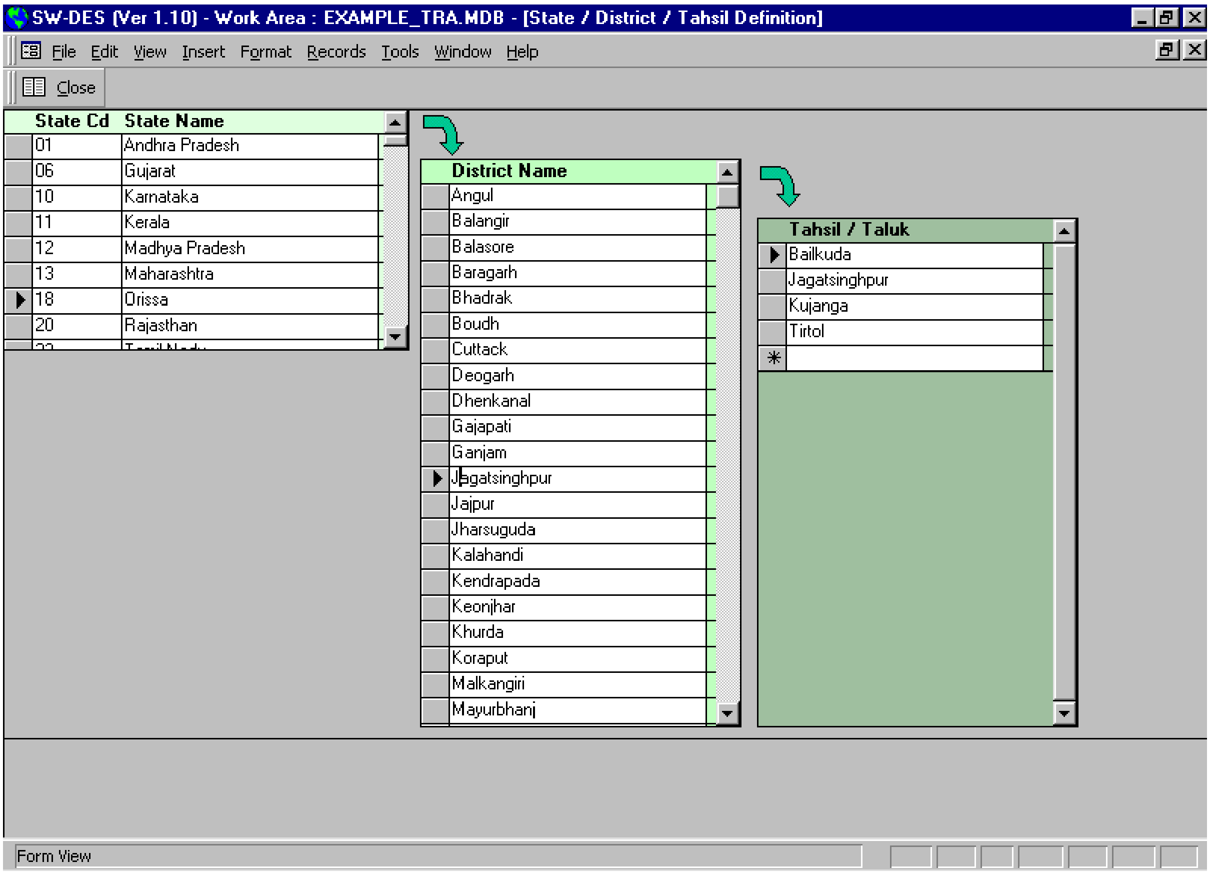



*Figure 2.3: Form for defining administrative boundaries*

## 2.4 ENTRY OF DRAINAGE BOUNDARIES

It is advantageous to identify the drainage boundaries so that observation stations can be associated with them and vice versa. Four levels of drainage basins can be defined in the program. These are: ***(a) major river basin/zone, (b) independent river, (c) tributary to independent river and (d) local river/basin***.

The classification of the drainage basins is based on the procedure followed by the Central Water Commission in which the country has been divided into 12 major river basins/zones. These river basins/zones are listed in ***Table 1 of Appendix B***. There are only six major river basins/zones covering the entire project area, however the list covers all the major river basins/zones for the purpose of completeness.

Each zone has a number of independent rivers flowing either into the sea in the Indian territory or crossing the international border to enter another country. An independent river is taken as those having more than 50 kms. of length in the Indian territory. The comprehensive list of 168 independent rivers of the country as identified by the Central Water Commission (Publication No. 9/92, CWC, 1992) is given in ***Table 2 of Appendix B***.

The third level is to identify tributaries flowing directly into the independent rivers. Criteria used for defining the tributary to the independent rivers is similar to that considered for independent rivers. Fourth level of drainage boundaries is used for defining the local river/basin. Local river/basin is not necessarily the immediate tributary to the tributary of the independent river and is used for defining the nearest local river/basin that is desired to be associated with an observation station. If the observation station pertains to the independent river or to a tributary to independent river itself then the name of local river/basin can also be given the name of independent river or of tributary to independent river respectively.

The hierarchical record of the information on these drainage boundaries is maintained with the help of the ***"Drainage Basin" button*** available on the switchboard. The option for editing this information is given only to the Level 1 users. This button initiates ***"Drainage Basin Definition" form*** as shown in Figure 2.4.

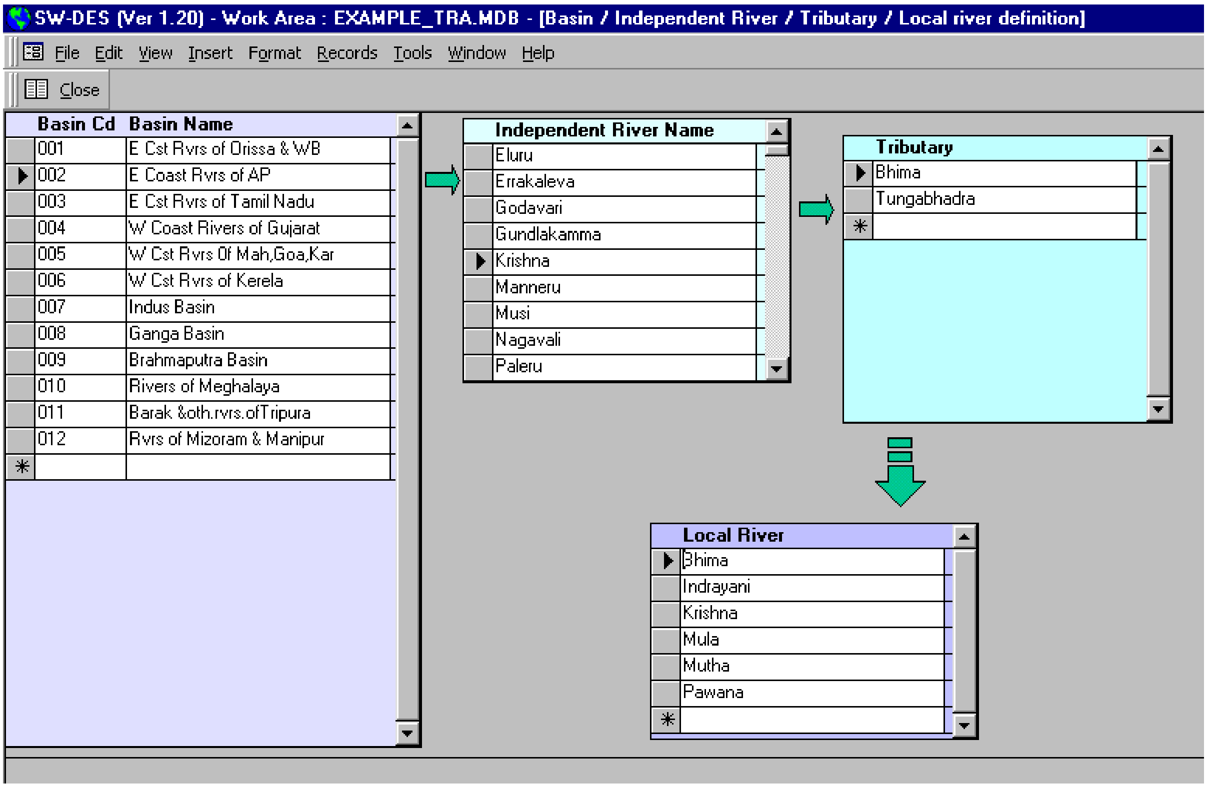



*Figure 2.4: Form of defining drainage boundaries*

All the four levels of drainage boundaries are displayed in the form of four separate columns. The relationship between two consecutive drainage boundaries in descending order is of "one to many" type. Location of the control at any point of time is indicated by a triangle at the left side of every column. When an item from the list of major river basin/zone is selected by clicking it by mouse, the corresponding list of independent rivers is displayed in the second column. On selecting an independent river, the corresponding list of tributaries to that independent river is displayed and so on. Entries in any column can be made by going to its last row and entering using the keyboard. The entries made in independent river and tributary to independent river would be automatically reflected as local river also.

Figure 2.5 gives an example for illustrating the meaning of these drainage boundaries. As can be seen from this illustration, for a rainfall station A, the four drainage boundaries are: East coast rivers of A.P., Krishna, Tungbhadra and Tunga respectively. The station A is on the upstream of Varda which is contributing to Tungabhadra, the tributary to the independent river Krishna in the zone of east coast rivers of A.P. The station contributes to the flow of nearby stream Tunga which is taken to be the local river/basin. For a stream gauging station B, which is on the independent river Godavari itself will obviously not have any tributary to the independent river to be associated with. The local river/basin in this case is also to be named as "Godavari". Similarly, for observation stations like C, which contribute, directly or through very small streams, to the sea will not have any independent river or tributary to independent river for association. In this case, East coast rivers of A.P will be the major zone and "directly draining to sea" can be used for local river/basin to indicate that it is draining to the sea directly.

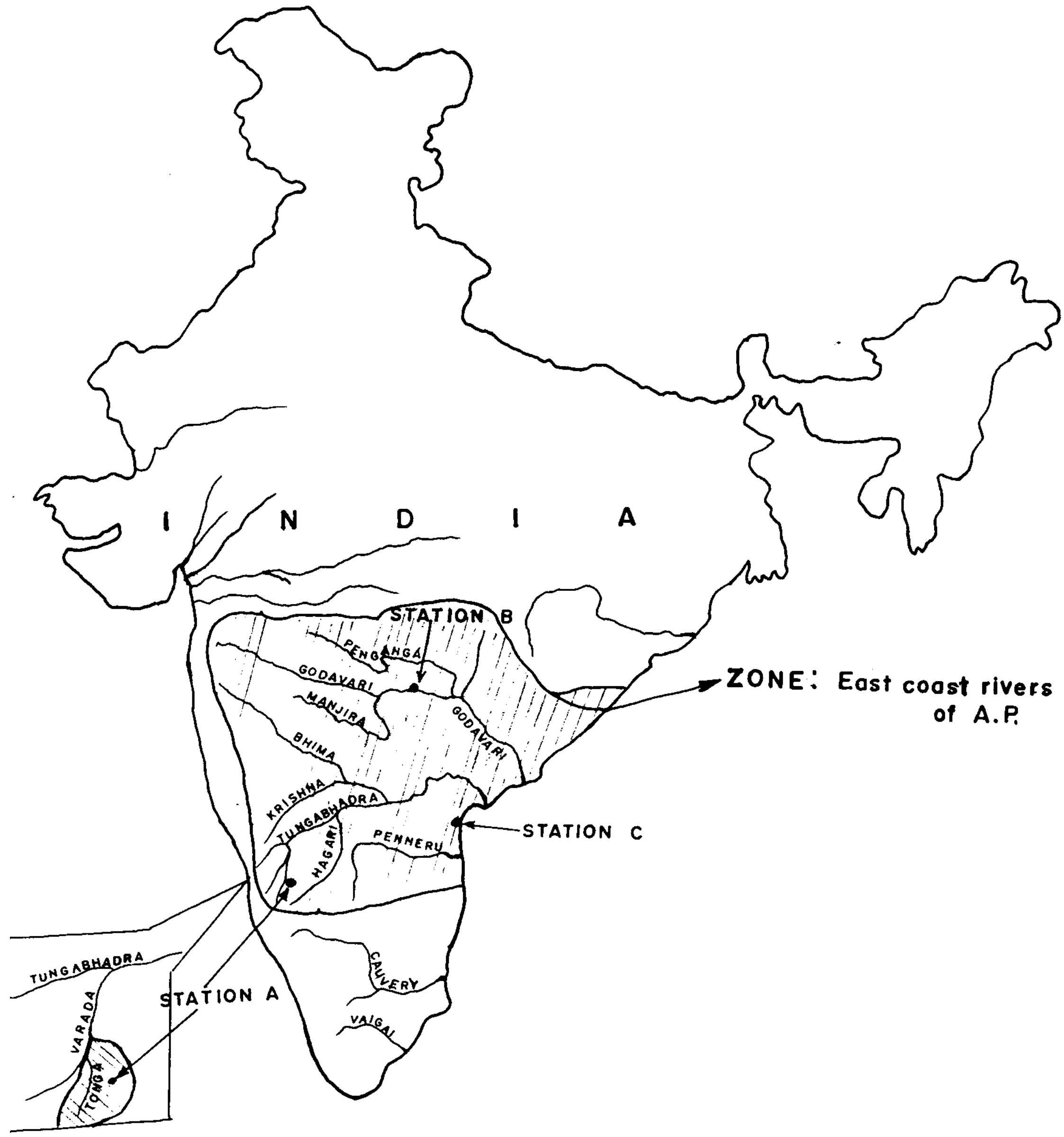



*Figure 2.5: Example illustrating definition of the drainage boundaries (Map not to scale)*

## 2.5 ENTRY OF OFFICE UNITS

It is very essential to maintain reference of various agencies and offices that control the activities and functioning of observation stations. There are a few State agencies and three central agencies which are primarily responsible for maintaining various hydrological and meteorological observation stations. All the States have one surface water and one groundwater organisation as the lead agency engaged in data collection besides a few other organisations like Revenue, Agricultural, Hydro-electric and Pollution departments which have limited mandate. Central agencies like Central Water Commission, Central Ground Water Board and India Meteorological Department play a vital role in collection and dissemination of data.

The hierarchical record of the information on these agencies and offices is maintained with the help of the ***"Agency/Offices" button*** available on the main switchboard. The option for editing this information is given only to the Level 1 users. This button initiates the ***"Agency/Office Definition" form*** as shown in Figure 2.6.

As shown in the form layout, distinction is made between "Owner agency" and "HIS Agency". Within HIS agencies, various office types can be defined. A brief description of these agencies and offices is given below:

- ***Owner Agency*** This is the name of the institution/organisation to which an observational station belongs to. There can be a few organisations in the state like Revenue, Agriculture etc. which, though, have observational network of their own are supplying data to Irrigation departments of the state for further processing and use.
- ***HIS Agency*** "HIS Agency" is the agency which has been entrusted with the task of entering, validating and processing data pertaining to an observation station.
- ***State/Regional Office*** Every State HIS Agency has a Centralised State level office which has the responsibility of the smooth functioning of system within the state. The Central agency, CWC has five Regional offices in the project area which correspond to the State level office of the State agencies. These regional offices cover the geographical areas of one or more states and are based on the drainage boundaries.

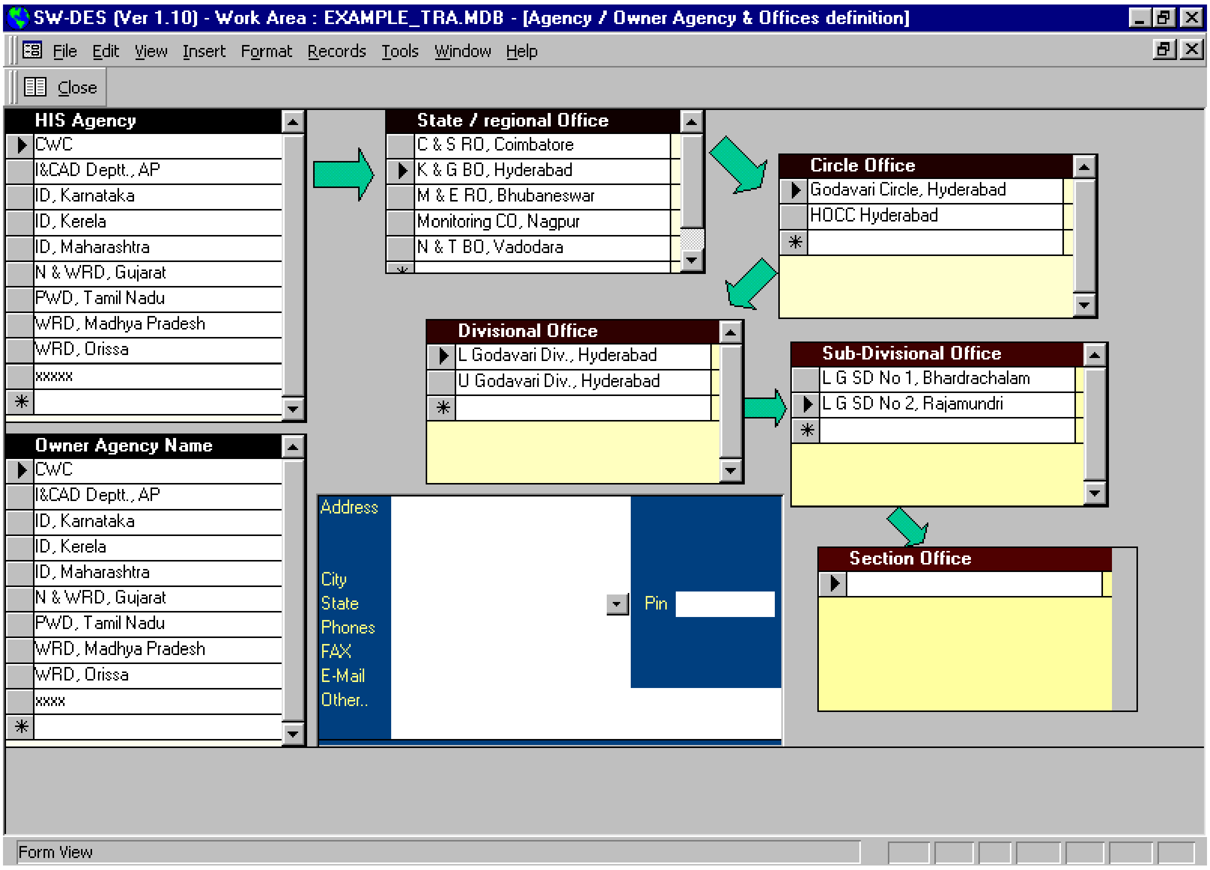



*Figure 2.6: Form for defining various agencies and offices.*

- ***Circle/Div./Sub-div. Offices*** Under each Regional/State level office there are a few Circle offices which in turn have several Divisional offices. Every Divisional office has one or more Sub-Divisional offices.

- ***Section offices*** In few agencies the Sub-divisional office controls the activities at the observational stations directly, whereas in some agencies there are a few section offices to look after the observational stations.

- ***Address*** Complete address of all offices can be maintained by entering it in the field provided. The control must be in the cell of a particular office for which the address is to be given.

On the ***"Agency/Office Definition" form*** the column for "Owner Agency' is available separately in the form of a column. For each "HIS Agency", the ***hierarchical order*** between all office types is apparent from the direction of arrow head joining two consecutive types of offices. The relationship between two consecutive office types, in descending order, is of "one to many" type. Location of the control at any point of time is indicated by an arrow at the left side of every column. When an item from the list of agencies is selected by clicking it the corresponding list of Regional/State level offices is displayed. On selecting a Regional/State office, the corresponding list of Circle offices is displayed and so on. Entries in any column can be made by going to its last row and entering using the keyboard.

# 3 ENTRY OF STATIC AND SEMI-STATIC DATA

## 3.1 GENERAL

Attributes associated with the observational stations or equipment which do not change with time are considered as ***static type of data***. Some of these attributes change but very infrequently and are thus taken to be of ***semi-static nature***. SWDES stores the characteristics associated with the observation stations, data series, reduced level of gauge zero and current meters so that the same is available for reference and querying subsequently. Options for X-section profiles data, salient features of reservoir/diversion scheme and elevation-area-capacity relationships are also available in this main option of static/semi-static data. The layout of the form showing the options on static/semi-static characteristics is as shown below in Figure 3.1. Description of these characteristics and various forms required for the entry of this information is given here.

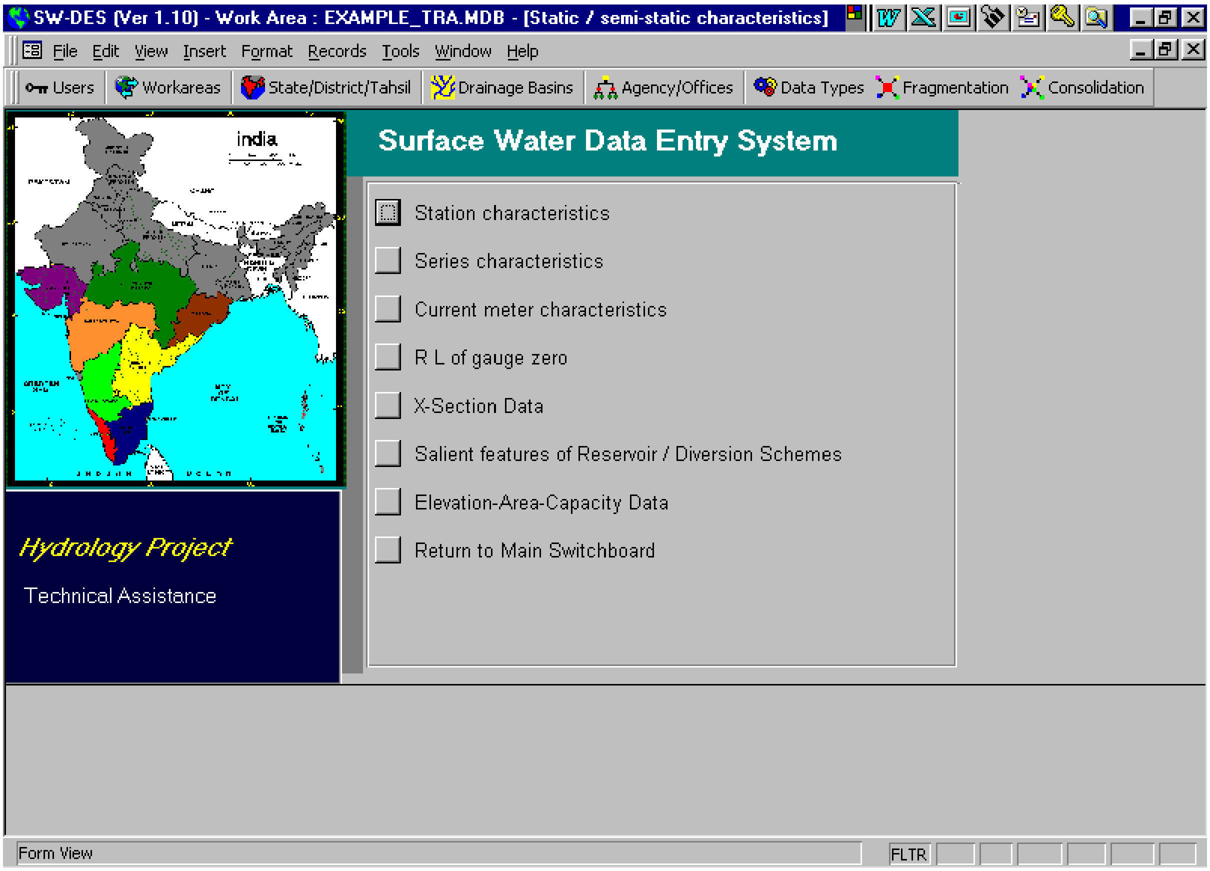



*Figure 3.1: Form for sub-options on static/semi-static characteristics*

## 3.2 ENTRY OF STATION CHARACTERISTICS

Many important attributes to each observational station can be assigned for defining its location in terms of geographical, administrative or drainage units and for indicating various offices which have control on its operations. Locational attributes are important for the purpose of finding inter station distances and difference in altitudes for the purpose of data processing. These characteristics are also very important for the purpose of retrieval of data pertaining to particular range of these attribute(s).

The station characteristics can be entered by choosing the option of ***"Static/Semi-static Characteristics"*** from the main switchboard and then choosing the menu item ***"Station Characteristics"***. On clicking the option of "Station Characteristics" the form for entry of station characteristic is opened which is given as shown in Figure 3.2.

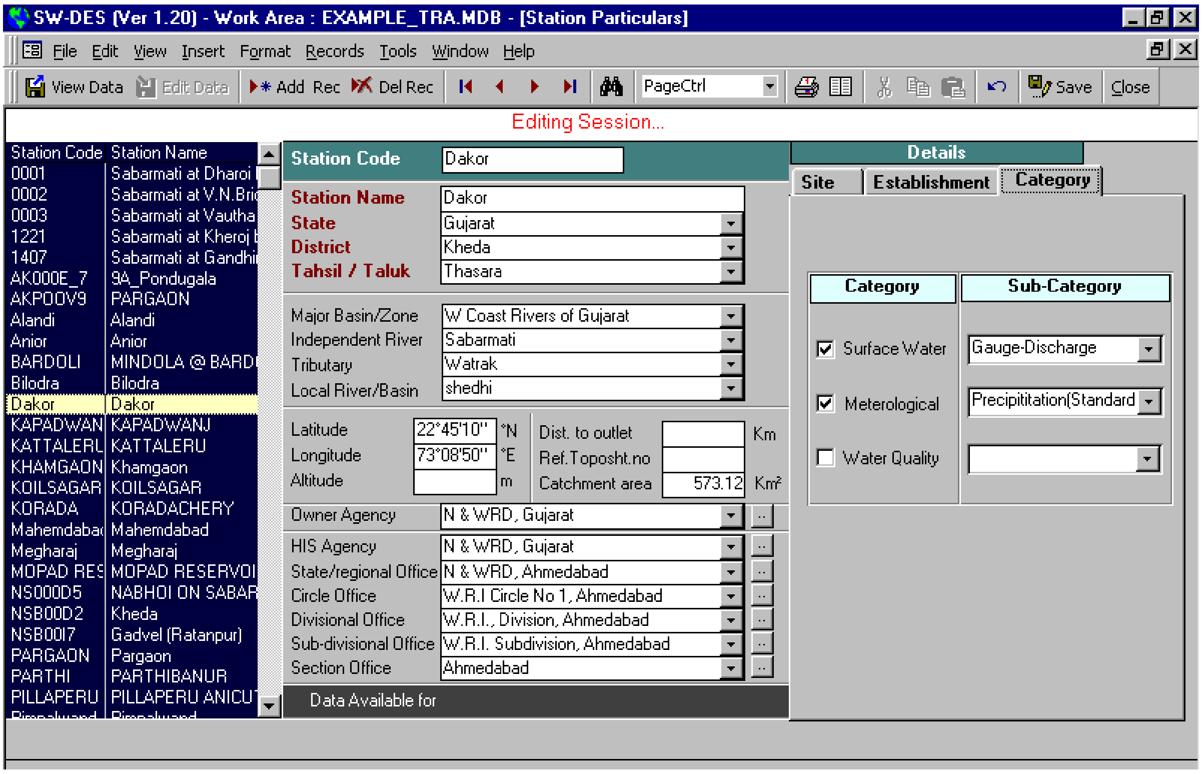



*Figure 4.2: Form for maintaining stations and entering associated characteristics*

The available station list is displayed at the left side of the form in the form of a list box. Characteristics of any station can be viewed by using the navigating buttons. For creating or deleting a station, ***"Add Record"*** or ***"Delete Record"*** button is clicked after the form has been brought in the edit mode. It is important to note that for deleting a station, it must be first selected in the list box and then deleted. A brief description of all the characteristics associated with the observational stations is given here.

### *Station Identification Code*

Station identification code is the ***unique 15 character code*** assigned to every station. This is the most important field of the database since most of the information in the database is associated with the observational stations and these stations are identified by this code. No two stations can have identical station identification code. The database is provided with in-built facility to ensure uniqueness of the station code for integrity of the database.

### *Station Name*

The station name is the full name of the observational station assigned by the agency for purpose of addressing it for all common uses. Generally, the station name is given on the basis of name of local river, village, town etc. together with some reference of nearby structure, institution etc. and thus is comparatively longer. A length of ***30 characters*** is reserved for indicating the station name. There is possibility of having two or more observational stations with the same station name within a large region. Though, identical station names do not cause any problem with respect to data integrity with in the database but it is always advisable to avoid such situations.

***Administrative Boundaries***

Every station falls under certain administrative or political boundary. Three levels of such political boundaries in the form of the name of the ***State, District, Tehsil/Taluka*** can be specified for any station. A length of ***30 characters*** is reserved for stating these names. The names of all states and districts of the project area are available in the system itself for easy selection and avoidance of use of different spellings for them by the users. Names of Tehsil/Taluka can be built up by the agencies themselves by using the form for "State/District/Tehsil Definition" form.

***Drainage Boundaries***

The observation stations can be associated with the physiographic or drainage boundaries. Upto four levels of such physiographic boundaries in the form of (a) ***major river basin/zone,*** (b) ***independent river,*** (c) ***tributary to independent river*** and (d) ***local river/basin*** can be stated for any observation station. The definition and classification for major river basin/zone and independent rivers is discussed earlier in the previous chapter. A comprehensive list of such drainage boundaries can be maintained by each agency using the "Basin Definition" form. These entries are made by selecting the required item from the available list of drainage boundaries.

***Location***

The location of a station is of prime importance in locating any observation station on the map. The location of a station is specified by entering the geographical co-ordinates in terms of latitude and longitude. The latitude and longitude is expressed in ***sexagesimal units***, called degrees. Degrees are subdivided into minutes (1 degree = 60 minutes) and minutes into seconds (1 minute = 60 seconds). For purpose of avoiding possible data entry mistakes, the program allows for entry of latitude and longitude from ***8°0′0″ to 38°0′0″*** and ***68°0′0″ to 98°0′0″*** only, respectively. These are the possible limits for geographical co-ordinates in the main land of the country.

***Altitude***

The height of the observation station with respect to the mean sea level is expressed as altitude. The units used for the altitude is meters. Program restricts the entries for altitude within ***–100 m and 9000 m*** for avoiding possible mistakes.

***Distance to Outlet***

For being able to know the distances between two or more stream gauging stations located on the same river reach, their distances from a common point is required. The outlet or mouth of the river where it meets the sea can be used for this purpose. Such information can be entered in the field of "distance to outlet (in kms.). Any positive value which is less than 100000 is considered as valid entry for this field.

***Catchment Area***

For the stream gauging observation stations, it is advantageous to indicate the catchment area drained through it. The catchment area is expressed in units of sq. kms. and any positive real number ***less than 1 million sq. kms.*** is accepted as valid entry.

***Reference Toposheet Number***

While working with the maps, it is required to know the serial number of map on which the observation station can be located. This information is stored in the database and thus can be retrieved for a ready reference. There are unique serial numbers allotted to each of ***Survey of India toposheets*** on the scale of ***1:50,000*** and the same is used to provide this reference toposheet number. The format of this toposheet number is ***nnA/NN*** where acceptable range, for toposheets covering the main land of the country, of ***nn*** is an integer from ***38 to 92***, ***A*** is an alphabet from ***A to P*** and ***NN*** is an integer from ***1 to 16***.

***Owner Agency***

The owner agency is the agency which own the observational stations. The data may be collected from these observational stations and processed by other agency. The list of all possible owner agencies is readily provided to the user for making the entry by way of selecting the required one.

***HIS Agency***

The HIS agency is the agency which is receiving data from observational stations belonging to various owner agencies and is entrusted with its validation, processing and dissemination.

***Controlling Offices***

Apart from the name of the main HIS agency, there are other offices which have the responsibility of processing of data. All possible levels of controlling offices in the form of (a) Regional, (b) Circle, (c) Divisional, (d) Sub-divisional and (e) Sectional offices can be entered for an observation station. The list of all offices pertaining to any agency is readily provided to the user for making the entry by way of selecting the required one.

***Site Details***

It is very useful to keep detailed information on the locational aspects of the observation station. This facilitates anyone who would like to visit the station for purpose of inspection or otherwise. Complete information on the ***station's location*** with respect to the surrounding area/river, its ***accessibility conditions*** can be entered separately. Full details about the ***station setup*** with respect to equipment availability and installation can be indicated. Input fields are provided for entering the general information about ***address, nearest town*** and ***transport facilities***. All these characteristics are available under the tab on "Site Details" in station characteristics form as shown in Fig. 2.15 in the chapter 2 earlier.

***Establishment Details***

Several important dates with respect to the establishment of the station can be associated with the station. ***Start date*** marks the establishment of the station. In case the station is closed down then the ***end date*** can be entered to show the date of closure. Several other dates for starting and closure of ***important observational activities*** like water level by manual means, water level by automatic equipment, discharge observation in general, discharge observation using current meters, observations on sediment and water quality variables. Similarly, the dates of initiating the rainfall and climatic observation by manual or automatic means can also be entered. Together with the dates there are check boxes available against each of these items. For certain types of data, like on stage-discharge, climate and water quality, it is mandatory to check these boxes for allowing the data to be entered. Thus all those stations for which stage-discharge data, climatic data and water quality data is to be entered are to be essentially checked in the boxes against such items under the establishment details tab. ***Only those stations which have been registered in this manner for the required data types (stage-discharge, climate, water quality) would appear in the respective data entry forms.***

A note on ***station history*** gives detail about the establishment of the station and other important maintenance, construction or installation activities carried out subsequently.

### *Station categorisation*

It is useful to categorise different types of observation stations in a few classes so that information belonging to a particular class can be easily used, displayed or retrieved. Input for Station Categorisation is to be provided from the ***Station Categorisation option*** on Station Characteristics form. There are two levels of categorisation: ***Category and Sub-category***. First, the category of the station has to be specified from among three types: (a) Surface water, (b) Meteorological and (c) Water Quality. It is possible to have simultaneous selection of both “Surface water” and “Meteorological” category implying thereby that the station is of river gauging type which also has meteorological observatory for observations on certain meteorological variables. Category of Water Quality can be also be chosen simultaneously with Surface water and/or Meteorological type of station category. Whenever a station is also chosen as Water quality station, it implies that water quality monitoring is being done at that station. However, it is not possible to choose only water quality as the category since any station for which water quality is monitored must either be surface water or meteorological station and has to be essentially chosen so.

Since the category is an indication of the type of station in a very broad sense only, the sub-category of the station is important to know as what is the exact nature of the station. The Table 3.1 below enlists all the probable sub-categories for various types of stations. If user require to use some other sub-category which is not listed in this list then the user may indicate this by inserting “other”.

| Category | Sub-Category | |
|---|---|---|
| **Meteorological** | Precipitation (Standard – SRG) | |
| | Precipitation (Autographic – ARG) | Y/N |
| | Precipitation (Digital) | Y/N |
| | Principle Climatological (Class I) | Y/N |
| | Ordinary Climatological (Class II – FCS:HP) | Y/N |
| | Ordinary Climatological (Class III) | Y/N |
| | Ordinary Climatological (Class IV) | Y/N |
| | Specific Purpose Climatological (Class VI) | |
| | Automatic Weather Station (AWS) | |
| | Other | |
| **Surface Water** | Gauge | |
| | Gauge-Discharge | |
| | Gauge-Discharge-Sediment | Y/N |
| | Hydraulic Structure | |
| | Reservoir | |
| | Lake | |
| | Non-Gauge | |
| | Other | |
| **Water Quality** | Baseline | |
| | Trend | |
| | Flux | |
| | Surveillance | |
| | Survey | |
| | Other | |

*Table 3.1: List of type of categories and sub-categories of observation stations*

## 3.3 ENTRY OF SERIES CHARACTERISTICS

The bulk of hydrological and hydro-meteorological data is ***time series data***. At every station a number of variables are observed and sometimes at varying time intervals. Thus, the time series data is required to be organised in different series at every station for each combination of the required variables and time intervals of observation. These series are attributed with certain key characteristics which are useful for identification and providing necessary information about the series and in validation of the elements of the series.

Any time series can be recognised by its series identification code. The identification code comprises of three parts: station code, data type and time interval code. The combination of these three entities is considered to be unique and thus defines a specific series. The combination of all the three results into the series code as illustrated here under:

Series identification code = Station code + Data type + Time interval code

The station code and data type has been described in preceding sections. Time interval code is used to indicate the interval of time between successive observations and is described here.

***Time interval code***

The bulk of hydrological or hydrometeorological data comprise of the time series data. Depending upon the variation of time interval between various observations the time series can be of three different types:

- equidistant
- cyclic and
- non-equidistant

For an equidistant time series all the data points are ***spaced equally in time*** (in terms of calendar or time units). Whereas the time interval between the data points in the non-equidistant series is ***not uniform***. The cyclic series is the one for which, though two or more adjacent time intervals may not be identical but there is a ***perfect repetition or recurrence*** of the set of these ***unequal time intervals***. Thus for the equidistant and cyclic time series the time instants of the observations can be uniquely defined if the time intervals are known. It is enough if the starting time and ensuing set of repetitive time interval(s) are known to fully define the times of observation of all the data in the series. Assigning codes for the time intervals facilitates defining the time intervals objectively and flexibly which also helps in exchanging data between different databases.

The ***time interval***, ***say*** $\Delta$***t***, represents: (a) time distance between successive series elements of instantaneous observations, or (b) time span of an accumulative observation. The time interval can be year, month, day or hour or a part thereof. The calendar units vary with time according to the ***Gregorian calendar***. Following time and calendar units are used by the program and codification is done as given below:

- ***Calendar units:*** Year : coded as 1
  Month : coded as 2
  Day : coded as 3

- ***Time units:*** Hour : coded as 4
  Minute : coded as 5

The time interval code for various series are assigned as follows:

**(a) Time interval code and time label for equidistant time series**

For an equidistant time series the time interval ∆t is coded as:

∆t = (time interval unit, divider)

where:

time interval unit (T.I.U) = year, month, day or hour

divider = division factor (integer: 1-99) applied to the relevant time interval unit to get the length of the time interval ∆t

Thus the time interval code occupies 3 character spaces, one for time interval unit and two for the divider.

***Examples:*** The use of the codes may be appreciated by looking at the following examples:

| Description of time interval | T.I.U | Divider | Time interval code |
|---|---|---|---|
| Yearly | 1 | 1 | (Year, 1) or (1,1) |
| Seasonal (four monthly seasons) | 1 | 4 | (Year, 4) or (1,4) |
| Monthly | 2 | 1 | (Month, 1) or (2,1) |
| Decade (ten daily)* | 2 | 3 | (Month, 3) or (2,3) |
| Weekly* | 1 | 52 | (Year, 52) or (1,52) |
| Daily | 3 | 1 | (Day, 1) or (3,1) |
| 8 hourly | 3 | 3 | (Day, 3) or (3,3) |
| Hourly | 4 | 1 | (Hour, 1) or (4,1) |
| 15 minute | 4 | 4 | (Hour, 4) or (4,4) |
| 1 minute | 4 | 60 | (Hour, 60) or (4,60) |

As is clear from above, for some intervals there is no unique combination of time interval unit and divider, e.g. month can be specified by (2, 1) or (1, 12); in such cases preference is to be given to the definition with the lowest divider.

Also, for some cases the divider divides the time interval unit perfectly (e.g., day divided into three parts always results in 8 hourly interval, hour divided into four parts always results in 15 minute interval). But for few other cases this division is not a perfect one (e.g., month divided into three parts does not always result in a unique time interval, year divided into 52 parts does not always result in a unique time interval). To define this irregularity, the ***"basic time interval"*** is introduced. It has a practical utility when the time interval is a week, a pentad (i.e. a period of five days) or a decade (i.e. a period of 10 days). The definition of the basic time interval is explained hereunder:

In case the user cannot or does not want to divide the time interval unit into equal parts, then in addition to the time interval unit $\Delta t$, a "basic time interval" or "basic $\Delta t$" expressed in numbers of smaller calendar or time units is required. E.g. for decades, which is parts of months, multiples of days are used to specify the interval; similarly for weeks, which are parts of years, multiples of days are used to specify the length of the interval. The basic $\Delta t$ is defined as follows:

Basic $\Delta t$ = (basic time interval unit, replicator)

where:

Basic time interval unit = month, day, hour or minute

Replicator = multiplying factor (integer: 1-99) applied to desired basic time interval unit so as to indicate the exact length of the time interval $\Delta t$.

Thus, the basic time interval code also occupies three character spaces, one for basic time interval unit and two for stating the replicator. The concept of basic time interval can be easily illustrated by taking the example of a ten daily series. The time interval for such a series is (month, 3) or (2, 3) which only states that a month has to be divided into three parts. It does not however give the idea about how long these parts are. To specify the length of each of these three parts the basic time interval is required. To specify that a decade consists of 10 days, the basic time interval should read: "basic $\Delta t$" = (day,10) = (3, 10). This states that the length of the parts is: a day multiplied by 10 (i.e., ten daily period). Then as much as possible intervals of 10 days will be defined in a month. In this case, since all months do not have 30 days, it is obvious that the first two parts of the month will have ten days followed by the third period equal to the remaining number of days in the month, i.e. 8, 9, 10 or 11 days as the case may be depending on the month and the year. For all those cases when it is not required to assign the code for basic time interval, the same has to be given the default code of (0,0).

This leads to the following generalisation. The time interval $\Delta t$ is built up of a number of basic $\Delta t$'s equal to the divider. The last time interval within a time interval unit may contain an amount of basic time interval units that differs from the replicator. Let the time interval unit, containing n basic $\Delta t$ units, be divided into k parts and let the replicator in the basic $\Delta t$ be m. Then the first "k-1" time intervals comprise m basic $\Delta t$ units. The last or k-th time interval contains ***[n-(k-1).m] basic $\Delta t$ units*** (see Fig. 4.3)

Apart from time interval code, a time label is required for defining the exact time to which the data point correspond to within the time interval unit. For example, for the daily observations at 0830 hrs., the time interval code and time label will be:

Time interval code = (day, 1) = (3, 1)

Time label = 08:30:00 hrs.

Similarly, the time interval code and time label for the data series of hourly observations made at the middle of every clock hour will be.

Time interval code = (hour, 1) = (4, 1)

Time label = 00:30:00 hrs.

This gives the complete information of the time for each of the data points in the series.

| | | |
|---|---|---|
| Decade in a month of 31days | Time interval unit = month | Basic Δt unit = day |

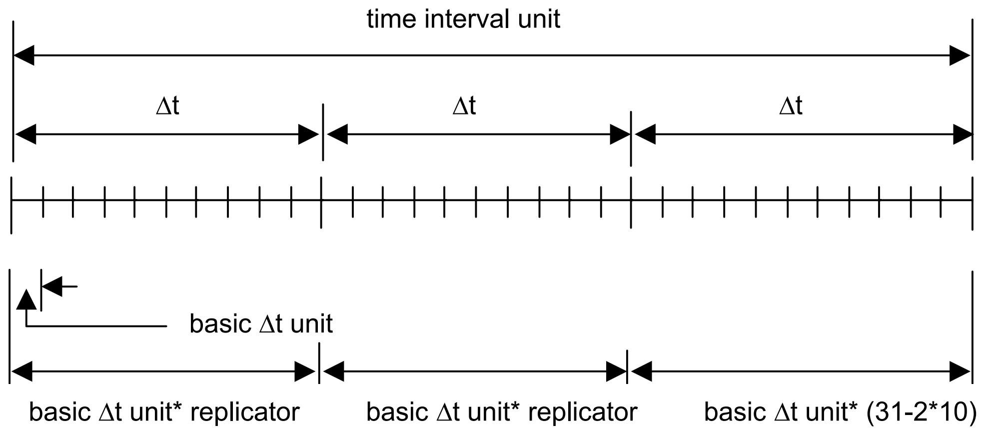



*Figure 3.3: Explanation of basic time interval*

**(b) Time interval code and time label(s) for a cyclic series:**

A cyclic time series is the one in which the set of unequal time intervals repeats. Consider an example of a time series in which observations are regularly taken at 0800 hrs. and 1730 hrs. every day. This is the case when the time interval between successive observations is 9 hours and 15 hours and this set of two time intervals repeats regularly. In this case, the time interval unit and divider are (day, 2) or (3, 2). But this repetition of unequal time intervals in a perfectly regular manner can not be defined by the basic time interval. This type of cyclic series is represented by assigning a code of ***"C"*** for basic time interval unit and replicator.

For example, the data series comprising observations made at 0830 and 1730 hrs. can be identified by:

Time interval code = (3, 2, C, C)

"C, C" is used here to indicate that the series is of cyclic nature.

Apart from time interval code, time labels are required for defining the time intervals between the consecutive data points. Time labels for the cyclic data series gives the exact timings at which the observations have been made in the time interval unit. It is to note here that the number of time labels is equal to that of the divider. However, for practical purpose this is limited to defining up to six time labels for a series. The time labels for the above example of two observations daily (at 0830 and 1730 hrs.) will be:

Time label 1 = 08:30:00 hrs.

Time label 2 = 17:30:00 hrs.

Similarly, the time interval code and time labels for the data series of thrice daily observations made at 0800, 1300 and 1800 hrs. will be.

Time interval code = (day, 3,C,C) = (3, 3,C,C)

Time label 1 = 08:00:00 hrs.

Time label 2 = 13:00:00 hrs.

Time label 3 = 18:00:00 hrs.

**(c) Time interval code for non-equidistant time series:**

Since the time intervals between various data points of a non-equidistant time series is not uniform there is no possibility of assigning any time interval code for the same. However, the fact that the time series is non-equidistant can be stated by assigning a value 0 to time interval unit, divider, basic time interval unit and replicator. Thus, for a non-equidistant time series the time interval code becomes ***(0,0,0,0)***.

It is obvious for the non-equidistant series to have time labels for each and every data point. These time labels are given in standard calendar and time units.

Thus, it can be stated that the complete time interval code for an equidistant, a cyclic or a non-equidistant time series can be specified using six character spaces. These six characters are: one for time interval unit, two for divider, one for basic time interval unit and two for replicator. And the required time labels can be specified by using calendar and time units.

***Example***

Consider the following time series: the station is Paleru Bridge site on river Krishna having "Paleru" as the station code, the parameter observed is water level w.r.t to mean sea level having "HHS" as the parameter code and the time interval is twice daily (at 0830 and 1730 hrs.) having "3,2,C,C" as the time interval code. The series code and time labels for such a time series will be:

Series code = "Paleru" + "HHS" + "3,2,C,C"

Time label 1 = 08:30:00 hrs.

Time label 2 = 17:30:00 hrs.

The data series identification and its characteristics can be entered by choosing the option of ***"Static/semi-static Characteristics"*** from the main switchboard and then choosing the menu item ***"Series Characteristics"***. On clicking the option of "Series Characteristics" the form for entry of series identification and characteristic is opened which is given as shown in Fig. 4.4.

The series codes of the available data series is displayed at the left side of the form in the form of a list box. Detailed series identification fields and associated characteristics of any series can be viewed by using the navigating buttons. For creating or deleting a new data series, "add button" or "delete" button is clicked after the form has been brought in the edit mode. It is important to note that for deleting a series, it must be first selected in the list box and then deleted. For creating a new series, the series identification code in the form of ***"station name"***, ***"data type"***, ***"time interval code"*** and ***"time labels"*** are specified in the corresponding fields. The list of stations, data type and options for time interval codes are available to the users for selection. The time labels have to be entered as per the requirement. A brief description of all other characteristics associated with the data series is given here.

### *Data Limits*

Every series is attributed with a few data limits, which are important in applying ***data entry checks*** and subsequently while ***screening the data*** for doubtful values. Since, most of the hydrological and meteorological variables are result of some physical process they are expected to occur or vary within certain limits. Though, these limits can not always be quantified accurately, however, a good estimate of these limits serves the purpose of scrutinising the data for their validity. Six such limits which can be assigned for any time series are (a) ***Minimum value,*** (b) ***Lower warning level,*** (c) ***Upper warning level,*** (d) ***Maximum value,*** (e) ***Maximum rate of rise and*** (f) ***Maximum rate of fall***.

***Minimum and maximum values*** are the lower and upper limits beyond which a parameter can either not exist at all or can exist rarely. For example, the values in a rainfall series can never be less than zero and so zero can be assigned as the minimum limit. Similarly, the water level in the river can seldom be above the upper margins of the flood plain and thus can be taken as the physical maximum limit. It is sometimes difficult to put a limit for a certain parameter but based on the experience from the past records and/or physical laws some justified value can always be assigned.

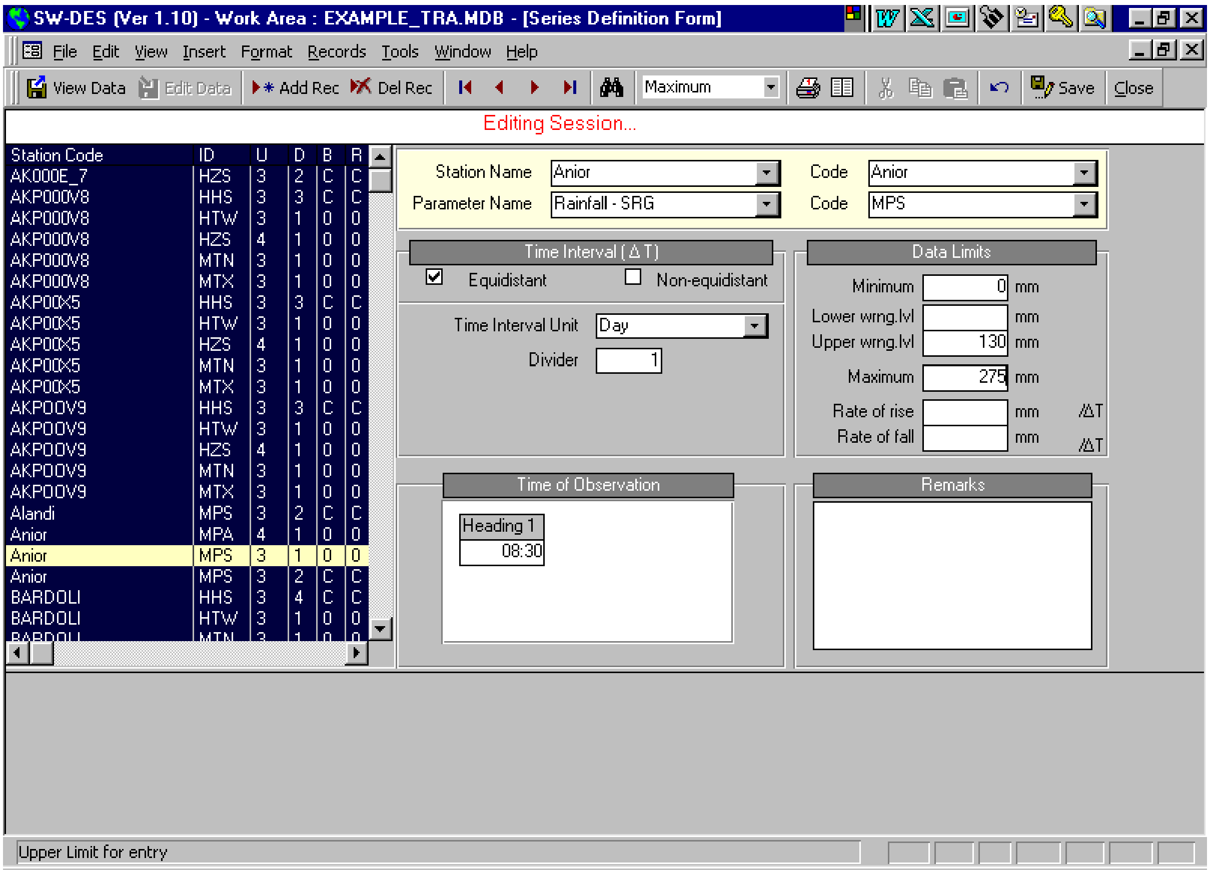



*Figure 3.4: Form for maintaining data series and entering associated characteristics*

***Lower and upper warning levels*** are two additional limits used as lower and upper bounds for scrutinising the data. These limits are based on certain statistical estimates of the past records. For example, it is advantageous to know if any value is lower than or higher than 10 or 90 percentiles of a data series. This allows for a stricter scrutiny of data as compared to the minimum and maximum limits which can either not be violated at all or are violated only rarely. For example, if for a certain stream gauging station it is known from the experience and/or records that the water level does not become lower than a particular value more than 10 percent of times then such value can be utilised as lower warning level. Similarly, a value on the upper side will serve for the upper warning level. The usefulness of such limits depends on the characteristics of the parameter and so it is only appropriate to use these limits wherever meaningful.

The temporal variation of some hydrological and meteorological processes are governed by the physical characteristics of the system. Thus, the ***maximum rate of rise or fall*** of such parameters can be estimated either on the basis of the physical laws governing the process or can be worked out on the basis of experience and past records. These values of maximum rate of change can then be utilised to check the correctness of data being entered or for scrutinising a data series subsequently.

***Remarks***

Remarks attached to any series helps in providing ***additional information*** about the series. These remarks can be explanatory notes on the history of the series, its starting and end dates or any other reference information that will be useful for the user in interpreting it.

## 3.4 ENTRY OF R L OF GAUGE ZERO

At the stream gauging stations, water level is always measured with respect to the ***zero of the gauge***. The zero of the gauge is established as per the requirement and flow conditions prevailing at individual stations. Thus, zero of the gauges for different stations are obviously at unequal elevation with respect to a common datum. For making any comparison of water level at two or more gauging stations it is necessary to bring all the water level observations at all the gauging stations to a ***common datum***. Also, with the passage of time, gauges may be displaced or destroyed or they may be changed in elevation as the result of erosion of beds. In order that the records of stage may assuredly refer to the same datum throughout the period of record, the datum of each gauge must be referred to and occasionally checked with at least one and preferably two or more bench marks that are entirely detached from the gauge, its support or shelter, and that are not liable to destruction or change in elevation.

The common datum is taken to be the ***mean sea level (m.s.l)*** and hence the reduced level (R.L.) of the zero of the gauges with respect to m.s.l for every station is a very important characteristic. Sometimes, due to floods or otherwise the gauges are required to be re-installed or adjusted. As such this characteristic is semi-static in nature and every value of R L of gauge zero has a ***period of validity***. To be able to compare the water level readings for different periods and for different stations it is very essential to properly store these values of R L of gauge zero alongwith their respective validity periods.

The entries for R.L. of gauge zero can be entered by choosing the option of ***"Static/semi-static Characteristics"*** from the main switchboard and then choosing the menu item ***"R.L. of Gauge Zero"***. On clicking this option, the form for entry of R.L. of gauge zero is opened which is given as shown in Figure 3.5.

The available list of R.L. of gauge zero records is displayed at the left side of the form in the form of a list box. The data and other details for any R.L. record for any station can be viewed by using the navigating buttons. For creating or deleting a new record, "Add Record" or "Delete Record" button is clicked after the form has been brought in the edit mode. It is important to note that for deleting a R.L. of gauge zero record, it must be first selected in the list box and then deleted. A brief description of all the attributes associated with the R.L. of gauge zero record is given here.

### *R L of zero of gauge*

This is the reduced level (R.L.) of the zero of the gauge with respect to the mean sea level (m.s.l). The water level readings are always taken with respect to the zero of the gauge and so for obtaining the water levels with respect to the common datum, i.e. m.s.l, this R.L. of gauge zero has to be added to each water level reading.

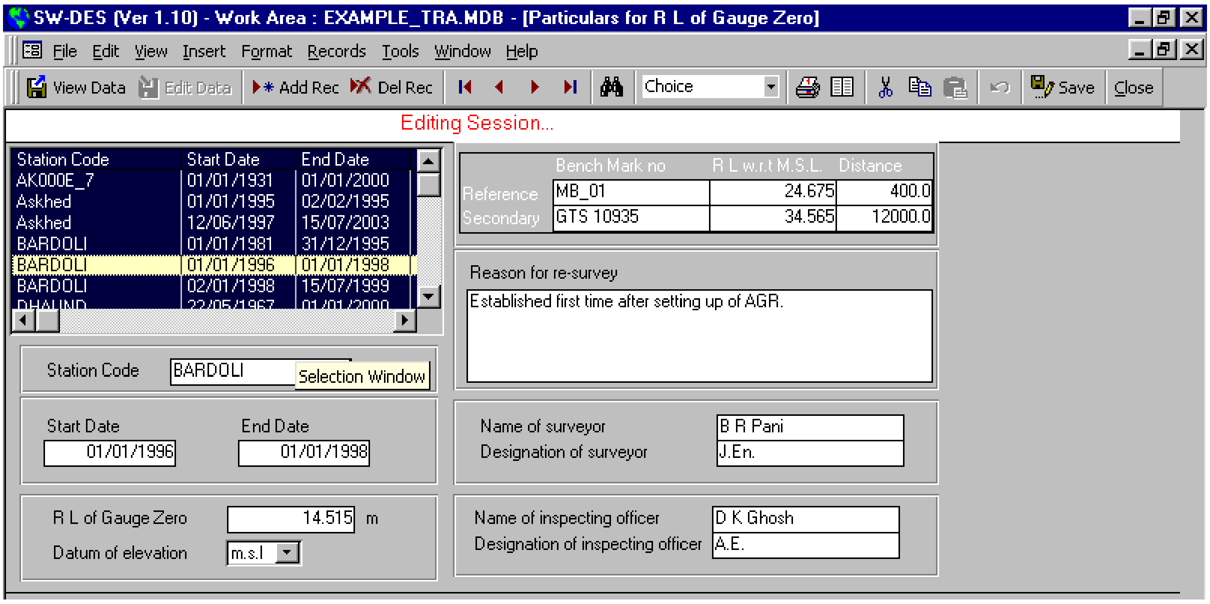



*Figure 3.5: Form for maintaining record of R.L. of gauge zero*

### *Validity period*

As stated earlier, the zero of the gauge has to be adjusted or re-installed, though not very frequently, due to variety of reasons. Such adjustments render the R.L. of gauge zero to be non-unique. In these circumstances it is very essential to attach a validity period to every setting of the zero of the gauge. This information provides the complete reference about the changes in the R.L. of gauge zero for any moment in the past.

### *Datum of elevation*

Water level readings are taken with respect to the local zero of the gauge. For the purpose of making use of these observations pertaining to different periods or comparing the records of two or more stations, it is essential to transform all the observations with respect to a common datum which does not change in time. Such a datum can be any arbitrarily defined datum and the mean sea level is taken as accepted for this purpose in the country.

### *Information regarding reference bench marks*

It is very necessary to have at least one bench mark very near to the station location (also called Musto Bench Mark) for making reference for the purpose of checking or adjusting the zero of the gauge at regular basis. R.L. of such reference bench mark and its distance from the zero of the gauge is recorded for the sake of information. Similarly the R.L. and distance of a secondary bench mark, from where the Musto bench mark has been carried, is also recorded.

***Information regarding adjustment of gauge zero***

Since any changes in the setting of the zero of the gauge will be very crucial in interpretation of the water level observations, it is appropriate to record the following: (a) reason of re-survey or adjustment, (b) name and designation of the Surveyor involved in the re-survey or adjustment of the gauge and (c) name and designation of the Inspecting officer.

## 3.5 ENTRY OF CURRENT METER RATINGS

Current meters or flow meters are one of the important equipment employed for measurement of flow velocities. The relation between the speed of rotation of the current meter to the velocity of the water which causes the rotation is defined by the meter rating. The current meter should be rated from time to time whenever it is repaired or modified in any way and in any event after a prescribed period of use.

The entries for current meter ratings are maintained with the help of two forms. One form, ***"Current Meter Information"***, is for maintaining the list of current meters and those properties which do not change with time. Other form, "***Current Meter Ratings"*** is for entering the actual current meter ratings for each current meter for various validity periods. Both these type of data can be entered by choosing the option of ***"Static/semi-static Characteristics"*** from the main switchboard and then choosing the menu item ***"Current Meter Characteristics"***. The form for entry of current meter information is as shown in Fig. 3.6.

The available list of current meter is displayed on this form. There are attributes required for describing the current meters. These are: the ***current meter number***, its ***type***, ***name of manufacturer*** and ***the date of manufacture*** of the current meter. For proper identification of the current meter it is necessary to enter the meter no. assigned by the manufacturer, the type of meter and the make or the name of manufacturer. The meter no. is the unique number allotted to every meter by the manufacturers themselves. The type of meter indicates the category to which the meter belongs to. For example, whether a meter is cup type, propeller type or pygmy type. Date of manufacture is also stored for purpose of reference. These four characteristics are static in nature and does not change with time for any current meter. The form for entry of current meter ratings is as shown in Figure 3.7.

The available current meter ratings for a number of current meters for various validity periods is displayed at the left side of the form in the form of a list box. The data and other details for any current meter rating record for any current meter can be viewed by using the navigating buttons. For creating or deleting a new record, "Add Record" or "Delete Record" button is clicked after the form has been brought in the edit mode. It is important to note that for deleting a current meter rating record, it must be first selected in the list box and then deleted. A brief description of all the attributes associated with the current meter ratings is given here.

***Validity period***

Every calibration is valid for a certain period only and the meter has to be re-calibrated at regular intervals after making its use for the prescribed period. It is very important to associate each current meter rating with the respective ***start and end dates*** of the period of validity. In the beginning, when a meter has just been calibrated the end date can be suitably put so as to indicate a tentative end date. This end date can later on be suitably changed to the actual period of validity. Consistency is maintained between the date of manufacture and various validity periods such that no validity period can start before the date of manufacture. Similarly, program checks if the end date of validity period is later than the start date.

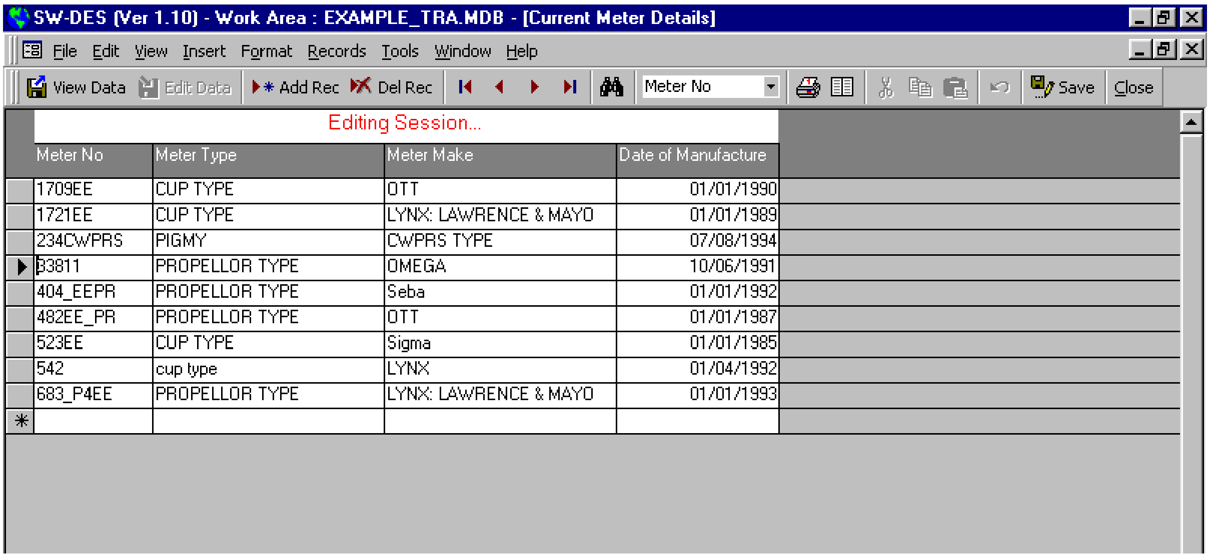



*Figure 3.6: Form for entering current meter information*

### ***Calibration done by***

It is very important to note the name of the agency which has carried out the calibration of the meter. Calibration of the meter is a very fundamental and important activity requiring special skills and equipment. Normally, all the agencies providing current meter calibration facilities must be certified to do so by appropriate authority.

### ***Velocity limits***

Every current meter calibration indicates two velocity limits between which the meter ratings are applicable and the meter is not supposed to be used beyond such boundaries. These limits are: (a) the ***threshold velocity*** and (b) the ***upper velocity*** limit. Limits are entered in units of m/sec and are used to exclude use of meter which indicate a velocity outside this range.

### ***Details of meter ratings***

The result of the meter calibration is presented in the form of one or more linear equations of the form:

$Y = A + B X.$

Here, A & B are the coefficients of the meter ratings, X is the number of revolutions the meter makes per second and Y indicates the velocity of flow of water in m/sec. Three characteristics are entered for the purpose of recording the details of any meter calibration and are: (a) ***number of rating equations***, (b) ***coefficients A & B*** for each of these equations and (c) the ***limits of applicability*** of these individual rating equations in units of revolutions/sec..

For example, if there are three equations which cover the full range of its applicability then the first limit is the point where the first equation ceases to be applicable and the second equation starts becoming applicable. Similarly, second limit is that point where the second equation ceases to be applicable and the third equation starts becoming applicable. This is illustrated in the Figure 3.8. An example output of this graph is also shown in Figure 3.9.

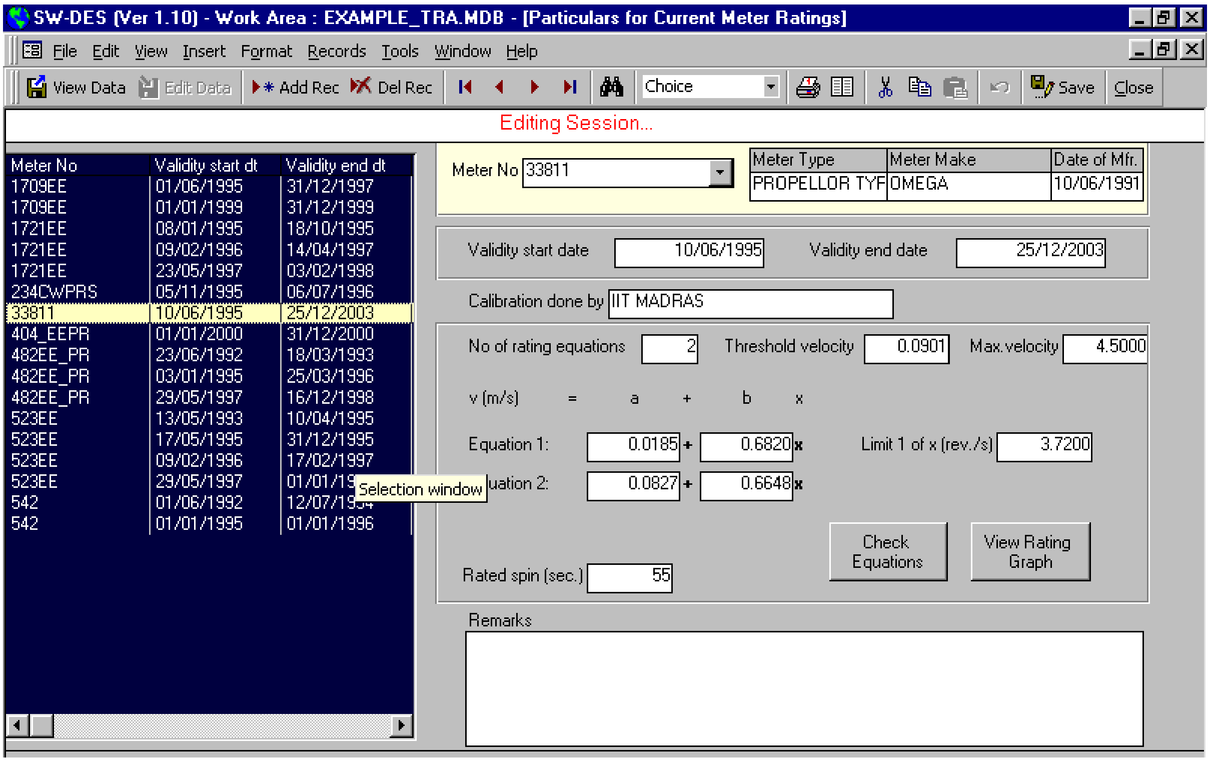



*Figure 3.7: Form for maintaining record of current meter ratings*

### *Rated spin*

It is important that a current meter, which is in constant use, be at all times in proper working condition, in other words, in as nearly as possible the same condition as it was calibrated. In order that the field engineer may be assured concerning the mechanical condition of the meter, a spin test is performed at the time of calibration. This is reported as the rated spin and is the ***number of revolutions*** which it makes after the meter is spinned by a quick movement of the hand until the meter comes to complete rest.

### *Remarks*

Any other remarks that pertains to the calibration of the meter or are vital for the use of meter ratings can be entered for every meter calibration having a specified validity period.

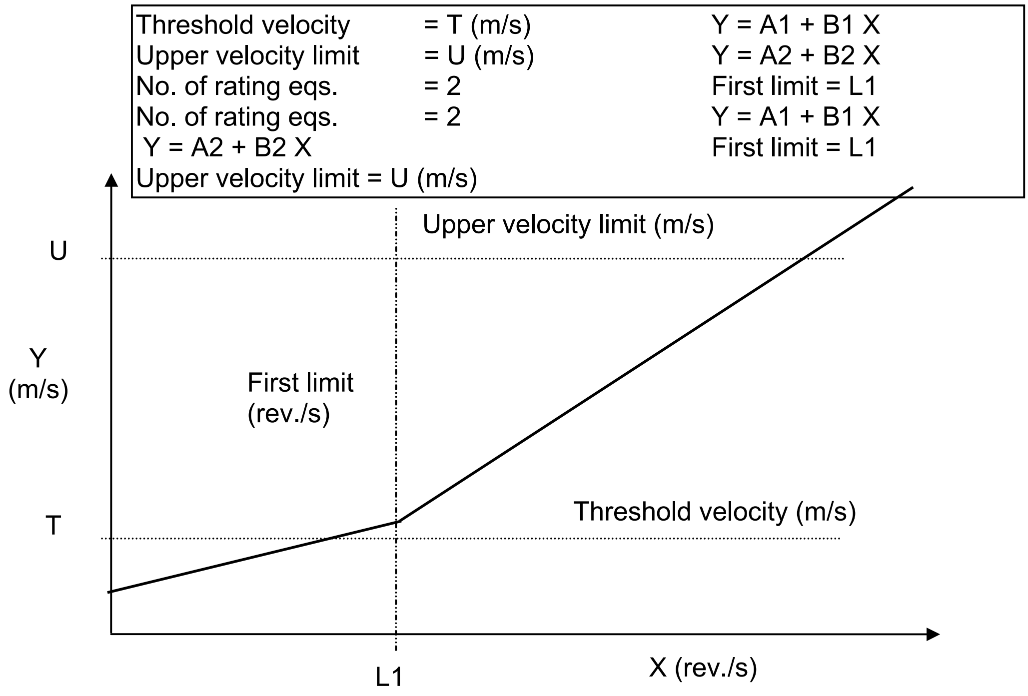



*Figure 3.8: Plot of a typical current meter rating and illustration of various limits and coefficients*

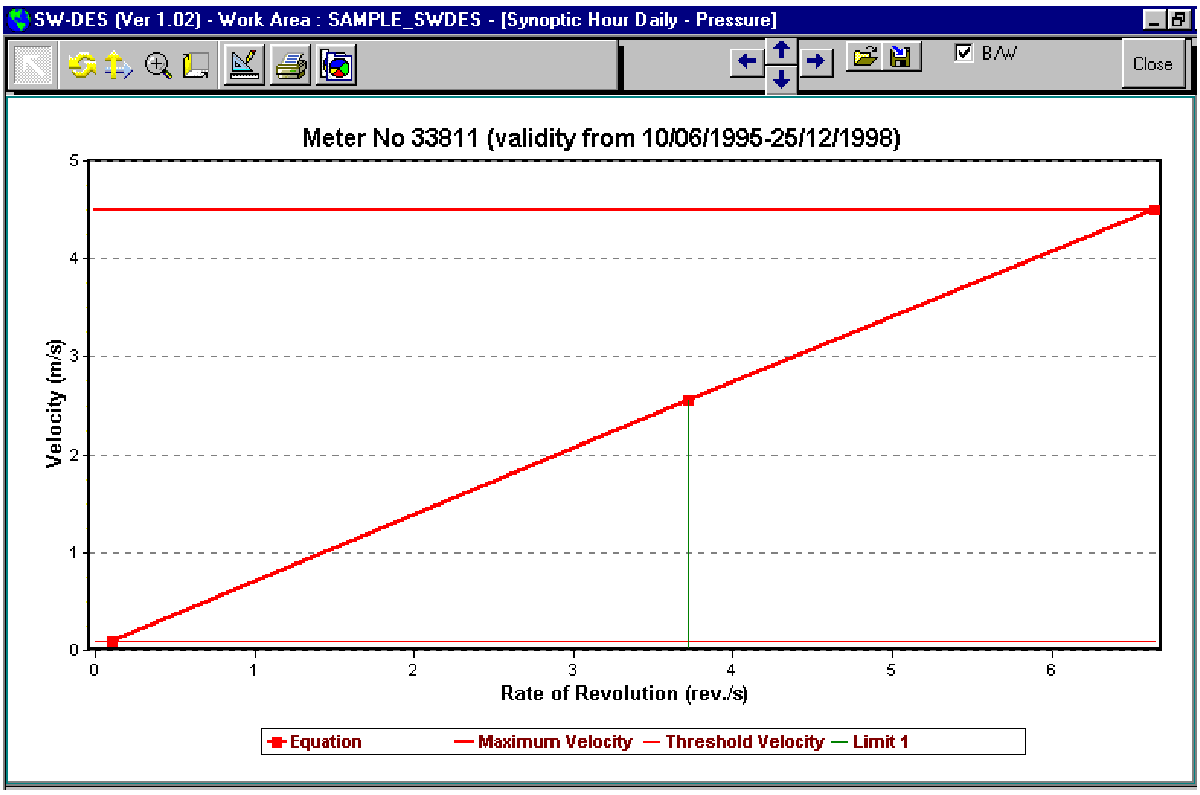



*Figure 3.9: Example plot of a current meter rating*

## 3.6 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 Figure 3.10:

Any cross-section record is identified by the station code and the date of the cross-section observation. Reference information on the gauge line can be entered as text in the field given on the form. The R.L. of gauge zero is brought from the database and is displayed for purpose of reference and plotting with the cross-section. 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 or R.D.)
- **Column 3:** is the elevation with respect to the mean sea level for U/S gauge line (UGL), if available
- **Column 4:** is the elevation with respect to the mean sea level for Central gauge line (CGL)
- **Column 5:** is the elevation with respect to the mean sea level for D/S gauge line (DGL), if available

Any number of data points in the cross-section profiles can be entered for each station. At the time of data entry all the reduced distances entered are checked if they are in increasing of the magnitude.

There are few more fields and buttons on the form to make the data set informative and easily keyed. A brief description of these fields and buttons is given here:

***Check boxes with UGL & DGL***

The UGL and DGL columns opens up only when these checked boxes are checked in. Thus for the stations for which these profiles are to entered the boxes against these names are checked in.

***Base Value***

This is an added facility for making a certain addition or subtraction from all elevation values entered in the table. It is mainly useful if the manuscript lists the elevations of various points with respect to the local datum and it is required to add the reduced level of this datum with respect to the mean sea level to all the points. The value to be added is to be entered in the field of “Base Value” and the small button given by its side is to be pressed for effecting the addition. This facility is available for all the three gauge lines individually.

***Standard Bank Side***

Standard bank side is the one from which all the references are made and operations initiated for stage-discharge measurements. Often this is the side (left or right) from which the river gauging side is often approached by the staff for all operations. This is required to be indicated for the central gauge line.

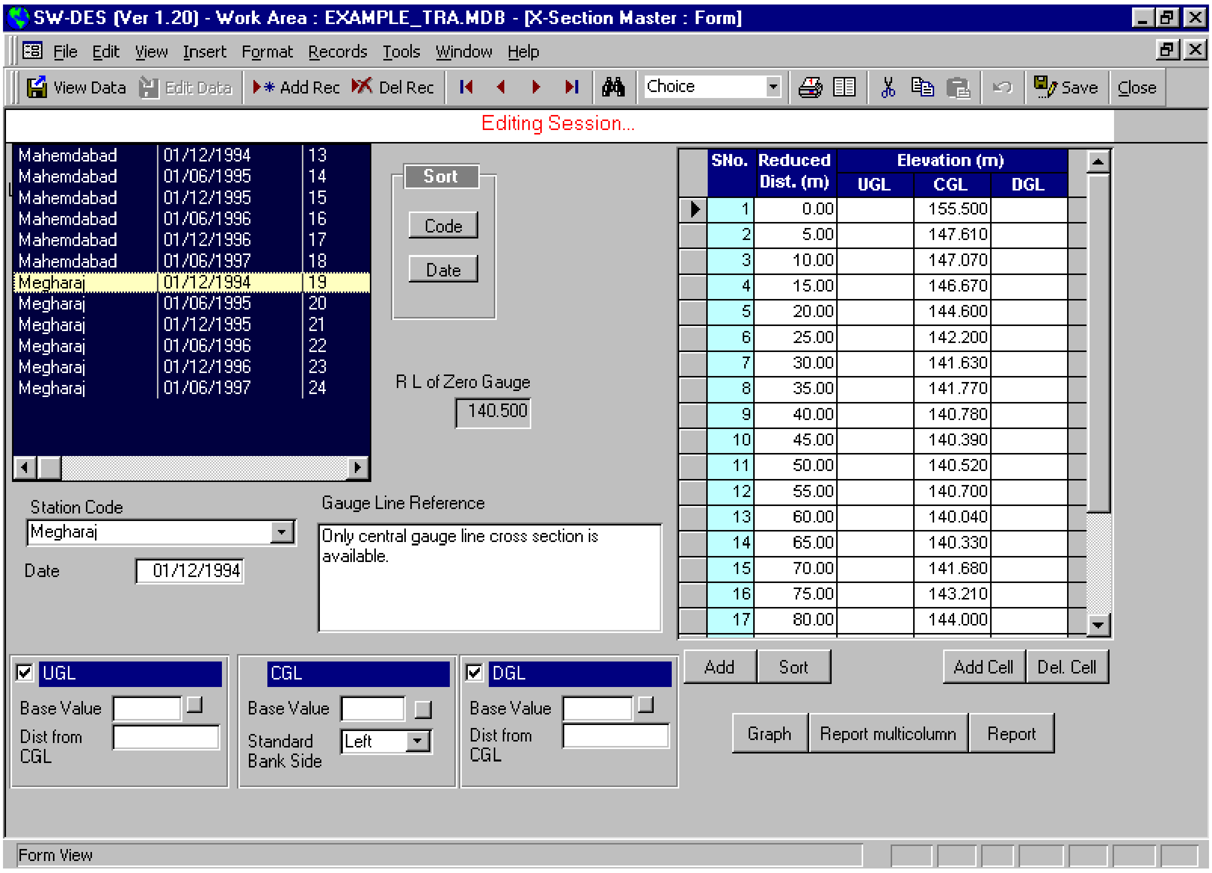



*Figure 3.10: Data entry form for cross sectional data*

***Distance from CGL***

For the upstream and downstream gauge lines it is required to indicate the distances from the central gauge line. These distances in meters can be given in the fields for "distance from CGL" available with upstream and downstream gauge lines.

***ADD***

This button is to facilitate automatic entry of reduced distances of various equidistant points of the x-section profile. Input in the form of R.D. of first and last points and the uniform distance between various points is required to make the entry of R.D.s automatically.

***Sort***

Sometimes the user misses the entry of a record completely. In that situation, a missed record can be entered in the last row of the table and then the "Sort" button may be pressed to put the entered record in the right place in the table according to the value of reduced distance of the point. This facility is also important if few "odd" R.D.s information could not be automatically entered using "Add" button.

***Add Cell & Delete Cell***

Add cell button is useful in those cases when one or more values of elevation are missed in the individual columns of the elevations. "Add Cell" button inserts a cell every time it is pressed at the location of the control (cursor). In this manner required new cells are inserted and the following cells are shifted down accordingly. The missed entries can then be made in these inserted cells. “Delete Cell” button is exactly similar to “Add Cell” in the concept with the only difference that this is required when one or more values have been repeated by mistake in the individual columns of elevation.

***Graph & Report***

Suitable options for making cross-section plots are available for obtaining cross-section profiles (see Figure 3.11). Options for making multiple cross-sections is available for making comparisons for different cross-section profiles (of different seasons or years) of the same station or different stations on a river. Buttons for plotting a line indicating R.L. of zero of the gauge and also the plot of CGL and UGL profiles together with CGL of any station is available.

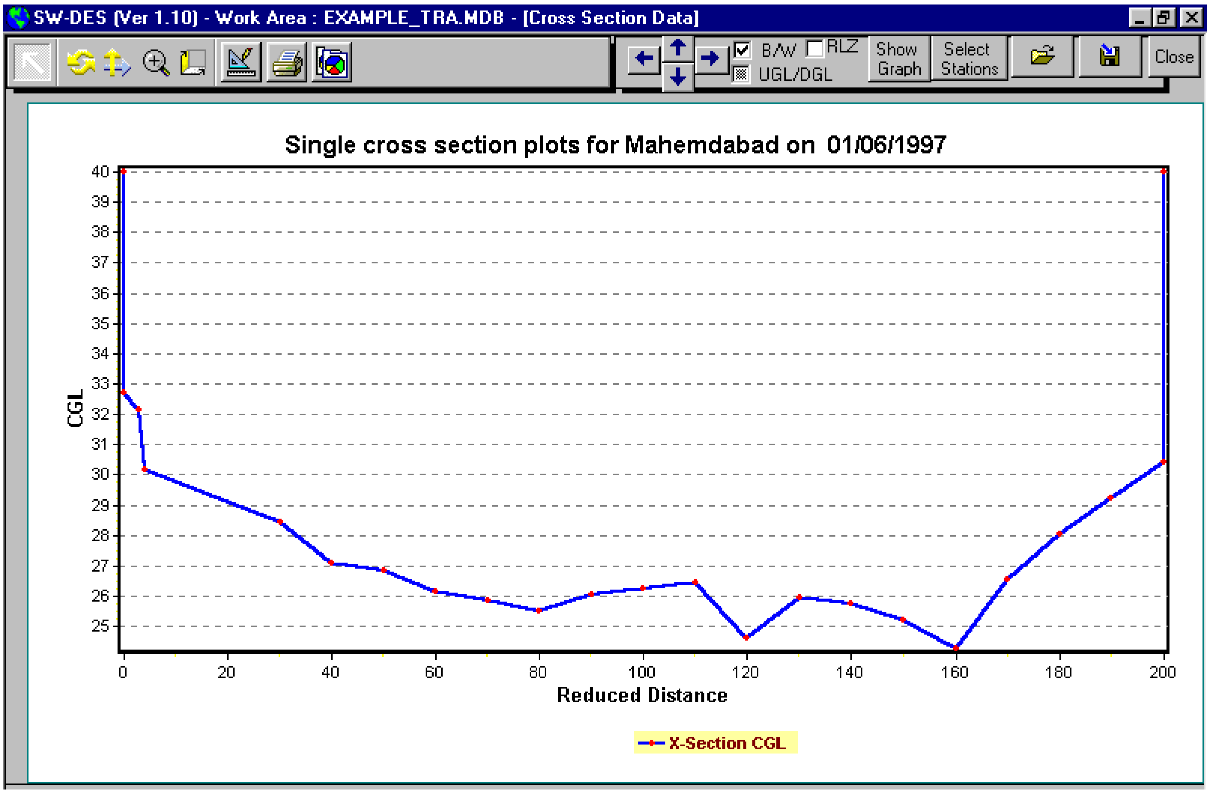



*Figure 3.11: Plot of cross sectional profile*

# 4 ENTRY OF RAINFALL DATA

## 4.1 GENERAL PRINCIPLES

There is a requirement to make all rainfall data available on computer for validation processing and reporting - the first step is therefore data entry.

Data entry will be carried out at Sub-divisional offices as near as possible to the observation station to ensure interaction between data processing and observation personnel.

Primary module of the dedicated hydrological data processing software (SWDES) is available for all types of surface water data entry including rainfall. This front-end module is specifically customised to suit the layout of data entry forms used by the field observers for recording the data and to carry out graphical and tabular data validation.

Initial emphasis is on the entry of current rainfall data, but SWDES also provides a very convenient and efficient means of entering historical data, from original data sheets where available and otherwise from published tabulations.

Prior to entry to computer two manual activities are essential:

- Registration of receipt - on the day of receipt (See volume 8, Operation Manual, Part 4, Chapter 5)
- Manual inspection of rainfall data sheets and charts

On completion of data entry and primary validation in the Primary module, data will be exported (transferred) to the Secondary module of dedicated hydrological data processing software at the Divisional office for further validation and processing.

## 4.2 SWDES AND RAINFALL DATA ENTRY

SWDES has been developed as specialist data entry software based on Microsoft Access to customise data entry for the individual needs of states and agencies, mimicking the forms and data sheets that are used by agencies for particular variables.

SWDES is primarily designed for the entry of time series data but it also incorporates space-oriented data sufficient to locate and catalogue the stations under the control of a particular state or agency. Stations and series can then be accessed from typical Windows Menus and Toolbars by clicking on appropriate buttons. This feature, of course, is common to all variables.

For all equidistant and cyclic time series data, SWDES provides entry screens automatically with date and time labels against which the variable values are entered. This simplifies data entry and avoids the potential errors of date/time entry.

SWDES provides data entry checking capability, rejecting clearly spurious values and flagging suspect ones for inspection. For example it will reject entry of an alpha character in a numeric field or duplicate decimal point and will highlight for inspection values above a pre-set limit. In addition options for plotting time series graphs, at time of entry are available in most cases.

SWDES provides a suitable format for each of the following rainfall instruments and frequencies:

- Standard non-recording raingauge - read daily (at selected standard time)
- Standard non-recording raingauge - read twice daily (at selected standard times)
- Autographic recording (siphon) raingauge – values tabulated at hourly intervals from chart
- Digital recording (tipping bucket) raingauge - digitally logged values at fixed intervals
- Digital recording (tipping bucket) raingauge - digitally logged values of each tip.

Data from standard non-recording raingauges and autographic gauges will be entered from keyboard; digital data will be by file transfer.

## 4.3 MANUAL INSPECTION OF FIELD RECORDS

Prior to data entry to computer an initial inspection of field records is required. This is done in conjunction with notes received from the observation station on equipment problems and faults, missing records or exceptional rainfall. Rainfall sheets and charts will be inspected for the following:

- Is the station name and code and month and year recorded?
- Do the number of record days correspond with the number of days in the month?

- Are there some missing values or periods for which rainfall has been accumulated during absence of the observer?
- Have monthly totals of rainfall and rain days been entered?
- Have the autographic rainfall hourly totals been extracted?
- Is the record written clearly and with no ambiguity in digits or decimal points?

Any queries arising from such inspection will be communicated to the observer to confirm ambiguous data before data entry. Any unresolved problems will be noted and the information sent forward with the digital data to Divisional office to assist in secondary validation. Any equipment failure or observer problem will be communicated to the supervising field officer for rectification.

## 4.4 ENTRY OF DAILY RAINFALL DATA

Using SWDES the station and daily series is selected and the screen for entry (or editing) of daily rainfall is displayed as given in Figure 4.1. Simultaneously, the station and series codes and corresponding Sub-division and local river/basin are also displayed. A window showing year and month, from which the month of entry may be selected. Also displayed are windows showing the upper warning limit which is used to flag suspect values; these values can be altered, for example depending on season. Negative values are rejected as well as values over a maximum limit

There are four columns for the date, daily data, and cumulative amount within the month and remarks respectively. The dates are filled automatically according to the month and year. The data corresponding to each day is to be entered by the user. The cursor goes in vertically downward direction by default after each data entry. When data are missing, the corresponding cell is left blank (not zero) and a remark entered against that day. Where the observer has missed readings over a period of days and an accumulated total is subsequently measured (e.g. rainfall, pan evaporation or wind run) the cells corresponding to the missed days will be left blank (not zero) and a remark will be inserted against the date of the accumulation to specify the period over which the accumulation has occurred (e.g. Accumulated from 23 to 27 Sept.).

**Note:** There are occasions when the climate observer is legitimately absent from his station, for example on account of sickness. The observer must be encouraged to leave such spaces “Missing” or “Accumulated” rather than guess the missing values. The completion procedures, based on adjoining information, are better able to estimate such missing values.

As the entries are made the cumulative amount within the month is computed and filled automatically. If any remarks are to be entered the same can be done by going to the specific date by using mouse/tab/cursor. At the bottom of the form, for each month, the number of rainy days, total and maximum rainfall for the month as available in the manuscript has to be entered. A rainy day is defined as that day on which the rainfall is more than 0.0 mm. The computed values of these quantities as per the entries by the user is automatically filled.

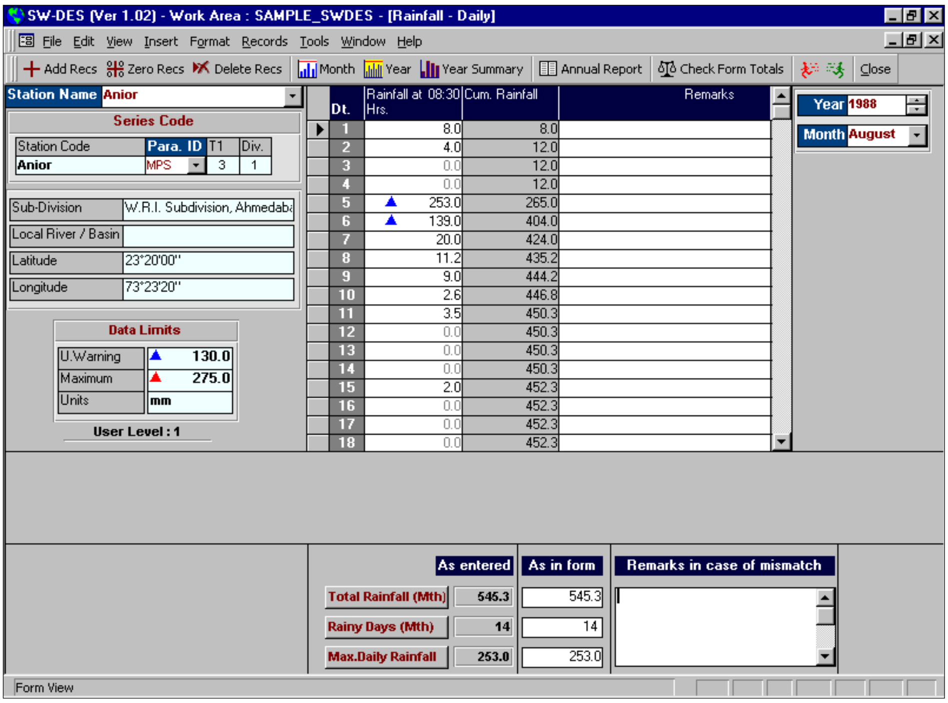



*Figure 4.1: Entry screen format for entering daily rainfall data*

During the process of making entries the user can draw the graph for the data being entered. There are three options in which the data being entered could to plotted: (a) to plot the daily data of the month (see Figure 4.2) and (b) to plot the daily data of the entire year (see Figure 4.3) and (c) to plot the monthly totals (summary, see Figure 4.4) for the whole year.

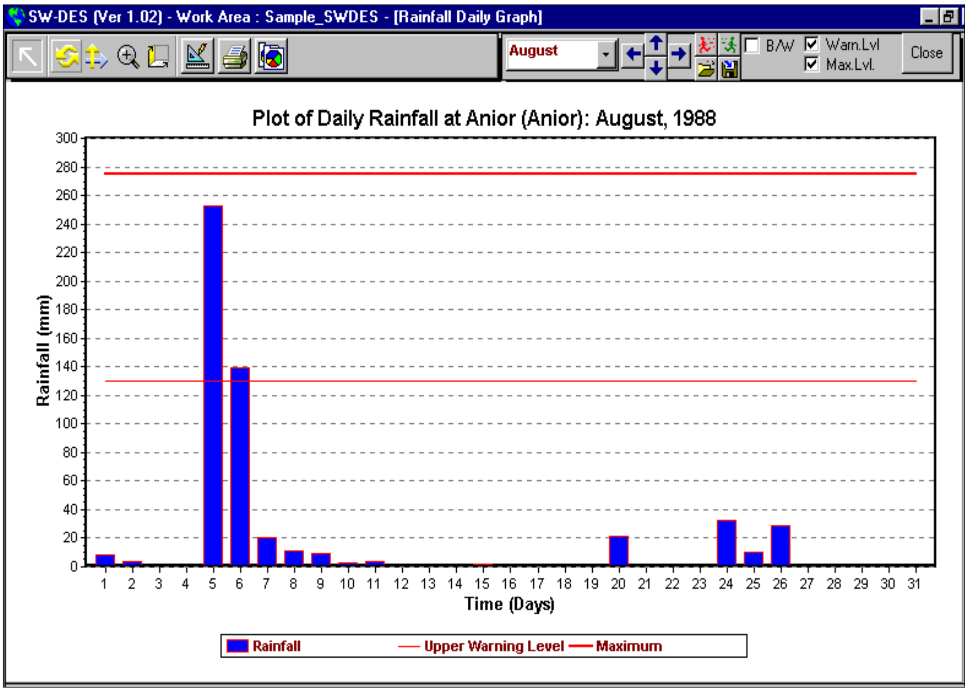



*Figure 4.2: Plot of daily rainfall for a month*

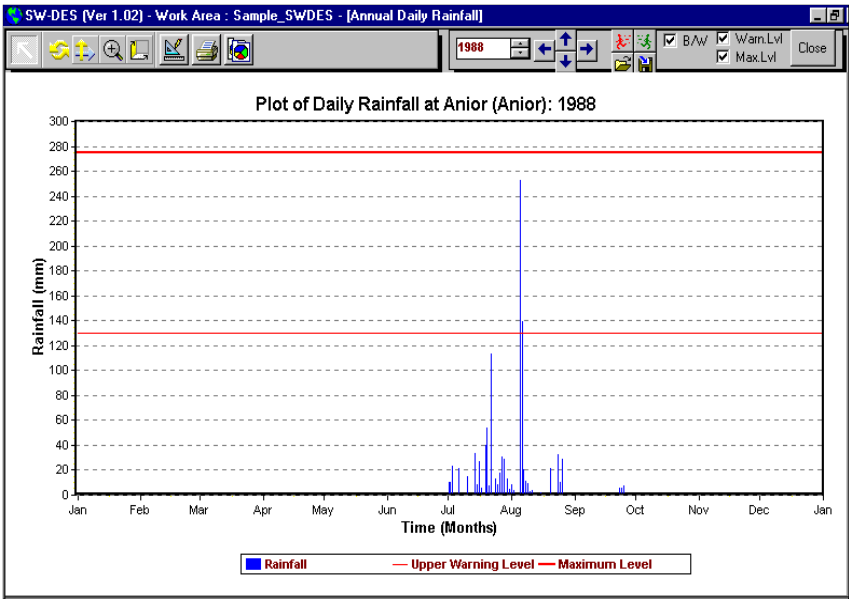



*Figure 4.3:*
*Plot of daily rainfall for a year*

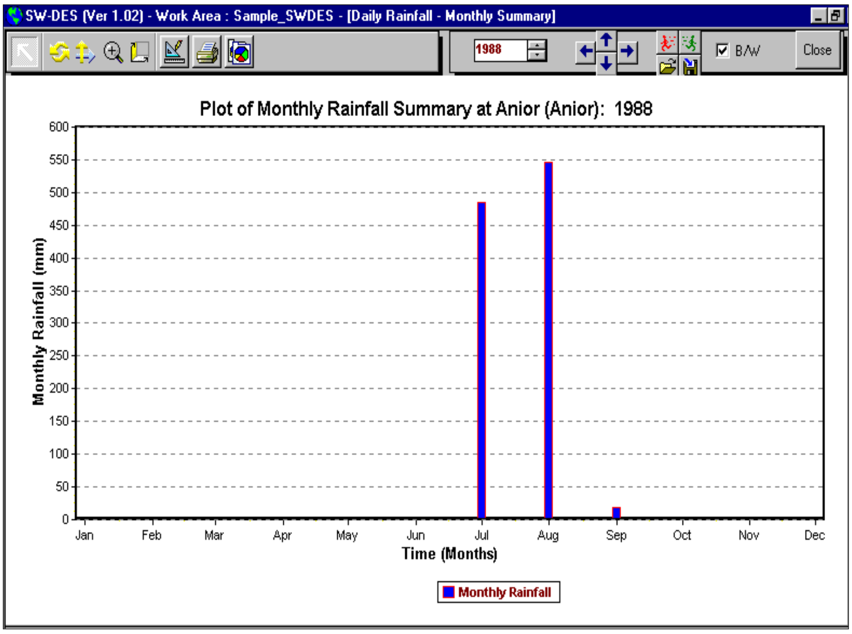



*Figure 4.4:*
*Plot of monthly rainfall summary (monthly total) for a year*

Two types of data entry checks are performed for this case of daily rainfall data.

(a) The entered daily data can be compared against upper warning level and maximum value. This allows the user to quickly know which data value has violated the prescribed limits. Upon such prompting the user can once again refer back to the manuscript to see if there was some mistake in entering the data. If such values which violated the maximum data limits are found to be actually reported in the manuscript then the user can put suitable remarks to indicate so.

(b) Checks are carried out to see if there is a proper match between the entered and computed values of number of rainy days in the month, maximum and total rainfall in the month. In case of any mismatch the user is prompted by colour highlighting of the mismatch, so that he can check back the entries. If cumulated values of daily series are also available in the manuscript then it becomes faster to pin down the mistake.

Scrutinising and checking the daily rainfall data month by month in this manner will leave little scope of any data being wrongly entered.

## 4.5 ENTRY OF RAINFALL DATA AT TWICE DAILY INTERVAL

The layout of the form for entering twice daily rainfall observed at standard times (at morning and evening synoptic hours) is as given in Figure 4.5.

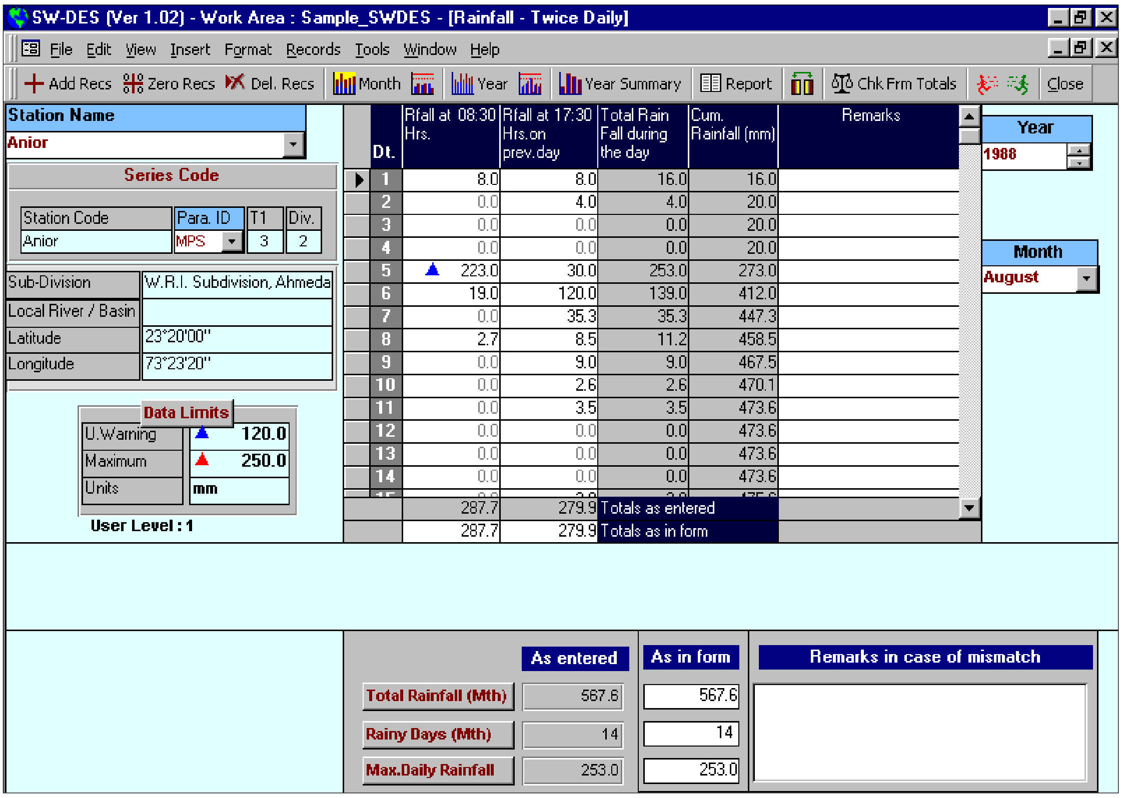



*Figure 4.5: Entry screen format for entering twice daily rainfall values*

As for the daily rainfall form this form also displays the information regarding station code, station name, sub-division and local river/basin. Two data limits: (a) Upper warning level and (b) Maximum value are also displayed on the screen. The year and month of the data displayed on the screen at any point of time are also displayed for reference purpose and to set to any desired month and year.

There are six columns in all: one for the date, two for each observation of the day and one each for total daily rainfall, cumulative amount within the month and remarks respectively. The dates are filled automatically according to the month and year. Data corresponding to each observation in the day is to be entered by the user. After entering any data the cursor, by default, goes horizontally to next record of the day and then goes to the first observation of the next day. As the entries are made the daily total and the cumulative amount within the month are computed and filled automatically. Remarks may be entered against any day.

At the bottom of the two data columns the respective column totals are to be entered as available in the manuscript. The corresponding computed values derived from the entries made by the user are computed and filled automatically. Apart from this, for each month, the number of rainy days, total and maximum rainfall for the month as available in the manuscript have to be entered. The computed values of these quantities derived from the entries by the user are automatically filled.

The graphical facility for this case is similar to that provided for the daily rainfall data with rainfall for both the observations in the day shown differently (see Figure 4.6).

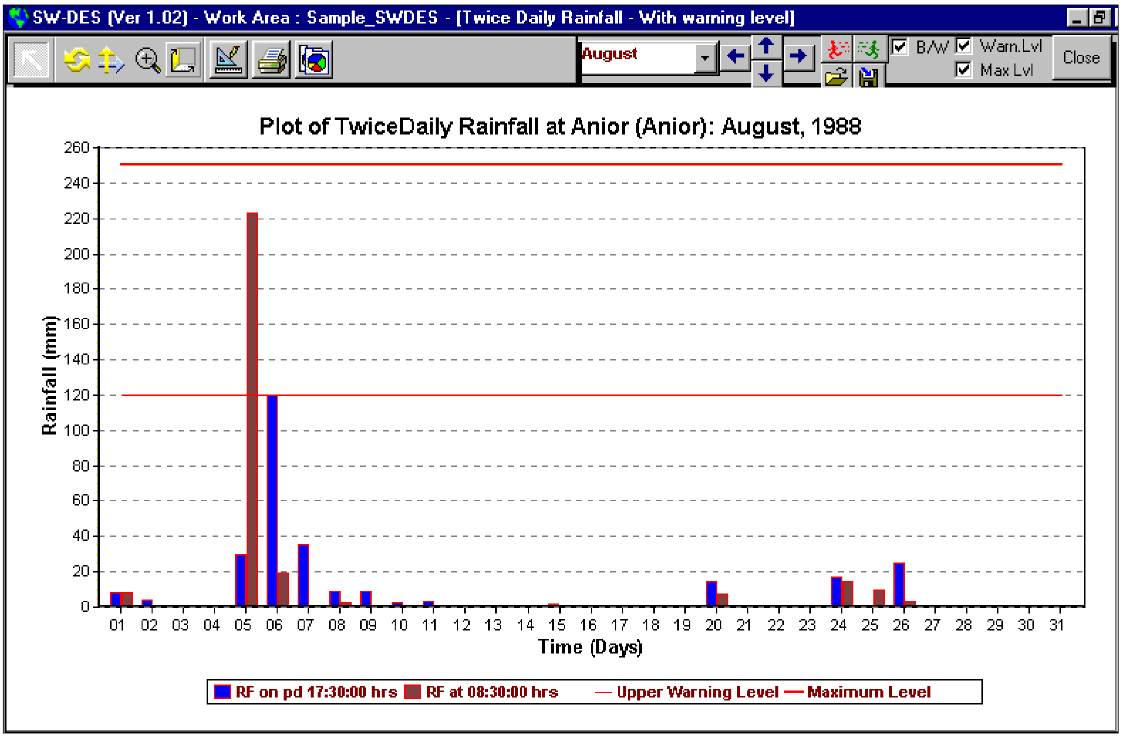



*Figure 4.6: Plot of twice daily rainfall for a month*

Two types of data entry checks are performed for this case of twice daily rainfall data.

(a) The entered daily data can be compared against upper warning level and/or maximum value.

(b) The second type of check is carried out to see if there is a proper match between the entered and computed values of totals for each column, number of rainy days in the month, maximum and total rainfall in the month. In case of any mismatch the user is prompted by coloured highlighting of the mismatch so as to check back the entries. If cumulated values of daily series are also available in the manuscript then it becomes faster to pin down the mistake.

Making checks on columnar totals, number of rainy days, monthly maximum and totals, provides adequate data entry checks and enables faster tracking down of errors. Any mismatch remaining after thorough checking with the manuscript must be due to incorrect field computations by the observer and must be communicated to him through the field supervisor.

## 4.6 ENTRY OF HOURLY DATA

Hourly rainfall data are obtained either from the chart records of the autographic type recording raingauge or by the digital data obtained from a tipping bucket raingauge (TBR). The data originating from data loggers, in digital form, can directly be imported into the database using the import option. A special form for entering hourly rainfall data abstracted from autographic charts is available. However, the option of entering the digital data using this form can also be made use of, if required. Moreover, after digital data have been imported they can be inspected graphically and validated for certain limit checks using this form.

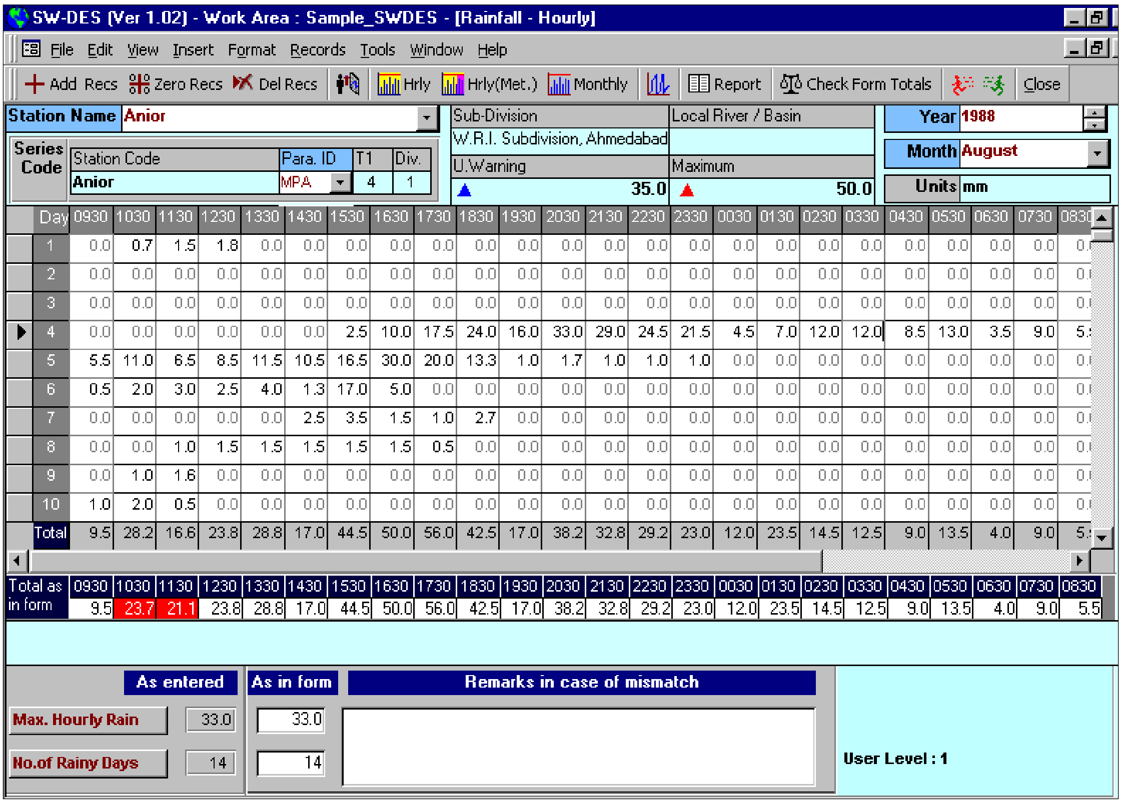
As for the daily rainfall form this form also displays the information regarding station code, station name, sub-division and local river/basin. Two data limits: (a) Upper warning level and (b) Maximum value are also displayed on the screen. The year and month of the data displayed on the screen at any point of time are also displayed for reference purpose.

The layout of the hourly rainfall form is as given in Figure 4.7

Hourly rainfall data are entered in the form of a matrix in which the columns are the hourly rainfall values for a day and the rows represents different days of the month. Time-label entries for the dates and hours are filled automatically. The rainfall value is entered to the time following the hour in which the rainfall occurred, e.g., rainfall falling and recorded from 1130 to 1230 is recorded against 1230. All the hourly values are entered by the user by navigating horizontally across the days. At the end of each day's entry the cursor moves to the column for entering the daily total as available in the manuscript. At the end of the last entry for the last day of the month, the cursor moves to the cells for entering the columnar totals for each hourly observation for the month as available in the manuscript. Finally, the monthly total as available in the manuscript has to be entered. The computed totals for each day, each hour across the month and for the month are filled automatically in the respective cells. Similarly, the maximum hourly rainfall recorded in the month and number of rainy days in the month are entered as available in the manuscript. The corresponding totals are computed and filled automatically by the system. Remarks, if available in the manuscript, can be entered on the daily basis.

There are three options for the graphical display of data: (a) to plot the data of any day from 0100 to 2400 hrs. in the form of hourly bar chart form (only for cases when the tabulation is not for standard hours (i.e. 0830 hrs to 0830 hrs next day), (b) to plot the data from 0830 hrs on any day to 0830 hrs of the next day in hourly bar chart form (see Figure 4.8) and (c) to plot the tabulated rainfall data back in the form of a continuous trace so as to replicate that obtained by the autographic chart recorder (see Figure 4.9). The least count of the simulated trace, of course, remain 1 hour which is the interval of rainfall tabulation).

The latter option is very useful in comparing the entered data with the analogue chart records. The user can navigate through different days in the month to see the corresponding plots without leaving the graph.




| Day | 0930 | 1030 | 1130 | 1230 | 1330 | 1430 | 1530 | 1630 | 1730 | 1830 | 1930 | 2030 | 2130 | 2230 | 2330 | 0030 | 0130 | 0230 | 0330 | 0430 | 0530 | 0630 | 0730 | 0830 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.7 | 1.5 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 10.0 | 17.5 | 24.0 | 16.0 | 33.0 | 29.0 | 24.5 | 21.5 | 4.5 | 7.0 | 12.0 | 12.0 | 8.5 | 13.0 | 3.5 | 9.0 | 5. |
| 5 | 5.5 | 11.0 | 6.5 | 8.5 | 11.5 | 10.5 | 16.5 | 30.0 | 20.0 | 13.3 | 1.0 | 1.7 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 6 | 0.5 | 2.0 | 3.0 | 2.5 | 4.0 | 1.3 | 17.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 3.5 | 1.5 | 1.0 | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 8 | 0.0 | 0.0 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 9 | 0.0 | 1.0 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| 10 | 1.0 | 2.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0. |
| Total | 9.5 | 28.2 | 16.6 | 23.8 | 28.8 | 17.0 | 44.5 | 50.0 | 56.0 | 42.5 | 17.0 | 38.2 | 32.8 | 29.2 | 23.0 | 12.0 | 23.5 | 14.5 | 12.5 | 9.0 | 13.5 | 4.0 | 9.0 | 5. |

| Total as in form | 0930 | 1030 | 1130 | 1230 | 1330 | 1430 | 1530 | 1630 | 1730 | 1830 | 1930 | 2030 | 2130 | 2230 | 2330 | 0030 | 0130 | 0230 | 0330 | 0430 | 0530 | 0630 | 0730 | 0830 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9.5 | 23.7 | 21.1 | 23.8 | 28.8 | 17.0 | 44.5 | 50.0 | 56.0 | 42.5 | 17.0 | 38.2 | 32.8 | 29.2 | 23.0 | 12.0 | 23.5 | 14.5 | 12.5 | 9.0 | 13.5 | 4.0 | 9.0 | 5.5 |

*Figure 4.7: Entry screen format for entering hourly rainfall data*

Four types of data entry checks are performed for hourly rainfall data.

a) The entered daily data can be compared against upper warning level and/or maximum values.
b) The entered and computed values for daily total for each day are compared.
c) A check is made to see if the entered and computed values of total for each hour across the month are in agreement.
d) The monthly total rainfall, the number of rainy days in the month and the maximum hourly rainfall in the month are compared between the observer calculated values and the computed values. In case of any mismatch the user is prompted by colour highlighting so as to check back the entries.

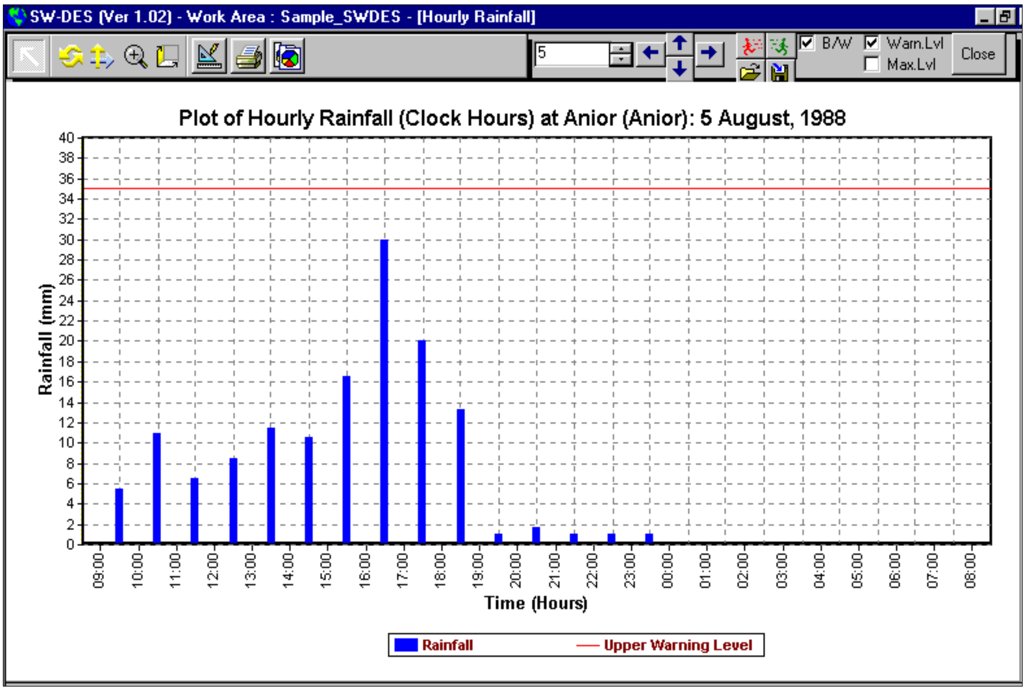



*Figure 4.8: Plot of hourly rainfall for a day*

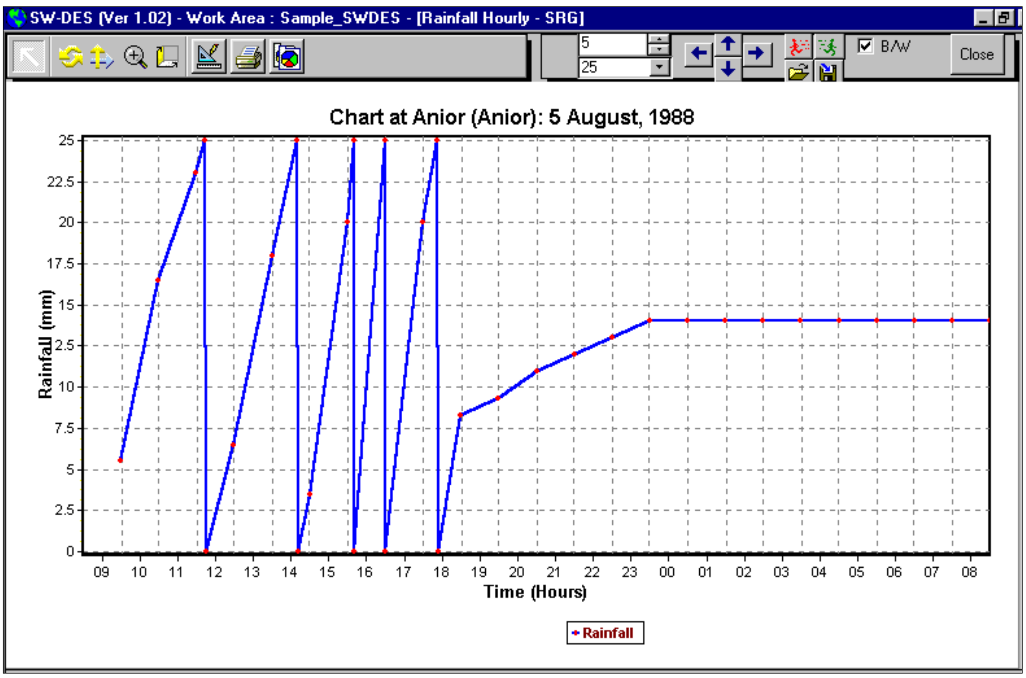



*Figure 4.9: Plot of hourly rainfall simulated as observed by the analogous chart recorder*

### 4.7 IMPORT/ENTRY OF DIGITAL DATA

A digital rainfall record is obtained from raingauge having a mechanism to record rainfall electronically into the data logger. Tipping bucket raingauges which register the occurrence of each tip of a bucket of known rainfall depth by means of a reed switch, provide such a facility.

There are two options by which such data can be stored.

a) The timings for each tip of the bucket are stored.
b) The other option is to store the number of tips or the amount of rainfall in a pre-set time interval. The pre-set interval can be 15 min., 30 min., 1 hour or any other desired interval.

In both cases the amount of rainfall corresponding to each tip of the bucket is also recorded. Since the former option gives the timings for each tipping to the nearest second it is possible to derive the rainfall values over any desired interval. Information on the station/instrument identification, year, month and day is also suitably stored.

Data stored on the data loggers can be downloaded in simple ASCII format with the help of the software and hardware as prescribed by the manufacturer. Loggers hold information on the instrument/station identification, amount of rainfall corresponding to each tip of bucket and timings for each tipping or amount of rainfall in the prescribed time interval. This information may be easily imported into the data entry system by having a conversion/import program which will read the output of the logger and import it. Such conversion/import programs have to be made for each type of data logger in the HIS. Since the format of the data obtained from the data loggers can be standardised to some extent there is possibility of developing appropriate templates which can then be employed for a range of data loggers. This feature will be developed according to the equipment acquired by the various states and agencies.

Rainfall observations stored in the data logger in the form of timings for each tip result in a data series of non-equidistant nature. By contrast, data observed as rainfall in the pre-set time interval forms an equidistant data series. Where the rainfall is recorded as a pre-set time interval and the interval is one hour, the same form may be used as for data recorded on autographic charts (As section 6 above). Where a different interval is required (15 min., 30 min. etc.) the general option for equidistant data series may be used. Data stored as tip timings must be stored using the layout for non-equidistant series. It is to note that provision of both these general options is yet to be made in the system.

# 5 PRIMARY VALIDATION FOR RAINFALL DATA

### 5.1 GENERAL

Data validation is the means by which data are checked to ensure that the final figure stored in the HIS is the best possible representation of the true value of the variable at the measurement site at a given time or in a given interval of time. Validation recognises that values observed or measured in the field are subject to errors which may be random, systematic or spurious.

Improvement in computing facilities now enables such validation to be carried out whereas in the past the volume of data the time required to carry out comprehensive manual validation was prohibitive.

Primary validation of rainfall data will be carried out at the Sub-divisional level using Primary module of dedicated data processing software and is concerned with data comparisons at a single station:

- for a single data series, between individual observations and pre-set physical limits
- between two measurements of a variable at a single station, e.g. daily rainfall from a daily gauge and an accumulated total from a recording gauge

Data entry checks will already have been carried out to ensure that there have been no transcription errors from the field sheets to the SWDES database. Some doubtful values may already have been flagged.

The high degree of spatial and temporal variability of rainfall compared to other climatic variables makes validation of rainfall more difficult. This is particularly the case on the Indian sub-continent, experiencing a monsoon type of climate involving convective precipitation.

More comprehensive checks can be carried out on daily and longer duration rainfall data by making comparisons with neighbouring stations. This will be described under secondary validation and carried out at Divisional offices.

## 5.2 INSTRUMENTS AND OBSERVATIONAL METHODS

### 5.2.1 GENERAL

The method of measurement or observation influences our view of why the data are suspect. To understand the source of errors we must understand the method of measurement or observation in the field and the typical errors of given instruments and techniques.

Data validation must never be considered a purely statistical or mathematical exercise. Staff involved in it must understand the field practice.

Three basic instruments are in use at climatological stations for measurement of daily and shorted duration rainfall:

- standard daily raingauge
- syphon gauge with chart recorder
- tipping bucket gauge with digital recorder

These will be separately described with respect to the typical errors that occur with each gauge or observation method, and the means by which errors may be detected (if at all).

### 5.2.2 DAILY RAINFALL GAUGE (SRG)

***Instrument and procedure***

Daily rainfall is measured using the familiar standard gauge (SRG). This consists of:

- a circular collector funnel with a brass or gun metal rim and a collection area of either 200 cm$^2$ (diameter 159.5 mm) or 100 cm$^2$ (diameter 112.8 mm), leading to a,
- base unit, partly embedded in the ground and containing,
- a polythene collector bottle

The gauge is read once or twice daily and any rain held in the polythene collector is poured into a measuring glass to determine rainfall in millimetres.

***Typical measurement errors***

- Observer reads measuring glass incorrectly
- Observer enters amount incorrectly in the field sheet

- Observer reads gauge at the wrong time (the correct amount may thus be allocated to the wrong day
- Observer enters amount to the wrong day
- Observer uses wrong measuring glass (i.e., 200 $cm^2$ glass for 100 $cm^2$ gauge, giving half the true rainfall or 100 $cm^2$ glass for 200 $cm^2$ gauge giving twice the true rainfall.
- Observed total exceeds the capacity of the gauge.
- Instrument fault - gauge rim damaged so that collection area is affected
- Instrument fault - blockage in raingauge funnel so that water does not reach collection bottle and may overflow or be affected by evaporation
- Instrument fault - damaged or broken collector bottle and leakage from gauge

It may readily be perceived that errors from most of these sources will be very difficult to detect from the single record of the standard raingauge, unless there has been a gross error in reading or transcribing the value. These are described below for upper warning and maximum limits.

Errors at a station are more readily detected if there is a concurrent record from an autographic raingauge (ARG) or from a digital record obtained from a tipping bucket raingauge (TBRG). As these too are subject to errors (of a different type), comparisons with the daily raingauge will follow the descriptions of errors for these gauges.

The final check by comparison with raingauges at neighbouring stations will show up further anomalies, especially for those stations which do not have an autographic or digital raingauge at the site. This is carried out under secondary validation at the Divisional office where more gauges are available for comparison.

### 5.2.3 AUTOGRAPHIC RAINGAUGE (NATURAL SYPHON)

***Instrument and procedure***

In the past short period rainfall has been measured almost universally using the natural syphon raingauge. The natural syphon raingauge consists of the following parts:

- a circular collector funnel with a gun metal rim, 324 $cm^2$ in area and 200 mm in diameter and set at 750 mm above ground level, leading to ,
- a float chamber in which is located a float which rises with rainfall entering the chamber,
- a syphon chamber is attached to the float chamber and syphon action is initiated when the float rises to a given level. The float travel from syphon action to the next represents 10 mm rainfall
- a float spindle projects from the top of the float to which is attached,
- a pen which records on,
- a chart placed on
- a clock drum with a mechanical clock.

The chart is changed daily at the principal recording hour. During periods of dry weather the rainfall traces a horizontal line on the chart; during rainfall it produces a sloping line, the steepness of which defines the intensity of rainfall. The chart is graduated in hours and the observer extracts the hourly totals from the chart and enters it in a register and computes the daily total.

***Typical measurement errors***

Potential measurement faults are now primarily instrumental rather than caused by the observer and include the following:

- Funnel is blocked or partly blocked so that water enters the float chamber at a different rate from the rate of rainfall
- Float is imperfectly adjusted so that it syphons at a rainfall volume different from 10 mm.
- In very heavy rainfall the float rises and syphons so frequently that individual pen traces cannot be distinguished.
- Clock stops; rainfall not recorded or clock is either slow or fast and thus timings are incorrect.
- Float sticks in float chamber; rainfall not recorded or recorded incorrectly.
- Observer extracts information incorrectly from the pen trace.

In addition differences may arise from the daily raingauge due to different exposure conditions arising from the effect of different level of the rim and larger diameter of collector. It has been traditional to give priority to the daily SRG where there is a discrepancy between the two.

### 5.2.4 TIPPING BUCKET RAINGAUGE

***Instrument and procedures***

Short period rainfall is more readily digitised using a tipping bucket raingauge. It consists of the following components.

- A circular collector funnel with a brass or gunmetal rim of differing diameters, leading to a
- Tipping bucket arrangement which sits on a knife edge. It fills on one side, then tips filling the second side and so on.
- A reed switch actuated by a magnet registers the occurrence of each tip
- A logger records the occurrence of each tip and places a time stamp with the occurrence

The logger stores the rainfall record over an extended period and may be downloaded as required. The logger may rearrange the record from a non-equidistant series of tip times to an equidistant series with amounts at selected intervals. The digital record thus does not require the intervention of the field observer. For field calibration, a known amount of rainfall is periodically poured into the collector funnel and checked against the number of tips registered by the instrument.

***Typical measurement errors:***

- Funnel is blocked or partly blocked so that water enters the tipping buckets at a different rate from the rate of rainfall
- buckets are damaged or out of balance so that they do not record their specified tip volume
- reed switch fails to register tips
- reed switch double registers rainfall tips as bucket bounces after tip. (better equipment includes a debounce filter to eliminate double registration.
- failure of electronics due to lightning strike etc. (though lightning protection usually provided)
- incorrect set up of measurement parameters by the observer or field supervisor

Differences may arise from the daily raingauge (SRG) for reasons of different exposure conditions in the same way as the autographic raingauge.

## 5.3 COMPARISON OF DAILY TIME SERIES FOR MANUAL AND AUTOGRAPHIC OR DIGITAL DATA

### 5.3.1 GENERAL DESCRIPTION

At stations where rainfall is measured at short durations using an autographic or a digital recorder, a standard raingauge is always also available. Thus, at such observation stations rainfall data at daily time interval is available from two independent sources. The rainfall data at hourly or smaller interval is aggregated at the daily level and then a comparison is made between the two. Differences which are less than 5% can be attributed to exposure, instrument accuracy and precision in tabulating the analogue records and are ignored. Any appreciable difference (more than 5%) between the two values must be probed further. The observation made using standard raingauge has generally been taken as comparatively more reliable. This is based on the assumption that there is higher degree of possibility of malfunctioning of autographic or digital recorders owing to their mechanical and electromechanical systems. However, significant systematic or random errors are also possible in the daily raingauge as shown above.

If the error is in the autographic or digital records then it must be possible to relate it either to instrumental or observational errors. Moreover, such errors tend to repeat under similar circumstances.

### 5.3.2 DATA VALIDATION PROCEDURE AND FOLLOW UP ACTIONS

This type of validation can be carried out in tabular or graphical form. For both approaches, the values of hourly data are aggregated to daily values to correspond to those observed using a standard raingauge. A comparison is made between the daily rainfall observed using standard and automatic gauges. Percent discrepancy can be shown by having a second axis on the plot. Tabular output for those days for which the discrepancy is more than 5% can be obtained. A visual inspection of such a tabulated output will ensure screening of all the suspect data with respect to this type of discrepancy.

The following provides a diagnosis of the likely sources of error with discrepancies of different sorts:

a) Where the recording gauge gives a consistently higher or lower total than the daily gauge, then the recording gauge could be out of calibration and either tipping buckets (TBRG) or floats (ARG) need recalibration.

**Accept SRG and adjust ARG or TBRG**

b) Where agreement is generally good but difference increases in high intensity rainfall suggests that for the ARG:

- the syphon is working imperfectly in high rainfall, or
- the chart trace is too close to distinguish each 10 mm trace (underestimate by multiples of 10 mm)

For the TBRG:

- gauge is affected by bounce sometimes giving double tips

**Accept SRG and adjust ARG or TBRG**

c) Where a day of positive discrepancy is followed by a negative discrepancy and rainfall at the recording gauge was occurring at the observation hour, then it is probable that the observer read the SRG at a different time from the ARG. The sum of SRG readings for successive days should equal the two-day total for the TBRG or ARG

**Accept TBRG or ARG and adjust SRG**

d) Where the agreement is generally good but isolated days have significant differences, then the entered hourly data should be checked against the manuscript values received from the field. Entries resulting from incorrect entry are corrected. Check that water added to the TBRG for calibration is not included in rainfall total. Otherwise there is probable error in the SRG observation.

**Accept ARG or TBRG and adjust SRG**

However, it will be very interesting to note that in certain cases the values reported for the daily rainfall by SRG and ARG matches one to one on all days for considerable period not withstanding the higher rainfall values etc. It is very easy to infer in those situations that there has been at attempt by the observer to match these values forcefully by manipulating one or both data series. It is not expected that both these data series should exactly match in magnitude. Since such variation must be there due to variance in the catch and instrumental and observation variations. And it is therefore highly undesirable that such matching is effected by manipulation.

**Example 5.1**

Consider the daily totals of hourly rainfall (observed by an autographic raingauge - ARG) and the daily rainfall observed by the standard raingauge (SRG) at station ASKHEDA of PARGAON catchment. The graphical and tabular comparison of these two data series for the period from 1/9/1996 to 31/10/99 is given in Figure 5.1 and Table 5.1 respectively.

It is amply clear from this graphical and tabular outputs that there has been a marked difference between the reported daily rainfall as observed from the standard raingauge and that obtained by compiling the hourly values, tabulated from autographic chart, to daily level.

| Year | Month | Day | ASKHEDA | | |
|---|---|---|---|---|---|
| | | | SRG | ARG | % Diff. |
| 1996 | 9 | 1 | 0 | 0 | - |
| 1996 | 9 | 2 | 0 | 0 | - |
| 1996 | 9 | 3 | 0 | 0 | - |
| 1996 | 9 | 4 | 0 | 0 | - |
| 1996 | 9 | 5 | 0 | 0 | - |
| 1996 | 9 | 6 | 18.7 | 18.5 | -1.1 |
| 1996 | 9 | 7 | 0 | 0 | - |
| 1996 | 9 | 8 | 3.7 | 4 | 8.1 |
| 1996 | 9 | 9 | 0 | 0.2 | - |
| 1996 | 9 | 10 | 0 | 0 | - |
| 1996 | 9 | 11 | 0 | 0 | - |
| 1996 | 9 | 12 | 0 | 0 | - |
| 1996 | 9 | 13 | 5 | 0 | -100.0 |
| 1996 | 9 | 14 | 0 | 4.8 | - |
| 1996 | 9 | 15 | 3.9 | 0 | -100.0 |
| 1996 | 9 | 16 | 3.8 | 4.8 | 26.3 |
| 1996 | 9 | 17 | 7.2 | 3.5 | -51.4 |
| 1996 | 9 | 18 | 0 | 6.9 | - |
| 1996 | 9 | 19 | 2 | 0 | -100.0 |
| 1996 | 9 | 20 | 0 | 2 | - |
| 1996 | 9 | 21 | 0 | 0 | - |
| 1996 | 9 | 22 | 0 | 0 | - |
| 1996 | 9 | 23 | 14 | 0 | -100.0 |
| 1996 | 9 | 24 | 13.2 | 14.8 | 12.1 |
| 1996 | 9 | 25 | 3.8 | 13.5 | 255.3 |
| 1996 | 9 | 26 | 6.8 | 3.5 | -48.5 |
| 1996 | 9 | 27 | 3 | 7.2 | 140.0 |
| 1996 | 9 | 28 | 0 | 3 | - |
| 1996 | 9 | 29 | 2.7 | 0 | -100.0 |
| 1996 | 9 | 30 | 0 | 2.4 | - |
| 1996 | 10 | 1 | 0 | 0 | - |
| 1996 | 10 | 2 | 19 | 18.3 | -3.7 |

| Year | Month | Day | ASKHEDA | | |
|---|---|---|---|---|---|
| | | | SRG | ARG | % Diff. |
| 1996 | 10 | 3 | 75.8 | 0.5 | -99.3 |
| 1996 | 10 | 4 | 2.8 | 1.5 | -46.4 |
| 1996 | 10 | 5 | 4 | 4.5 | 12.5 |
| 1996 | 10 | 6 | 0 | 0 | - |
| 1996 | 10 | 7 | 0 | 0 | - |
| 1996 | 10 | 8 | 0 | 0 | - |
| 1996 | 10 | 9 | 0 | 0 | - |
| 1996 | 10 | 10 | 0 | 0 | - |
| 1996 | 10 | 11 | 0 | 0 | - |
| 1996 | 10 | 12 | 0 | 0 | - |
| 1996 | 10 | 13 | 0 | 0 | - |
| 1996 | 10 | 14 | 0 | 0 | - |
| 1996 | 10 | 15 | 0 | 0 | - |
| 1996 | 10 | 16 | 0 | 0 | - |
| 1996 | 10 | 17 | 0 | 0 | - |
| 1996 | 10 | 18 | 0 | 0 | - |
| 1996 | 10 | 19 | 0 | 0 | - |
| 1996 | 10 | 20 | 2 | 1.8 | -10.0 |
| 1996 | 10 | 21 | 50.3 | 50.1 | -0.4 |
| 1996 | 10 | 22 | 0.7 | 1.5 | 114.3 |
| 1996 | 10 | 23 | 70 | 70.5 | 0.7 |
| 1996 | 10 | 24 | 9 | 8.9 | -1.1 |
| 1996 | 10 | 25 | 0 | 0 | - |
| 1996 | 10 | 26 | 0 | 0 | - |
| 1996 | 10 | 27 | 0 | 0 | - |
| 1996 | 10 | 28 | 0 | 0 | - |
| 1996 | 10 | 29 | 6 | 6 | 0.0 |
| 1996 | 10 | 30 | 0 | 0 | - |
| 1996 | 10 | 31 | 0 | 0 | - |

*Table 5.1: Tabular comparison of daily rainfall obtained from SRG and ARG at the same station*

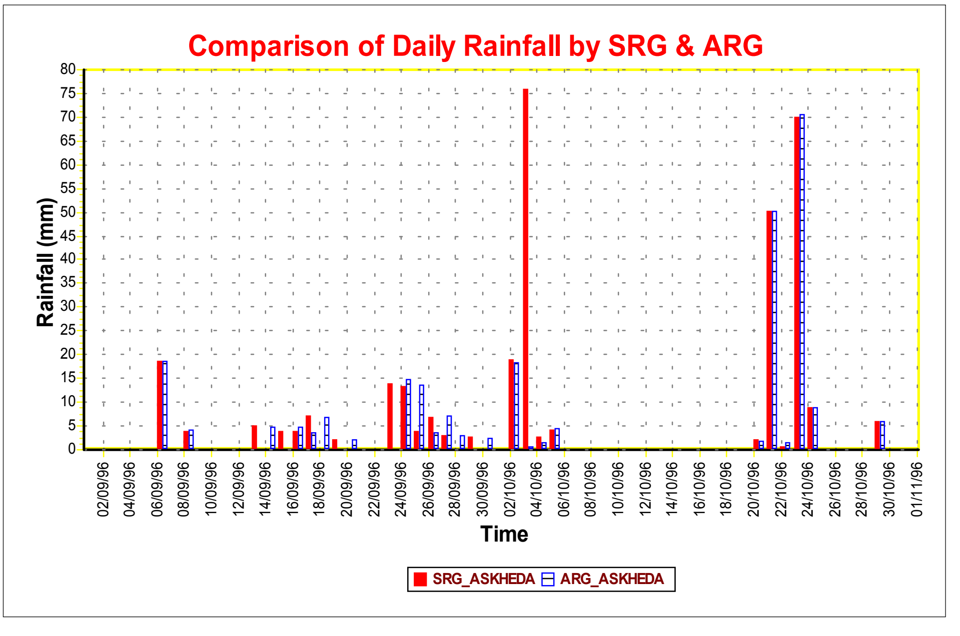



*Figure 5.1: Graphical comparison of daily rainfall obtained from SRG and ARG at the same station.*

*Following points can be noticed:*

a) The difference in daily values from SRG and ARG varies considerably; from a very reasonable deviation like 1.1, 0.4, 0.7 % (on 6/9/96, 21/10/96 and 23/10/96 respectively) to unacceptably high values like 51.4, 255.3, 99.3 % (on 17/9/96, 25/9/96 and 3/10/96 respectively).

b) In this example, the resulting errors can be categorised in three types major classes:

- There are many instances where a larger difference is caused by the shifting of one of the data series by one day. From 13/9/96 to upto 31/9/96 a shift of one day in one of the series can be very clearly noticed. This shift is not present before and after this period. Such errors are not exactly due the differences in the two observations but are the result of recording or entering one of the data series inappropriately against wrong date. However, even if this time shift were not present, then also there would have been substantial differences in the corresponding values as can be easily inferred from the tabulated values.
- There are a few instances where the difference is due to mistake in recording or entering or might even be due to failure of ARG. Such differences like the one on 3/10/96 where SRG record shows 75.8 mm whereas ARG data shows 0.5 are clear cases of mistakes. Such errors are very easy to be detected also.
- There are lot of instances where the percent difference is moderate to high which can be attributed to observational errors, instrumental errors and the variation in the catch in the two raingauge. Most of these high percentage differences are for the very low rainfall values which also highlights the variation in the catch or the accuracy of equipment at such low rainfall events.

Following actions must be taken as a follow-up of data validation:

a) The cause of the shift in one of the data series can be very easily detected and removed after looking at the dates of the ARG charts and corresponding tabulated data.

b) Cause of mistake like that on 3/10/96 can be removed if ARG chart also shows comparable rainfall. If ARG data is found correct according to the chart and there does not seem to be any reason to believe instrumental failure etc. then the daily rainfall as reported by the SRG can be corrected to correspond to the ARG value. Else, if there is any scope of ambiguity then the daily data has to be flagged and it has to be reviewed at the time of secondary validation on the basis on rainfall recorded at the adjoining stations.

c) Moderate to large differences (more than 5%) in the two data series are to be probed in detail by looking at the ARG chart and corresponding tabulations. Any errors in tabulations are to be corrected for. Inspection of the differences in this case shows that there is no particular systematic error involved. Sometime the SRG value is more by a few units and sometimes ARG is more by similar magnitude. Sometimes this might be due to observation SRG at non-standard times or incorrect tabulation of the ARG chart. At low rainfall these differences can also be due to variation in the catch or due to inaccuracy of the equipment. In both circumstances, it must be ensured whether standard equipment and exposure conditions are maintained at the station.

## 5.4 CHECKING AGAINST MAXIMUM AND MINIMUM DATA LIMITS

### 5.4.1 GENERAL DESCRIPTION

Rainfall data, whether daily or hourly must be validated against limits within which it is expected to physically occur. Such limits are required to be quite wide to avoid the possibility of rejecting true extreme values. For rainfall data, it is obvious that no data can be less than zero which perfectly serves as the limiting minimum value. However, it is quite difficult to assign an absolute maximum limit for the rainfall data in a given duration occurring at a particular station. Nevertheless, on the basis of past experience and physical laws governing the process of rainfall it is possible to arrive at such maximum limits which in all probability will not be exceeded. The limit may be set as the maximum capacity of the raingauge, but care should be taken in rejecting values on this basis where the gauge observer has read the gauge several times to ensure the gauge capacity was not exceeded.

Maximum limits also vary spatially over India with climatic region and orography. Also, this maximum limit has a strong non-linear relationship with rainfall duration. For example, for any place, the maximum limit for daily rainfall is not equal to 24 times the maximum limit for hourly rainfall. It is certainly much lower than this amount. For this reason, it is essential to set maximum limits for rainfall for durations other than 1-day. Limits for 1-day and 1-hour should be set and this will generally be sufficient to identify gross errors over the intervening range of duration.

For 1-day duration, the India Meteorological Department and Indian Institute of Tropical Meteorology have prepared atlas for 1 day Probable Maximum Precipitation (PMP) which gives the expected maximum amount that can physically occur in a given duration at a given location. Values extracted from this map should be applied or else could be derived as the historical maximum value from the long term records now available for most of the regions. Though there might be some variation in the values obtained from both these atlases but for the purpose of prescribing the maximum limit here such differences may be ignored. Alternatively, the derived information on observed maximum 1-Day point rainfall, which is available for scores of stations across the country from long term records, can be used as a reasonably good estimate of the maximum limit of rainfall.

Similarly, use can be made of the maps showing 50 year – 1 hour maximum rainfall, as developed by India Meteorological Department, for presecribing the maximum data limit for the case of hourly rainfall data. Such initial estimates can be adjusted on the basis of local judgement adjusted on the basis of experience or of local research studies based on either:

- storm maximisation by considering precipitable moisture and inflow of moist air
- statistical analysis of observed extreme values for shorter durations

### 5.4.2 DATA VALIDATION PROCEDURE AND FOLLOW UP ACTIONS:

Setting minimum and maximum limits in SWDES ensures filtering of values outside the specified limits. Such values are considered suspect. They are first checked against manuscript entries and corrected if necessary. If manuscript and entry agree and fall outside prescribed limits, the value is flagged as doubtful. Where there are some other corroborative facts about such incidents, available in manuscript or notes of the observer or supervisor then they must be incorporated with the primary data validation report. This value then has to be probed further at the time of secondary data validation when more data from adjoining stations become available.

However, when the current data is being entered in subsequent month and there happens a entries which are more than the prescribed maximum limit and such heavier rainfall events are also very fresh in the minds of data processing staff then it implies that the earlier maximum has been crossed in reality. In such circumstances the maximum limit is reset to a suitable higher value. In such cases there will surely be a few adjoining stations recording similar higher rainfall and will support such inferences. However, if no such basis is available for justification of such very high values then the value is reported in the form of a remark which can be reviewed at the secondary validation stage.

**Example: 5.2**

Consider the long term daily rainfall at MEGHARAJ station in KHEDA catchment as shown in Figure 5.2.

This is a long term rainfall data of the station (37 years) and it can be seen that the maximum daily rainfall in any year has usually been about 100 mm on an average. A few times the daily rainfall has been more than 150 mm and only thrice in a period of 37 years the value has exceeded 200 mm. Only once the value has exceeded 250 mm. So, if value of about 320 – 325 mm is taken for setting the maximum limit for daily rainfall at this station then it will help in validating if certain data values are beyond this value.

Such values can be derived from the isolines of maps giving observed maximum 1-Day rainfall or 1-Day PMP values.

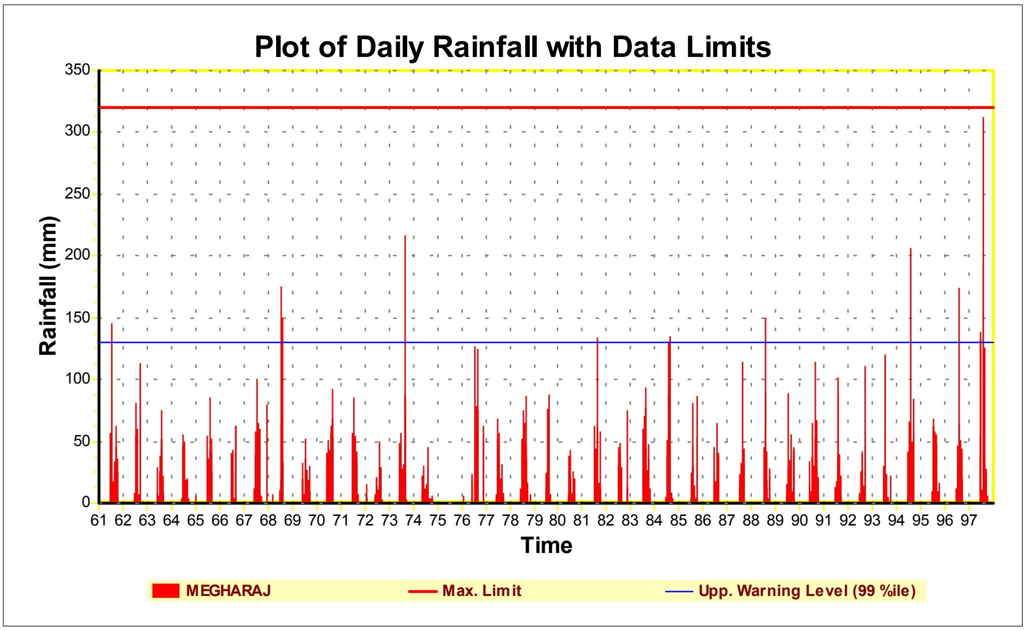



*Figure 5.2: Graphical plot showing physical significance of maximum limit and upper warning level*

## 5.5 CHECKING AGAINST UPPER WARNING LEVEL

### 5.5.1 GENERAL DESCRIPTION

Validation of rainfall data against an absolute maximum value does not discriminate those comparatively frequently occurring erroneous data which are less than the prescribed maximum limit. In view of this, it is advantageous to consider one more limit, called the upper warning level, which can be employed to see if any of the data value has violated it. This limit is assigned a value with an intention of screening out those high data values which are not expected to occur frequently. The underlying purpose of carrying out such a test is to consider a few high data values with suspicion and subsequently scrutinising them.

For the daily rainfall data this limit can be set statistically, for example, equal to 99 percentile value of the actual rainfall values excluding zero rainfall values. In other words, it leads to screening out those values which are higher than that daily rainfall value which is exceeded only once in 100 rainfall events on an average. Say, if the data for 30 years is available and there are 3456 non-zero daily rainfall values then 99 percentile value will be about $34^{th}$ highest in the lot. It indicates that rainfall value which is equalled or exceeded, on an average, once in every 100 rainfall events.

Similar statistic can be employed for obtaining suitable value for upper warning level for hourly rainfall data. The central idea while setting these upper warning levels is that the higher rainfall data is screened adequately, that is the limits must be such that it results in not too many and not too less data values being flagged for validation.

### 5.5.2 DATA VALIDATION PROCEDURE AND FOLLOW UP ACTIONS

Setting warning limits in the Primary module (like maximum limits) results in filtering values outside specified limits. Values are checked against manuscript entries and corrected if necessary. Remaining values are flagged as doubtful, and any associated field notes or corroborative facts are incorporated with the primary validation report and forwarded to the Divisional Data Processing Centre for secondary validation.

**Example: 5.3**

Same example as mentioned for example 3.2 can be considered for illustrating the meaning of another data limits as Upper warning level (see Figure 3.2)

As can be seen that a value of 130 mm is taken as the Upper warning level and that this is crossed in as many as 9 years and on about 12-13 instances. Now this frequency of violation of data limit is such that on an average once in 3-4 years certain higher values will be checked for its validity. The limit of 130 mm is worked out here on the basis of 99 percentile value of the set of non-zero rainfall value in this long period of 37 years. Such a statistic provides a value which has been exceeded only once in 100 occasions of rainfall event. Normally, for this station there are about 50-60 rainy days in any year and 99 %ile means that, on an average such value will be exceeded about once in 2 years time. Flagging of all those instances is done which are larger than this value of 130 mm so that cross checking on such large values can be ensured.

# 6 ENTRY OF CLIMATIC DATA

## 6.1 GENERAL PRINCIPLES

Climatological data are required in hydrology only for the computation of evapotranspiration by theoretical and empirical methods. Climatological data for the purpose of this module include the direct measurement of pan evaporation. Rainfall measurement is treated separately

There is a requirement to make all climatic data available on computer for validation processing and reporting - the first step is therefore data entry.

Data entry will be carried out at Sub-divisional offices as near as possible to the observation station to ensure interaction between data processing and observation personnel.

All data entry of climatic data will be done through the primary module of dedicated hydrological data processing software (SWDES) which is specifically tailored for the purpose. Digital data from a limited number of Automatic Weather Stations (AWS) may be available.

Initial emphasis will be on the entry of current climatic data, but SWDES also provides a suitable means of entering historical data, from original data sheets where available and otherwise from published tabulations.

Prior to entry to computer two manual activities are essential:

- Registration of receipt - on the day of receipt (See Volume 8, Operational Manual, Part 4, Chapter 5)
- Manual inspection of climatic data sheets and charts

On completion of data entry and primary validation in the primary module, data will be exported (transferred) to the secondary module for further validation and processing at the Divisional office.

## 6.2 SWDES AND CLIMATIC DATA ENTRY

SWDES is primarily designed for the entry of time series data but it also incorporates space-oriented data sufficient to locate and catalogue the stations under the control of a particular state or agency. Stations, and series can then be accessed from typical Windows Menus and Toolbars by clicking on appropriate buttons. This feature, of course common to all variables.

For all time series data, SWDES provides entry screens automatically with date and time labels against which the variable values are entered. This simplifies data entry and avoids the potential errors of date/time entry.

SWDES provides data entry checking capability, rejecting clearly spurious values and flagging suspect ones for inspection. For example, it will reject entry of an alpha character in a numeric field or duplicate decimal point and will highlight for inspection values above a pre-set limit. In addition options for plotting time series graphs, at time of entry are available in most cases.

SWDES provides a suitable format for entry of data for all standard instruments installed at the Full Climate Stations (FCS) set up under Hydrology Project and their frequencies of operation:

- Dry bulb temperature - read daily or twice daily
- Wet bulb temperature - read daily or twice daily
- Maximum thermometer - read daily or twice daily
- Minimum thermometer - read daily or twice daily
- Relative humidity - historical data previously computed
- Instantaneous wind speed - read daily or twice daily
- Daily wind run - read daily
- Wind direction - read daily or twice daily
- Pan evaporation - read daily or twice daily
- Pan water temperature - read daily or twice daily
- Atmospheric pressure - read daily or twice daily
- Autographic recording of relative humidity - tabulated values on chart
- Autographic recording of temperature - tabulated values on chart
- Autographic recording of atmospheric pressure - tabulated values on chart
- Sunshine hours - from Campbell stokes sunshine recorder card.

## 6.3 MANUAL INSPECTION OF FIELD RECORDS

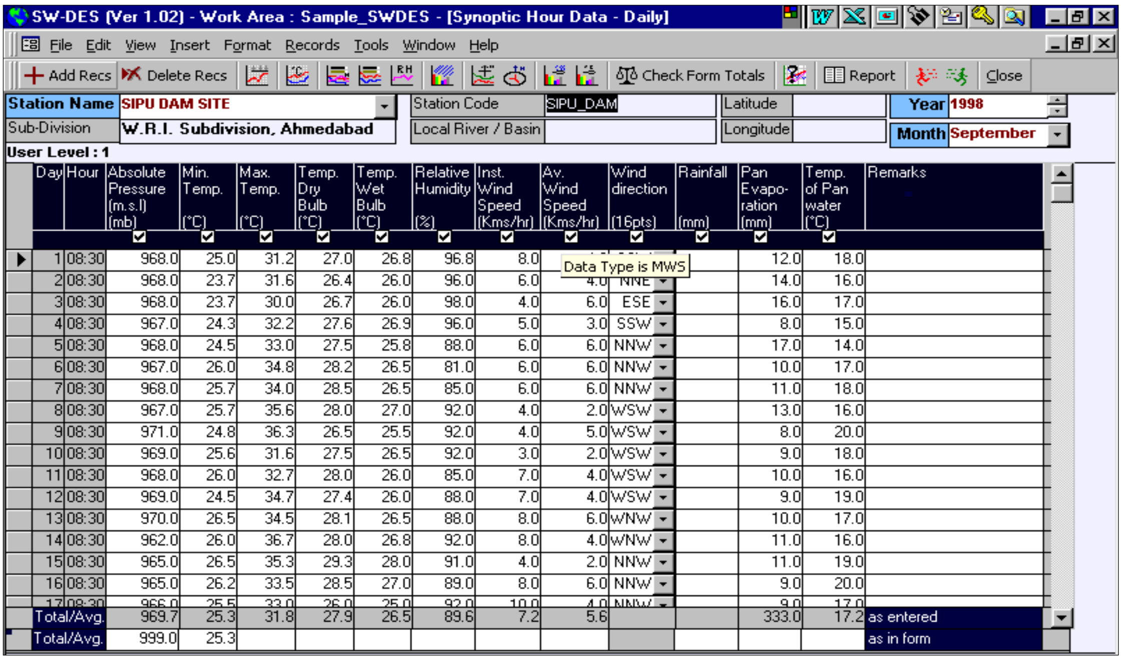
Prior to data entry to computer an initial inspection of field records is required. This is done in conjunction with notes received from the observation station on equipment problems and faults, missing records or exceptional rainfall. Climate sheets and charts will be inspected for the following:

- Is the station name and code and month and year recorded?
- Do the number of record days correspond with the number of days in the month?
- Are there missing values or periods for which values of a variable have been accumulated during absence of the observer?
- Have monthly totals or averages of variables been entered?
- Have the autographic records been extracted correctly? Do the check manual readings at the beginning and end agree with the chart values, and if not has a correction been applied?
- Are the records written clearly and with no ambiguity in figures or decimal points?

Any queries arising from such inspection will be communicated to the observer to confirm ambiguous data before data entry. Any unresolved problems will be noted and the information sent forward with the digital data to Divisional office to assist in secondary validation. Any equipment failure or observer problem will be communicated to the supervising field officer for rectification.

## 6.4 ENTRY OF DAILY CLIMATIC DATA

Using SWDES the station and daily series is selected and the screen for entry (or editing) of daily rainfall is displayed as shown in Figure 6.1. Simultaneously displayed are the station and series codes and corresponding Sub-division and local river/basin are also displayed. A window showing year and month, from which the month of entry may be selected. Upper and lower warning and maximum and minimum limits can also be specified for each variable. As there may be insufficient space available on the data entry screen, this must be specified on a separate screen on which the data series is defined.


SW-DES (Ver 1.02) - Work Area : Sample_SWDES - [Synoptic Hour Data - Daily]

Station Name: SIPU DAM SITE | Station Code: SIPU_DAM | Latitude: | Year: 1998
Sub-Division: W.R.I. Subdivision, Ahmedabad | Local River / Basin: | Longitude: | Month: September

User Level : 1

| Day | Hour | Absolute Pressure (m.s.l) (mb) | Min. Temp. (°C) | Max. Temp. (°C) | Temp. Dry Bulb (°C) | Temp. Wet Bulb (°C) | Relative Humidity (%) | Inst. Wind Speed (Kms/hr) | Av. Wind Speed (Kms/hr) | Wind direction (16pts) | Rainfall (mm) | Pan Evapo-ration (mm) | Temp. of Pan water (°C) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 08:30 | 968.0 | 25.0 | 31.2 | 27.0 | 26.8 | 96.8 | 8.0 | [illegible] | [illegible] | | 12.0 | 18.0 | |
| 2 | 08:30 | 968.0 | 23.7 | 31.6 | 26.4 | 26.0 | 96.0 | 6.0 | 4.0 | NNE | | 14.0 | 16.0 | |
| 3 | 08:30 | 968.0 | 23.7 | 30.0 | 26.7 | 26.0 | 98.0 | 4.0 | 6.0 | ESE | | 16.0 | 17.0 | |
| 4 | 08:30 | 967.0 | 24.3 | 32.2 | 27.6 | 26.9 | 96.0 | 5.0 | 3.0 | SSW | | 8.0 | 15.0 | |
| 5 | 08:30 | 968.0 | 24.5 | 33.0 | 27.5 | 25.8 | 88.0 | 6.0 | 6.0 | NNW | | 17.0 | 14.0 | |
| 6 | 08:30 | 967.0 | 26.0 | 34.8 | 28.2 | 26.5 | 81.0 | 6.0 | 6.0 | NNW | | 10.0 | 17.0 | |
| 7 | 08:30 | 968.0 | 25.7 | 34.0 | 28.5 | 26.5 | 85.0 | 6.0 | 6.0 | NNW | | 11.0 | 18.0 | |
| 8 | 08:30 | 967.0 | 25.7 | 35.6 | 28.0 | 27.0 | 92.0 | 4.0 | 2.0 | WSW | | 13.0 | 16.0 | |
| 9 | 08:30 | 971.0 | 24.8 | 36.3 | 26.5 | 25.5 | 92.0 | 4.0 | 5.0 | WSW | | 8.0 | 20.0 | |
| 10 | 08:30 | 969.0 | 25.6 | 31.6 | 27.5 | 26.5 | 92.0 | 3.0 | 2.0 | WSW | | 9.0 | 18.0 | |
| 11 | 08:30 | 968.0 | 26.0 | 32.7 | 28.0 | 26.0 | 85.0 | 7.0 | 4.0 | WSW | | 10.0 | 16.0 | |
| 12 | 08:30 | 969.0 | 24.5 | 34.7 | 27.4 | 26.0 | 88.0 | 7.0 | 4.0 | WSW | | 9.0 | 19.0 | |
| 13 | 08:30 | 970.0 | 26.5 | 34.5 | 28.1 | 26.5 | 88.0 | 8.0 | 6.0 | WNW | | 10.0 | 17.0 | |
| 14 | 08:30 | 962.0 | 26.0 | 36.7 | 28.0 | 26.8 | 92.0 | 8.0 | 4.0 | WNW | | 11.0 | 16.0 | |
| 15 | 08:30 | 965.0 | 26.5 | 35.3 | 29.3 | 28.0 | 91.0 | 4.0 | 2.0 | NNW | | 11.0 | 19.0 | |
| 16 | 08:30 | 965.0 | 26.2 | 33.5 | 28.5 | 27.0 | 89.0 | 8.0 | 6.0 | NNW | | 9.0 | 20.0 | |
| 17 | 08:30 | 966.0 | 25.5 | 33.0 | 26.0 | 25.0 | 92.0 | 10.0 | 4.0 | NNW | | 9.0 | 17.0 | |
| Total/Avg. | | 969.7 | 25.3 | 31.8 | 27.9 | 26.5 | 89.6 | 7.2 | 5.6 | | | 333.0 | 17.2 | as entered |
| Total/Avg. | | 999.0 | 25.3 | | | | | | | | | | | as in form |

*Figure 6.1: Entry screen format for entering daily climate data*

A single computer form in SWDES is used to enter all the variables for a month corresponding with the common field sheet for all observed variables. The first two columns are for the date and time, and then there are as many columns as there are parameters. The name and units of all the variables are given on the top of each column. There is facility available for switching off any column if that type of data is not available at certain station. In such cases the cursor will jump over this inactive column to go directly to the next active column. The data corresponding to each day is to be entered by the user. The cursor first goes horizontally to each column and then goes to the next day. Remarks may be entered against any specific date by using the mouse/tab/cursor.

When data are missing, the corresponding cell is left blank (not zero) and a remark entered against that day. Where the observer has missed readings over a period of days and an accumulated total is subsequently measured (e.g. pan evaporation) the cells corresponding to the missed days will be left blank (not zero) and a remark will be inserted against the date of the accumulation to specify the period over which the accumulation has occurred (e.g. Acc. 23 to 27 Sept).

**Note:** There are occasions when the climate observer is legitimately absent from his station, for example on account of sickness. The observer must be encouraged to leave such spaces “Missing” or “Accumulated” rather than guess the missing values. The computer validation procedures are better able to estimate the missing values.

At the bottom of the form, the monthly total or average (excepting wind direction), as appropriate is entered from the manuscript. The computed values of these quantities are also calculated from the entered quantities.

During the process of making entries the user can draw the graph for the data being entered. Various individual variables and combinations of variables are pre-set for plotting the monthly data as: (a) pressure, (b) min. and max. temperatures, (c) humidity and difference of dry and wet bulb temperatures (see Figure 6.2) , (d) dry and wet bulb, (e) relative humidity, (f) rainfall, (g) average and instantaneous wind speed, (h) wind direction (see Figure 6.3), (i) pan evaporation and (j) pan temperature. Any individual variable can also be plotted if required using a separate option. Data for instantaneous variables (e.g. dry bulb temperature are plotted as line graphs; data for cumulative variables (e.g. pan evaporation) are plotted as bars. The graph of the wind direction will be in the form of a rose diagram.

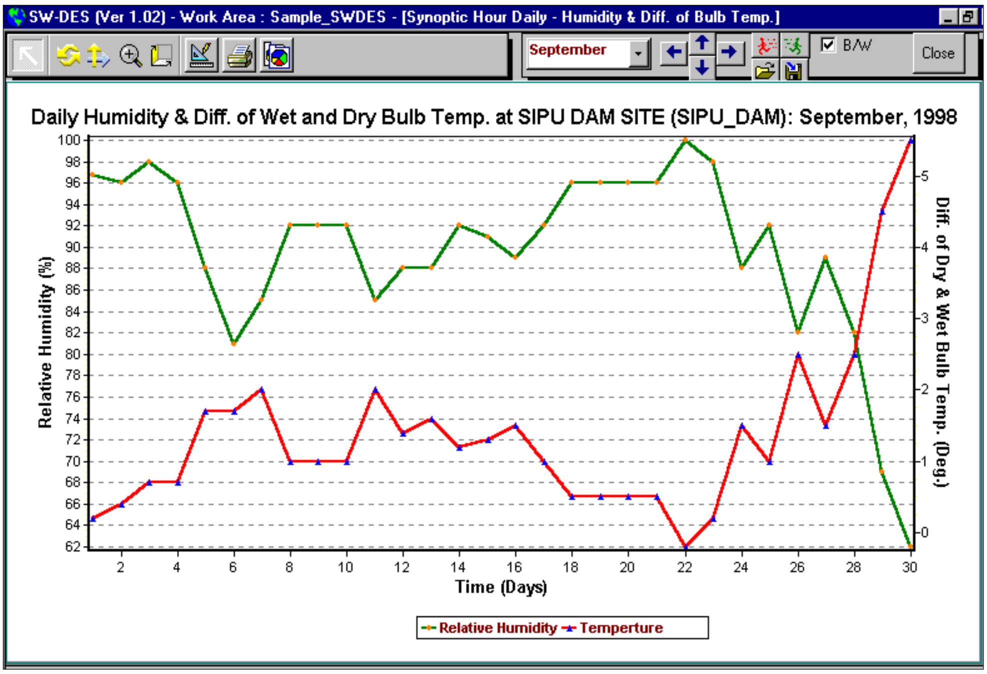



*Figure 6.2: Plot of relative humidity and difference of dry and wet bulb temperatures*

Two types of data entyr checks are performed for daily climate data:

a) The entered daily data can be compared against upper warning level and maximum value. This allows the user to quickly know which data value has violated the prescribed limits. Upon such prompting the user can once again refer back to the manuscript to see if there was some mistake in entering the data. If such values which violated the maximum data limits are found to be actually reported in the manuscript then the user can put suitable remarks to indicate so.

b) Checks are carried out to see if there is a proper match between the entered and computed values of averages or totals of variables in the month. In case of any mismatch the user is prompted by colour highlighting of the mismatch, so that he can check back the entries.

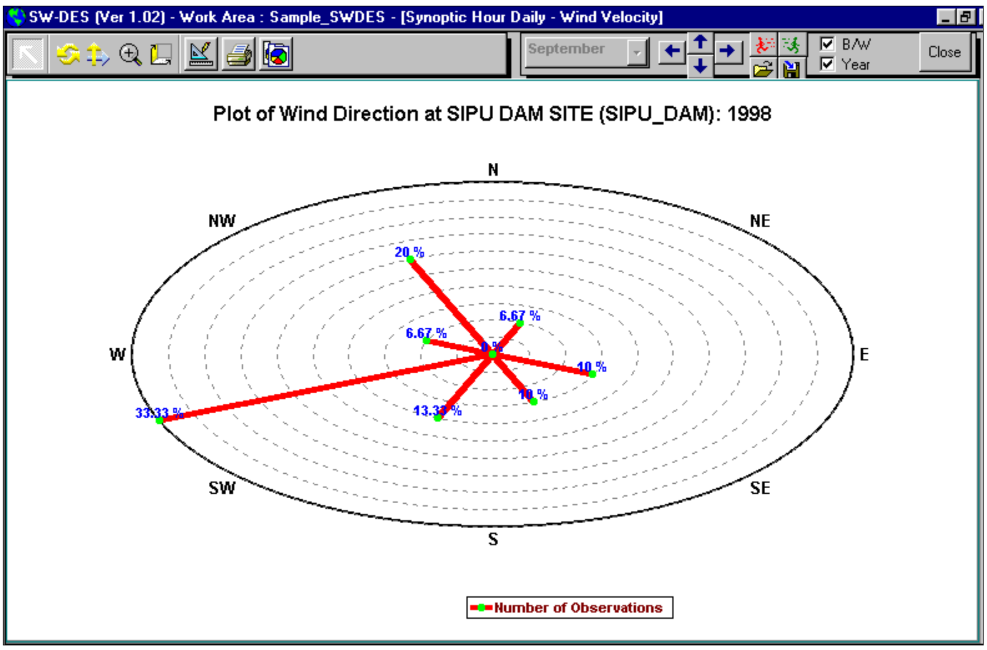


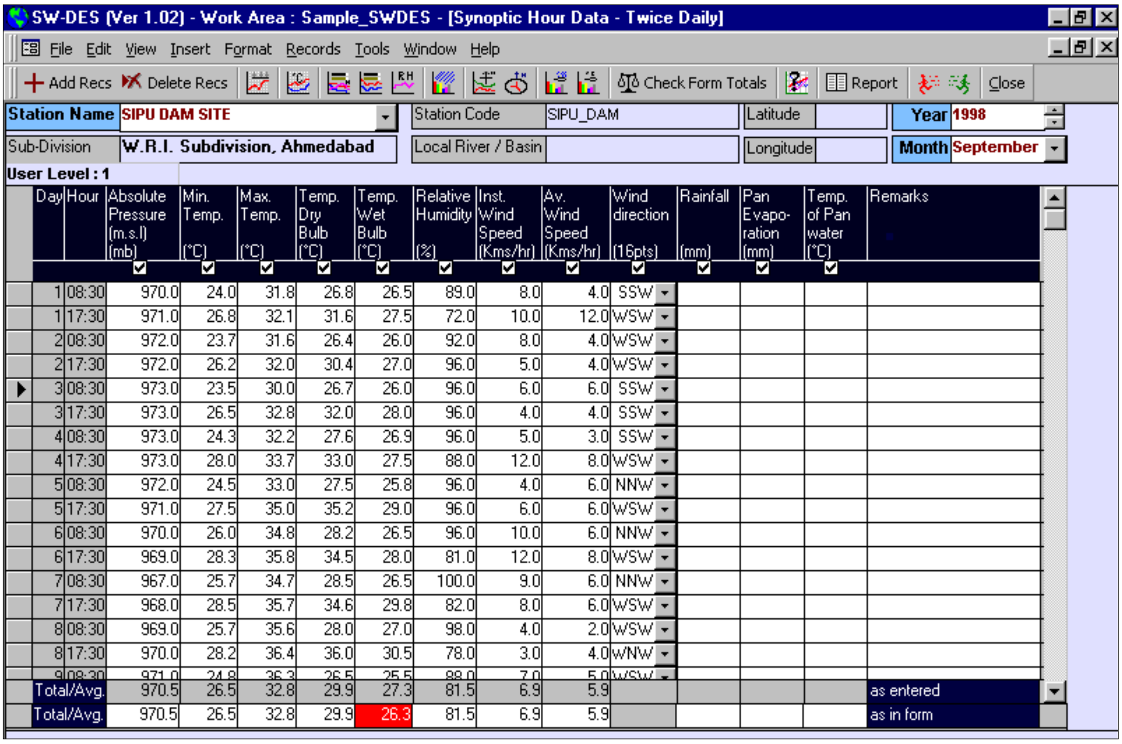

*Figure 6.2: Plot of relative humidity and difference of dry and wet bulb temperatures*

## 6.5 ENTRY OF TWICE DAILY CLIMATIC DATA

The layout of the form for entry of climatic data two times a day is similar to that for daily data as described above and is shown below. The only difference is that for every date there are two rows, one for each of the two observations in the day. The variables available are the same as for daily data. These data are entered for both the observations made at the standard times of observation i.e., 0830 and 1730.

All the data entry operations and facilities are the same as in the case of daily climatic data and similar graphical facilities for display are available. Checks are performed in the same way with respect to comparison of values with warning limits and comparison of manually-calculated totals with computed totals.

It is recommended that the twice daily form should **not** be used for the entry of daily data.



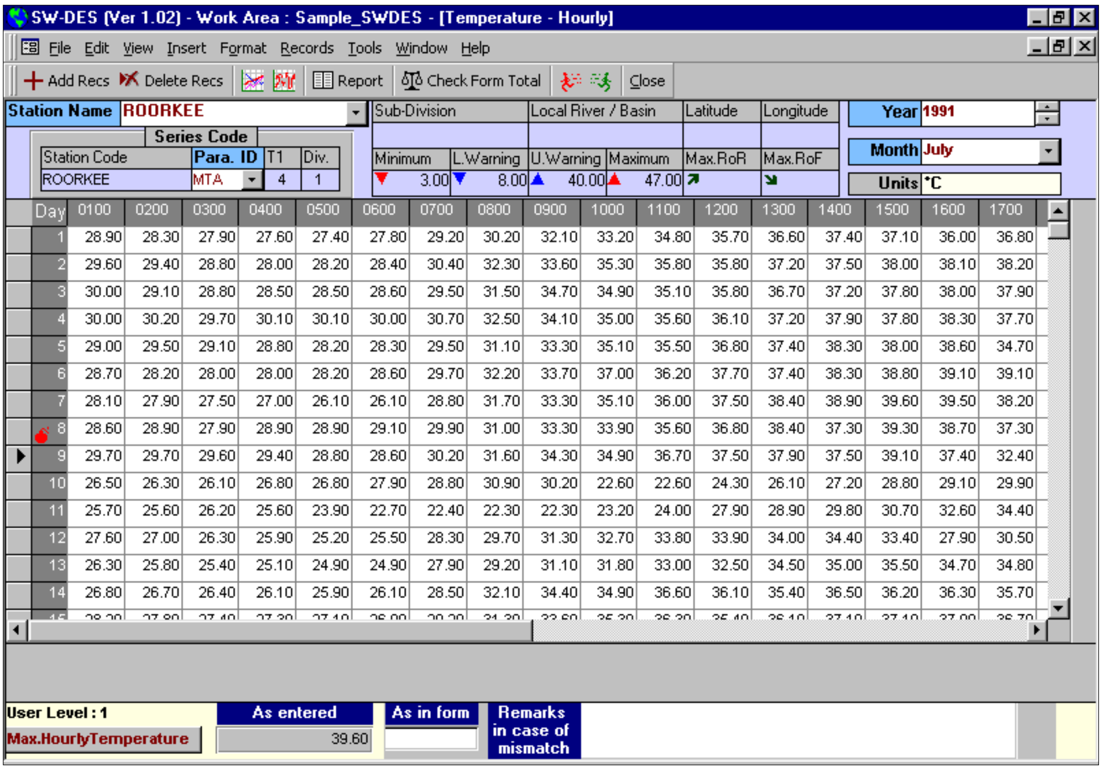

| Day | Hour | Absolute Pressure (m.s.l) (mb) | Min. Temp. (°C) | Max. Temp. (°C) | Temp. Dry Bulb (°C) | Temp. Wet Bulb (°C) | Relative Humidity (%) | Inst. Wind Speed (Kms/hr) | Av. Wind Speed (Kms/hr) | Wind direction (16pts) | Rainfall (mm) | Pan Evapo-ration (mm) | Temp. of Pan water (°C) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 08:30 | 970.0 | 24.0 | 31.8 | 26.8 | 26.5 | 89.0 | 8.0 | 4.0 | SSW | | | | |
| 1 | 17:30 | 971.0 | 26.8 | 32.1 | 31.6 | 27.5 | 72.0 | 10.0 | 12.0 | WSW | | | | |
| 2 | 08:30 | 972.0 | 23.7 | 31.6 | 26.4 | 26.0 | 92.0 | 8.0 | 4.0 | WSW | | | | |
| 2 | 17:30 | 972.0 | 26.2 | 32.0 | 30.4 | 27.0 | 96.0 | 5.0 | 4.0 | WSW | | | | |
| 3 | 08:30 | 973.0 | 23.5 | 30.0 | 26.7 | 26.0 | 96.0 | 6.0 | 6.0 | SSW | | | | |
| 3 | 17:30 | 973.0 | 26.5 | 32.8 | 32.0 | 28.0 | 96.0 | 4.0 | 4.0 | SSW | | | | |
| 4 | 08:30 | 973.0 | 24.3 | 32.2 | 27.6 | 26.9 | 96.0 | 5.0 | 3.0 | SSW | | | | |
| 4 | 17:30 | 973.0 | 28.0 | 33.7 | 33.0 | 27.5 | 88.0 | 12.0 | 8.0 | WSW | | | | |
| 5 | 08:30 | 972.0 | 24.5 | 33.0 | 27.5 | 25.8 | 96.0 | 4.0 | 6.0 | NNW | | | | |
| 5 | 17:30 | 971.0 | 27.5 | 35.0 | 35.2 | 29.0 | 96.0 | 6.0 | 6.0 | WSW | | | | |
| 6 | 08:30 | 970.0 | 26.0 | 34.8 | 28.2 | 26.5 | 96.0 | 10.0 | 6.0 | NNW | | | | |
| 6 | 17:30 | 969.0 | 28.3 | 35.8 | 34.5 | 28.0 | 81.0 | 12.0 | 8.0 | WSW | | | | |
| 7 | 08:30 | 967.0 | 25.7 | 34.7 | 28.5 | 26.5 | 100.0 | 9.0 | 6.0 | NNW | | | | |
| 7 | 17:30 | 968.0 | 28.5 | 35.7 | 34.6 | 29.8 | 82.0 | 8.0 | 6.0 | WSW | | | | |
| 8 | 08:30 | 969.0 | 25.7 | 35.6 | 28.0 | 27.0 | 98.0 | 4.0 | 2.0 | WSW | | | | |
| 8 | 17:30 | 970.0 | 28.2 | 36.4 | 36.0 | 30.5 | 78.0 | 3.0 | 4.0 | WNW | | | | |
| 9 | 08:30 | 971.0 | 24.8 | 36.3 | 26.5 | 25.5 | 88.0 | 7.0 | 5.0 | WSW | | | | |
| Total/Avg. | | 970.5 | 26.5 | 32.8 | 29.9 | 27.3 | 81.5 | 6.9 | 5.9 | | | | | as entered |
| Total/Avg. | | 970.5 | 26.5 | 32.8 | 29.9 | 26.3 | 81.5 | 6.9 | 5.9 | | | | | as in form |

*Figure 6.3: Entry screen format for the entry of twice daily climatic data*

## 6.6 ENTRY OF HOURLY CLIMATIC DATA

Hourly climatic data such as temperature, atmospheric pressure and relative humidity are obtained from autographic chart recorders, from which the hourly (or other interval values) are tabulated by the field observer.. Hourly data are entered separately for each variable.

Hourly climate data are entered in the form of a matrix in which the columns are the hourly variable values for a day and the rows represents different days of the month. Time-label entries for the dates and hours are filled automatically. Rows commence either at 0100 and end 2400 hrs or, start from 0830 and end at 0730. The value entered represents the instantaneous value of the variable at that hour. All the hourly values are entered by the user by navigating horizontally across the days. At the end of each day's entry the cursor moves to the column for entering the daily minimum, maximum and average as available in the manuscript. Finally, the monthly minimum, maximum and average as available in the manuscript have to be entered. The computed minimum, maximum and average for each day and for the month is filled automatically in the respective cells. Remarks, if available in the manuscript, can be entered on a daily basis.




| Day | 0100 | 0200 | 0300 | 0400 | 0500 | 0600 | 0700 | 0800 | 0900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28.90 | 28.30 | 27.90 | 27.60 | 27.40 | 27.80 | 29.20 | 30.20 | 32.10 | 33.20 | 34.80 | 35.70 | 36.60 | 37.40 | 37.10 | 36.00 | 36.80 |
| 2 | 29.60 | 29.40 | 28.80 | 28.00 | 28.20 | 28.40 | 30.40 | 32.30 | 33.60 | 35.30 | 35.80 | 35.80 | 37.20 | 37.50 | 38.00 | 38.10 | 38.20 |
| 3 | 30.00 | 29.10 | 28.80 | 28.50 | 28.50 | 28.60 | 29.50 | 31.50 | 34.70 | 34.90 | 35.10 | 35.80 | 36.70 | 37.20 | 37.80 | 38.00 | 37.90 |
| 4 | 30.00 | 30.20 | 29.70 | 30.10 | 30.10 | 30.00 | 30.70 | 32.50 | 34.10 | 35.00 | 35.60 | 36.10 | 37.20 | 37.90 | 37.80 | 38.30 | 37.70 |
| 5 | 29.00 | 29.50 | 29.10 | 28.80 | 28.20 | 28.30 | 29.50 | 31.10 | 33.30 | 35.10 | 35.50 | 36.80 | 37.40 | 38.30 | 38.00 | 38.60 | 34.70 |
| 6 | 28.70 | 28.20 | 28.00 | 28.00 | 28.20 | 28.60 | 29.70 | 32.20 | 33.70 | 37.00 | 36.20 | 37.70 | 37.40 | 38.30 | 38.80 | 39.10 | 39.10 |
| 7 | 28.10 | 27.90 | 27.50 | 27.00 | 26.10 | 26.10 | 28.80 | 31.70 | 33.30 | 35.10 | 36.00 | 37.50 | 38.40 | 38.90 | 39.60 | 39.50 | 38.20 |
| 8 | 28.60 | 28.90 | 27.90 | 28.90 | 28.90 | 29.10 | 29.90 | 31.00 | 33.30 | 33.90 | 35.60 | 36.80 | 38.40 | 37.30 | 39.30 | 38.70 | 37.30 |
| 9 | 29.70 | 29.70 | 29.60 | 29.40 | 28.80 | 28.60 | 30.20 | 31.60 | 34.30 | 34.90 | 36.70 | 37.50 | 37.90 | 37.50 | 39.10 | 37.40 | 32.40 |
| 10 | 26.50 | 26.30 | 26.10 | 26.80 | 26.80 | 27.90 | 28.80 | 30.90 | 30.20 | 22.60 | 22.60 | 24.30 | 26.10 | 27.20 | 28.80 | 29.10 | 29.90 |
| 11 | 25.70 | 25.60 | 26.20 | 25.60 | 23.90 | 22.70 | 22.40 | 22.30 | 22.30 | 23.20 | 24.00 | 27.90 | 28.90 | 29.80 | 30.70 | 32.60 | 34.40 |
| 12 | 27.60 | 27.00 | 26.30 | 25.90 | 25.20 | 25.50 | 28.30 | 29.70 | 31.30 | 32.70 | 33.80 | 33.90 | 34.00 | 34.40 | 33.40 | 27.90 | 30.50 |
| 13 | 26.30 | 25.80 | 25.40 | 25.10 | 24.90 | 24.90 | 27.90 | 29.20 | 31.10 | 31.80 | 33.00 | 32.50 | 34.50 | 35.00 | 35.50 | 34.70 | 34.80 |
| 14 | 26.80 | 26.70 | 26.40 | 26.10 | 25.90 | 26.10 | 28.50 | 32.10 | 34.40 | 34.90 | 36.60 | 36.10 | 35.40 | 36.50 | 36.20 | 36.30 | 35.70 |

*Figure 6.4: Entry screen format for the entry of hourly climatic data.*

For the graphical display of data there are two options:

a) to plot the data of any day (see Figure 6.5)

b) to plot the data for the whole month (see Figure 6.6)

Three types of data entry checks are performed for hourly climate data.

a) The entered hourly data can be compared against upper minimum, lower warning level, upper warning level and maximum value.

b) A check is carried out to see if there is a proper match between the manuscript and computed values for minimum, maximum and the average for each day.

c) The monthly minimum, maximum and average are checked. In case of any mismatch the user is prompted to check back with the manuscript entries.

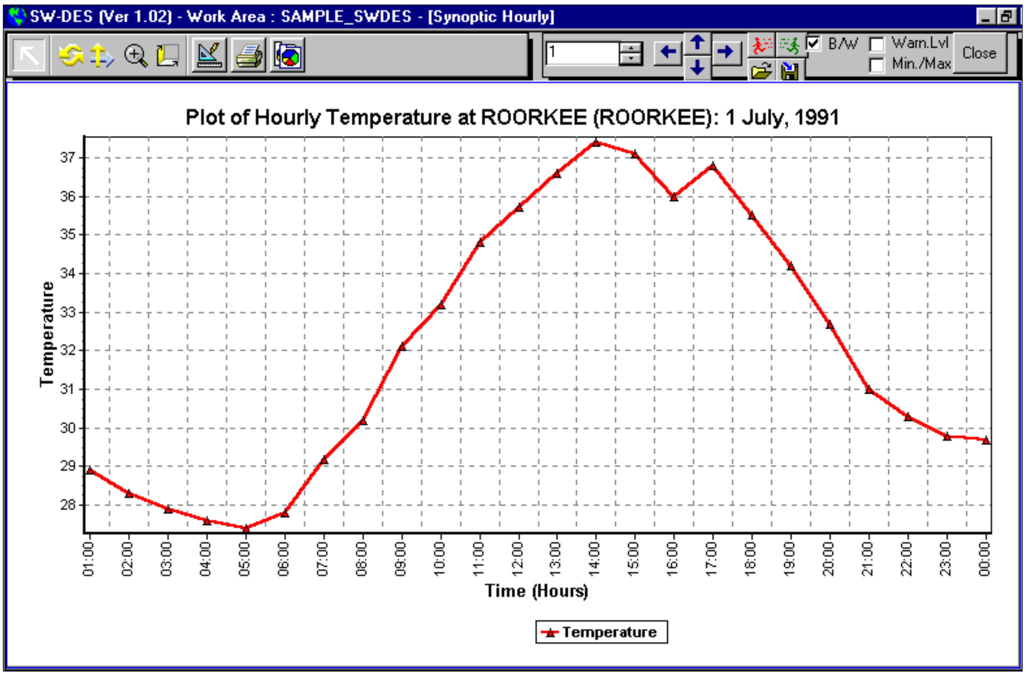



*Figure 6.5: Plot of hourly temperature data for a day*

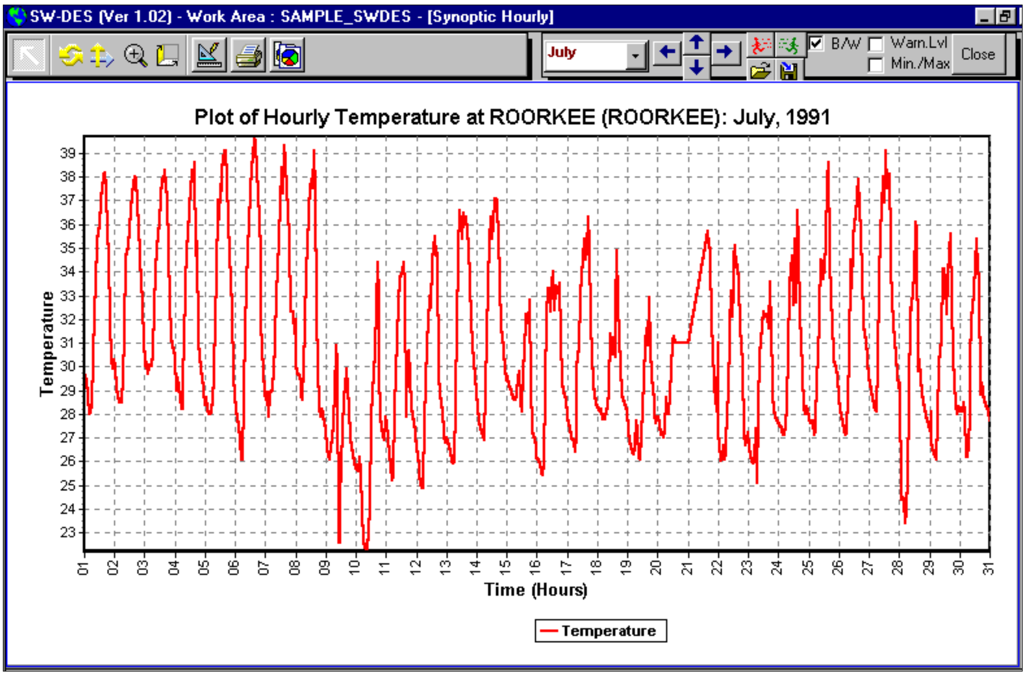
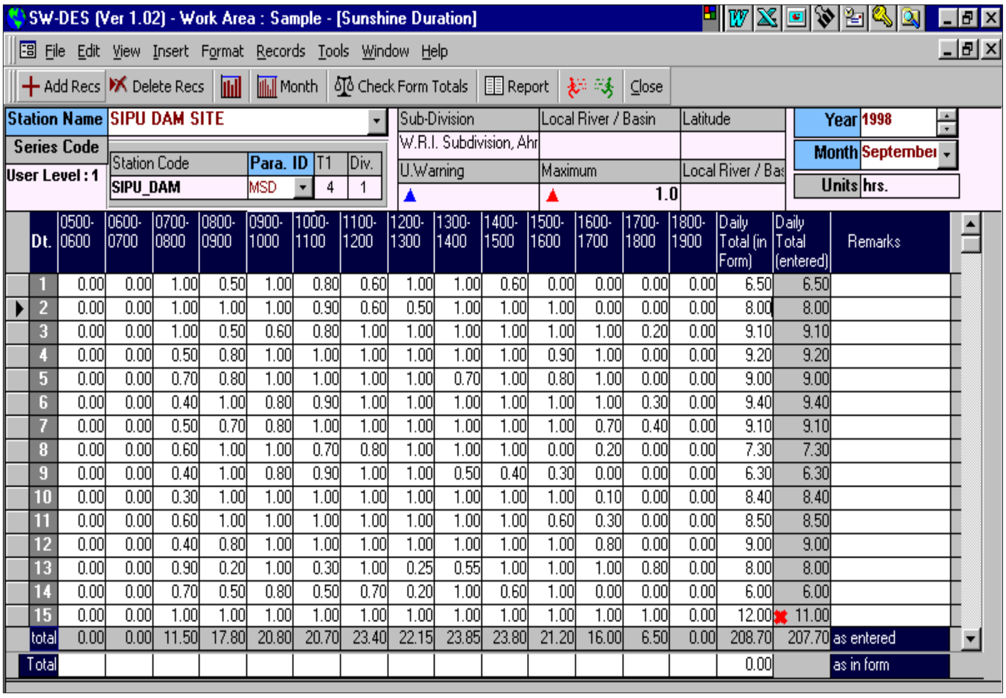



*Figure 6.6: Plot of hourly temperature data for a month*

## 6.7 ENTRY OF HOURLY SUNSHINE DURATION DATA

A special form is provided for the entry of sunshine duration data derived from the analogue strip chart produced by Campbell Stokes sunshine recorders. Sunshine duration is reported for each clock hour starting from 0600 hrs and ending at 1900 hrs. Beyond these hours there is no possibility of having any sunshine at any place within the country. Each hourly value represents the duration of sunshine during the hourly intervals ending at each of these clock hours.

The layout of the hourly sunshine duration form is as shown below:




| Dt. | 0500-0600 | 0600-0700 | 0700-0800 | 0800-0900 | 0900-1000 | 1000-1100 | 1100-1200 | 1200-1300 | 1300-1400 | 1400-1500 | 1500-1600 | 1600-1700 | 1700-1800 | 1800-1900 | Daily Total (in Form) | Daily Total (entered) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 1.00 | 0.50 | 1.00 | 0.80 | 0.60 | 1.00 | 1.00 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 6.50 | 6.50 | |
| 2 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.90 | 0.60 | 0.50 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 8.00 | 8.00 | |
| 3 | 0.00 | 0.00 | 1.00 | 0.50 | 0.60 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.20 | 0.00 | 9.10 | 9.10 | |
| 4 | 0.00 | 0.00 | 0.50 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.90 | 1.00 | 0.00 | 0.00 | 9.20 | 9.20 | |
| 5 | 0.00 | 0.00 | 0.70 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 1.00 | 0.80 | 1.00 | 0.00 | 0.00 | 9.00 | 9.00 | |
| 6 | 0.00 | 0.00 | 0.40 | 1.00 | 0.80 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.30 | 0.00 | 9.40 | 9.40 | |
| 7 | 0.00 | 0.00 | 0.50 | 0.70 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.40 | 0.00 | 9.10 | 9.10 | |
| 8 | 0.00 | 0.00 | 0.60 | 1.00 | 1.00 | 0.70 | 0.80 | 1.00 | 1.00 | 1.00 | 0.00 | 0.20 | 0.00 | 0.00 | 7.30 | 7.30 | |
| 9 | 0.00 | 0.00 | 0.40 | 1.00 | 0.80 | 0.90 | 1.00 | 1.00 | 0.50 | 0.40 | 0.30 | 0.00 | 0.00 | 0.00 | 6.30 | 6.30 | |
| 10 | 0.00 | 0.00 | 0.30 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.10 | 0.00 | 0.00 | 8.40 | 8.40 | |
| 11 | 0.00 | 0.00 | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.60 | 0.30 | 0.00 | 0.00 | 8.50 | 8.50 | |
| 12 | 0.00 | 0.00 | 0.40 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.00 | 0.00 | 9.00 | 9.00 | |
| 13 | 0.00 | 0.00 | 0.90 | 0.20 | 1.00 | 0.30 | 1.00 | 0.25 | 0.55 | 1.00 | 1.00 | 1.00 | 0.80 | 0.00 | 8.00 | 8.00 | |
| 14 | 0.00 | 0.00 | 0.70 | 0.50 | 0.80 | 0.50 | 0.70 | 0.20 | 1.00 | 0.60 | 1.00 | 0.00 | 0.00 | 0.00 | 6.00 | 6.00 | |
| 15 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 12.00 | 11.00 | |
| total | 0.00 | 0.00 | 11.50 | 17.80 | 20.80 | 20.70 | 23.40 | 22.15 | 23.85 | 23.80 | 21.20 | 16.00 | 6.50 | 0.00 | 208.70 | 207.70 | as entered |
| Total | | | | | | | | | | | | | | | 0.00 | | as in form |

*Figure 6.7: Data entry screen for the entry of hourly sunshine duration records*

In common with other data entry screens information on station code, station name sub-division and local river/basin is displayed In this case minimum and maximum limits of 0 and 1 respectively are automatically selected and displayed for reference.

The data entry screen outline is as for other hourly data except that there are 14 columns rather than 24 for entering sunshine duration from 0600 to 1900 hrs. Data entry and checking are otherwise similar to other options. There are two option for making graphs: (a) hourly variation of sunshine during a day and (b) daily variation of sunshine during the month and condensed hourly variation within each day (see Figure 6.8).

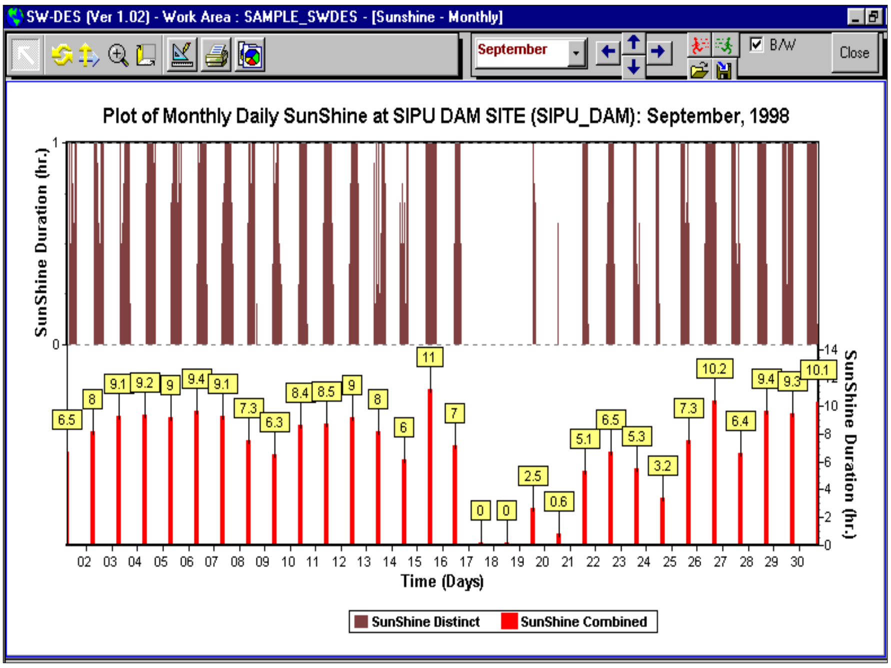



*Figure 6.8: Plot of daily variation of sunshine during a month and condensed hourly variation within each day of the month*

## 6.8 ENTRY OF SPECIAL VARIABLES

Where additional variables are measured at certain principal stations, facility for entry of data is through general entry screens for equidistant or non-equidistant data. Such entries might include:

- soil or earth temperatures at different depths
- net radiation, shortwave radiation or extra terrestrial radiation

Screen can be set up for selected stations for selected measurement intervals and all the checks available for specially designed screens will be available.

# 7 PRIMARY VALIDATION FOR CLIMATIC DATA

## 7.1 GENERAL

Data validation is the means by which data are checked to ensure that the final figure stored in the HIS is the best possible representation of the true value of the variable at the measurement site at a given time or in a given interval of time. Validation recognises that values observed or measured in the field are subject to errors which may be random, systematic or spurious.

Improvement in computing facilities now enables such validation to be carried out whereas in the past, the volume of data and the time required to carry out comprehensive manual validation was prohibitive.

Primary validation of climatic data will be carried out at the Sub-divisional level using primary module and is concerned with data comparisons at a single station:

- for a single data series, between individual observations and pre-set physical limits
- for a single series between sequential observations to detect unacceptable rates of change and deviations from acceptable hydrological behaviour most readily identified graphically
- between two measurements of a variable at a single station, e.g. dry bulb thermometer and a thermograph recorder.

Comparisons between stations for climatic data are not considered in primary validation

## 7.2 AN EXAMPLE WITH LESSONS

Data validation in its simplest form involves inspection of a data set and being able to say what is realistic and what is unrealistic and correcting the unrealistic if it is possible.

The question can then be asked - what is realistic? To the uninitiated it is just a set of numbers. How do we know that one set of numbers is better or worse than the ones which have been provided? To illustrate some general principles a simple example is used of a climatic number set. We are given dry bulb temperatures at a station at hourly intervals;

0700 25.0$^{o}$C

0800 28.0$^{o}$C

0900 40.0$^{o}$C

We could reasonably assume that there was a mistake in one or more of the readings, probably the last. We don't expect the temperature to rise by 12$^{o}$C in one hour. If the next reading at 1000 was 32$^{o}$C we would be even more confident that the figure of 40$^{o}$C entered for 0900 was incorrect and that the most likely cause was that the observer had incorrectly read 40$^{o}$C for 30$^{o}$C (or had read it correctly but written it down wrong). From this simple example we can draw several lessons.

a) The numbers in a data set are representative of a variable and the sequence of the variable represents a physical process which has physical behaviour and physical limits. In the example above the numbers represent a physical process of atmospheric warming under the influence of solar radiation. A rise in temperature of 12$^{o}$C in one hour is quite unrealistic. The lesson is that if we want to know what is realistic we must first understand the physical process, its behaviour and limits.
b) The method of measurement or observation influences our view of why the data are suspect. In the example above, we can make a reasonable guess of the source of the error because we know that the measurement was taken manually by an observer. Observers are not infallible; they make mistakes - even the best observers. The lesson here is that to understand the source of errors we must understand the method of measurement or observation in the field and the typical errors of given instruments and techniques.

Data validation must never be considered a purely statistical or mathematical exercise. Staff involved in it must understand the physical process and field practice.

c) Graphical inspection permits detection of errors which are more difficult to identify by numerical techniques. Take for example a variation on the above set of temperatures. Say, the temperature listed in the data set at 0900 was 35$^{o}$C would we still consider that the value was a mistake? Perhaps yes, but we would not be so certain; we would consider it suspicious but not impossible. If such a value were plotted on a graph for the day as available in SWDES and HYMOS, an error both for 40$^{o}$C and for 35$^{o}$C becomes a near certainty

Primary validation will therefore be considered, variable by variable, looking in summary at the physical process, behaviour and limits, and then its field measurement and typical errors, for the following variables:

- Temperature
- Humidity
- Wind speed
- Pan evaporation
- Atmospheric pressure
- Sunshine

## 7.3 PRIMARY VALIDATION OF TEMPERATURE

### 7.3.1 TEMPERATURE VARIATION AND CONTROLS

Temperature is a measure of the ability of a body (in this case the atmosphere) to communicate heat to other bodies and to receive heat from them (IMD definition). Temperature varies primarily with the magnitude of solar radiation and observes cyclic diurnal and seasonal patterns. It is influenced at particular times by prevailing air masses and by the incursion of air masses from other source areas with different insolation properties and by prevailing cloudiness which limits incoming radiation. These factors limit the maximum and minimum temperatures which are expected at a given location for given season and time of day. They also limit the rates of change expected from hour to hour and from day to day.

With respect to location, temperature varies with latitude (which controls solar radiation), altitude and proximity to the ocean. Generally temperature is a spatially conservative element which has strong correlation (at least on an averaged basis) with neighbouring stations within the same air mass. There is normally a regular decrease in mean temperature with altitude at a rate of approximately 0.6$^o$C per 100 metres for moist air and 0.9$^o$C for dry air. Stations in close proximity to the sea have their temperature moderated by its influence so that maxima tend not to be so high, minima not so low, thus giving a reduced diurnal range.

Specific site conditions also affect the temperature measured. Stations in topographic hollows may experience temperature inversions in calm conditions, reversing the normal lapse rate of temperature with altitude. Stations sited in urban areas have generally higher temperatures than adjacent rural areas. The nearby prevailing ground cover, whether bare or vegetated, influences the measured temperature - including the proximity of trees which shade the site or of buildings which alternately shade and reflect heat to the station.

Validation based on location and site conditions are best considered in the comparison between stations and is discussed under secondary validation.

### 7.3.2 TEMPERATURE MEASUREMENT

Temperature is periodically observed (once or twice daily) using a set of four thermometers, located in a thermometer (or Stevenson) screen, which from its construction and installation provides a standard condition of ventilation and shade. The four thermometers are:

| | |
|---|---|
| Dry bulb thermometer - | measuring ambient air temperature |
| Wet bulb thermometer - | which provides a basis for calculating relative humidity |
| Maximum thermometer - | to indicate the highest temperature reached since the last setting |
| Minimum thermometer - | to indicate the lowest temperature reached since the last setting. |

Graduations are etched on the glass stem of the thermometer. In the case of the dry bulb, wet bulb and maximum thermometers, observations are of the position of the end of the mercury column but in the case of the minimum thermometer, the reading is taken of the position of the end of the dumb-bell shaped index furthest from the bulb. Each thermometer has a calibration card which shows the difference between the true temperature and that registered by the thermometer. Corrections for a given temperature are applied to each observation. When the maximum and minimum thermometers have been read they are reset (twice per day for minimum; once per day for maximum) using a standard procedure.

Temperature is also measured continuously using a thermograph in which changes in temperature are recorded through the use of a bi-metallic strip. The temperature is registered on a chart on a clock-driven revolving drum and the measurement (chart) period may be either one day or one week. The observer extracts temperatures at a selected interval from the chart. The manually observed reading on the dry bulb thermometer is measured and recorded at the beginning and end of the chart period and if these differ from the chart value, a correction is applied to the chart readings at the selected interval.

### 7.3.3 TYPICAL MEASUREMENT ERRORS

- Observer error in reading the thermometer, often error of 1$^o$C (difficult to detect) but sometimes 5$^o$C or 10$^o$C. Such errors are made more common in thermometers with faint graduation etchings.
- Observer error in registering the thermometer reading
- Observer reading meniscus level in minimum thermometer rather than index
- Thermometer fault - breaks in the mercury thread of the dry, wet or maximum thermometer

- Thermometer fault - failure of constriction of the maximum thermometer
- Thermometer fault - break in the spirit column of minimum thermometer or spirit lodged at the top or bubble in the bulb.
- Thermograph out of calibration and no correction made.

Thermometer faults will result in individual or persistent systematic errors in temperature.

### 7.3.4 ERROR DETECTION

Many of the above faults will have been identified by the field supervisor or at data entry but others may be identified by setting up appropriate maximum minimum and warning limits for the station in question. These may be altered seasonally. For example, summer maximum temperature can be expected not to exceed 50$^{o}$C nor winter maximum temperature to exceed 33$^{o}$C.

Other checks carried out by SWDES include:

- Dry bulb temperature should be greater than or (rarely) equal to the wet bulb temperature.
- Maximum temperature should be greater than minimum temperature
- Maximum temperature measured using the maximum thermometer should be greater than or equal to the maximum temperature recorded by the dry bulb during the interval, including the time of maximum observation. The value of the maximum will be set to the observed maximum on the dry bulb if this is greater.
- Minimum temperature should be less than or equal to the minimum temperature recorded by the minimum thermometer during the interval, including the time of observation of the minimum thermometer. The value of the minimum will be set to the observed minimum on the dry bulb if this is lower.
- Thermograph readings at time of putting on and taking off should agree with the manually observed readings.

## 7.4 PRIMARY VALIDATION OF HUMIDITY

### 7.4.1 HUMIDITY VARIATIONS AND CONTROL

The standard means of assessing the relative humidity or moisture content of the air is by means of the joint measurement of dry bulb and wet bulb temperature. From these two measurements, the dew point temperature, actual and saturated vapour pressures may also be calculated. The relative humidity (%) is the ratio of the actual vapour pressure to saturated vapour pressure corresponding to the dry bulb temperature. Whilst the actual vapour pressure may vary little during the day (except with the incursion of a new air mass), the relative humidity has a regular diurnal pattern with a minimum normally coinciding with the highest temperature (when the saturation vapour pressure is at its highest). It also shows a regular seasonal variation.

Generally relative humidity is a spatially conservative element which has strong correlation (at least on an average basis) with neighbouring stations within the same air mass. Stations in close proximity to the sea have higher relative humidities than those inland and a smaller daily range.

### 7.4.2 HUMIDITY MEASUREMENT

Wet and dry bulb thermometers used for temperature assessment also used for calculating various measures of humidity. The wet bulb is covered with a clean muslin sleeve, tied round the bulb by a cotton wick which is then led to a water container, by which the wick and muslin are kept constantly moist.

The observer calculates the relative humidity from the wet bulb depression using a set of tables.

Relative humidity may also be measured continuously by means of hygrograph in which the sensor is human hair whose length varies with relative humidity. The humidity is registered on a chart on a clock-driven revolving drum and the measurement (chart) period may be either one day or one week. The observer extracts humidity at a selected interval from the chart. A manually computed reading from dry and wet bulb thermometers is recorded at the beginning and end of the chart period and if these differ from the chart value, a correction is applied to the chart readings at the selected interval.

### 7.4.3 TYPICAL MEASUREMENT ERRORS

Measurement errors using dry and wet bulb thermometers in the assessment of humidity are the same as those for temperature. In addition an error will occur if the muslin and wick of the wet bulb are not adequately saturated. Similarly there will be an error if the muslin becomes dirty or covered by grease. These defects will tend to give too high a reading of wet bulb temperature and consequently too high a reading of relative humidity. Errors in the hygrograph may also result from poor calibration or the failure to correct for manually observed values at the beginning and end of the chart period.

### 7.4.4 ERROR DETECTION

Errors may be detected by setting up upper and lower warning limits appropriate to the station and season. The maximum is set at 100%. If the wet bulb is greater than dry bulb and the resulting calculated relative humidity is greater than 100%, then the observation will be rejected by SWDES. Graphic inspection of the daily series can be used to identify any anomalous values.

The observer calculated values of relative humidity may be compared with those calculated by the computer. However in view of the fact that the calculation can be done very simply in the office there seems little point in continuing the field calculation except in those cases where it is used to calibrate the hygrograph.

Accompanying field notes should be inspected for observations by the supervisor of errors in the thermometers or of a dry or dirty muslin. Hygrograph records can be inspected for departures of starting and finishing values measured by manual methods.

## 7.5 PRIMARY VALIDATION OF WIND SPEED

### 7.5.1 WINDSPEED VARIATIONS AND CONTROLS

Wind speed is of particular importance in hydrology as it controls the advective component of evaporation. Wind speed exhibits wide variation not only from place to place but also shows strong diurnal variation at the same place. Wind flow and speeds are controlled by local pressure anomalies which in turn are controlled by the temperature. It may also be influenced by local topographic features which may funnel the wind and increase it above the areal average; conversely some stations will have wind speeds reduced by shelter. Extraordinary wind speeds may be experienced in some parts of the country through the incursion of tropical cyclones.

### 7.5.2 MEASUREMENT OF WIND SPEED AND DIRECTION

Wind speed is measured using an anemometer, usually a cup counter anemometer. The rate of rotation of the anemometer is translated by a gear arrangement to read accumulated wind total (km) on a counter. By observing the counter reading at the beginning and end of a period, the wind run over the period can be determined and the average speed over the interval can be determined by dividing by the time interval. Standard Indian practice is to measure the wind speed over a three minute period as representing an effectively instantaneous wind speed at the time of observation. Daily wind run or average wind speed is also calculated from counter readings on successive days at the principal observation times.

Wind direction is commonly measured and may be used in the calculation of evapo-transpiration with respect to finding the fetch of the wind. It is observed using a wind vane and reported as 16 points of the compass either as a numerical figure or an alpha character

### 7.5.3 TYPICAL MEASUREMENT ERRORS

Errors in wind speed might arise as the result of observer errors of the counter total, or arithmetic errors in the calculation of wind run or average wind speed. Instrumental errors might arise from poor maintenance or damage to the spindle which might thus result in reduced revolutions for given wind speed.

### 7.5.4 ERROR DETECTION

Because of extreme variability in wind speed in space and time, it is difficult to set up convincing rules to detect suspect values. Nevertheless simple checks are as follows:

- Wind speeds should be zero where the direction is reported as ‘0’ (calm)
- Wind speeds cannot exceed 5 km/hr when the wind speed is reported as variable.
- Wind speeds in excess of 200 km per hour should be considered suspect and will result in a warning flag.

## 7.6 PRIMARY VALIDATION OF ATMOSPHERIC PRESSURE

### 7.6.1 ATMOSPHERIC PRESSURE VARIATIONS AND CONTROLS

Atmospheric pressure is a measure of the weight of the air column vertically above a unit area. The principal variation is with altitude but a correction is always made to reduce the observed measurement of pressure to a standard sea level pressure so that spatial variations can be more readily investigated.

Pressure changes within a relatively narrow range and rates of change are comparatively slow. Lowest pressures and the most rapid rates of change are experienced in tropical cyclones.

Variations in atmospheric pressure are of great importance in weather forecasting but its influence on evapotranspiration is very limited and can often be assessed with acceptable accuracy with the use of a mean value of atmospheric pressure. It is of importance for pressure correction where non-vented pressure transducers are used for the measurement of water level.

### 7.6.2 MEASUREMENT OF ATMOSPHERIC PRESSURE

Atmospheric pressure is usually measured using a mercury barometer where the weight of the mercury column represents the atmospheric pressure. Commonly the Kew pattern barometer is used in India. It is read using a Vernier scale. Corrections are made for index error and for temperature (reducing to a standard temperature of 0oC using a set of tables. It is also reduced to mean sea level pressure.

A barograph is also used for the continuous measurement of pressure. It consists of an aneroid sensor which expands and contracts with changes in pressure. These are registered on a clock-driven drum chart. Values of pressure may be extracted at hourly or other intervals from the chart and it is calibrated and set up to correspond with the reading using the more accurate mercury barometer.

### 7.6.3 TYPICAL MEASUREMENT ERRORS

Observer errors may result from incorrect observation incorrect registration or in the application of corrections for temperature or reduction to sea level. Observation problems can result from the use of the Vernier scale.

Instrumental errors result from the entry of air into the space above the mercury and mechanical defects in the Vernier head.

### 7.6.4 ERROR DETECTION

Primary validation is mainly through the setting up of upper and lower warning and maximum and minimum limits. Values outside the maximum and minimum limits are rejected; values outside the warning limits are flagged.

## 7.7 PRIMARY VALIDATION OF SUNSHINE DURATION

### 7.7.1 SUNSHINE VARIATIONS AND CONTROLS

Sunshine duration is a very important contributor to the evapotranspiration equation and is widely used in the absence of direct measurements of radiation. The potential maximum sunshine duration varies regularly with latitude and with season. Actual sunshine also varies with ambient weather conditions and is generally lower during the monsoon than during the dry season. In urban areas the amount of bright sunshine may be reduced by atmospheric pollution and in coastal areas it may be reduced by sea mists.

### 7.7.2 MEASUREMENT OF SUNSHINE

The only instrument in common use in India for sunshine measurement is the Campbell Stokes sunshine recorder. This consists of a glass sphere mounted on a section of a spherical bowl. The sphere focuses the sun's rays on a card graduated in hours, held in the grooves of the bowl which burns the card linearly through the day when the sun is shining. The card is changed daily after sunset. Hence the sunshine recorder uses the movement of the sun instead of a clock to form the time basis of the record. Different grooves in the bowl must be used in winter summer and the equinoxes, taking different card types. The total length of the burn in each hour gives an hourly sunshine duration.

### 7.7.3 TYPICAL MEASUREMENT ERRORS

The instrument is very simple in principle and the use of the sun rather than a clock as a time base avoids timing errors. Potential errors may arise from the use of the wrong chart which may result in the burn reaching the edge of the chart, beyond which it is not registered. Possible errors may result from extraction of information from the chart by the observer.

### 7.7.4 ERROR DETECTION

SWDES may be used to detect and if necessary reject suspect values. Thus:

- Values of hourly sunshine greater than 1.0 or less than 0.0 are not permitted
- Sunshine records before 0500 and after 1900 are rejected and hence daily totals greater than 14.0 hours are rejected.

Daily warning limits may be set seasonally within SWDES based on the maximum possible sunshine for the location and time of year.

# 7.8 PRIMARY VALIDATION OF PAN EVAPORATION

## 7.8.1 PAN EVAPORATION VARIATIONS AND CONTROLS

Evaporation is the process by which water changes from the liquid to the vapour state. Pan evaporation provides an estimate of open water evaporation. It is a continuous process in which the rate of evaporation depends on a wide range of climatic factors:

- amount of incoming solar radiation (represented by sunshine hours)
- temperature of the air and the evaporating surface
- saturation deficit - the amount of water that can be taken up by the air before it becomes saturated (represented in measurement by the wet bulb depression)
- wind speed

Evaporation again maintains a regular seasonal pattern with highest totals before the onset of the monsoon, during which evaporation is suppressed by decreasing saturation deficit.

## 7.8.2 MEASUREMENT OF PAN EVAPORATION

The standard measurement in India is made using the US Class A pan evaporimeter. It is a circular pan 1.22 m in diameter and 0.255 m deep. It rests on a white painted wooden stand and is maintained level. The pan is covered by a wire mesh to avoid loss of water due to birds and animals. The inner base of the pan is painted white. A stilling well is situated in the pan within which there is a pointer gauge. Measurement must take account not only of evaporation losses but also gains due to rainfall; the raingauge nearby is used to assess the depth of rain falling in the pan.

On days without rain at daily (or twice-daily) reading, water is poured into the pan using a graduated brass cylinder (cup) to bring the level up precisely to the top of the pointer gauge. The number of cups (and part cups) is recorded and represents a depth of evaporation.

On days with rain since the last observation the rainfall may exceed evaporation and water must be removed from the pan to bring it to the hook level. The adjacent raingauge is used to assess the rainfall inflow.

On days with forecast heavy rainfall a measured amount of water may be removed from the pan in advance of the rainfall occurrence (to avoid pan overflow)

## 7.8.3 TYPICAL MEASUREMENT ERRORS

- Observer errors - the observer over- or underfills the pan - such values will be compensated for the following day
- Instrument errors
  - Leakage: this is the most serious problem and it occurs usually at the joint between the base and the side wall. Small leaks are often difficult to detect in the field but may have a significant systematic effect on measured evaporation totals.
  - Animals may gain access to the pan, especially if the wire mesh is damaged
  - Algae and dirt in the water will reduce the measured rate of evaporation
  - Errors arise in periods of high rainfall when the depth caught by the raingauge is different in depth from the depth caught in the pan as a result of splash or wind eddies round the gauges.

#### 7.8.4 ERROR DETECTION

Warning and maximum limits may again be allocated to screen spurious values arising from observer error, leakage, animal interference or dirty water.

Where leakage has been identified and is recorded in the field record book, the records for a period preceding the discovery will be inspected and flagged as suspect and for review under secondary validation

# 8 ENTRY OF WATER LEVEL DATA

## 8.1 GENERAL

The receipt of water level data at Sub-divisional offices from gauging stations is first recorded on a standard form with the date of the receipt.

Field tabulations and chart records are then scrutinised for obvious errors before entry to computer.

Primary module of dedicated hydrological data processing system (SWDES) is available to facilitate data entry. Data entry is simplified by screen format which matches typical formats from observational records, such that observed values can be entered against pre-formatted date and time.

Data are then entered to computer using the keyboard for observered tabulated data on data sheets from staff gauges and data extracted from autographic charts, or directly loaded from data logger files for digital data. From the staff gauges the observations are generally made once in a day in lean season and at multiple times a day during flood times. For a flashy river staff gauges may even be read at hourly intervals during flood season. However, standard timings are generally followed for the observations during the day by different agencies. An autographic type of water level recorder on the other hand gives a continuous record of water level in time. Levels are extracted manually from these autographic records and the data are normally reported at hourly time interval. Digital data from a digital water level recorder can either be at equal intervals of time (usually at quarter, half hour or hourly intervals) or can be reported for only those instances when there is a change in water level which is more than a pre-set amount. This latter option will only rarely be used. The entry of all such water level data series can be accomplished using various forms as described below:

SWDES provides data entry checking, ensuring correct entry of station name and parameter name and rejection of alpha characters in a numeric field. Provision is also made for graphical inspection of time series graphs.

## 8.2 SCRUTINY OF MANUSCRIPTS, ANALOGUE AND DIGITAL WATER LEVEL RECORDS

Before keying in of data to the computer, staff gauge water level tabulations must be checked for correct entry of station name, year month and date, and any ambiguity in handwriting in the tabulated numbers.

Similarly a rapid comparison is made between levels registered on the autographic chart and tabulated staff gauge readings. In particular, levels of peaks and troughs in the hydrograph should be compared and unclear hand-written values checked. Where uncertainty remains, reference should be made back to the observer or field supervisor for clarification.

Improper entry to the 31st day of a month with 30 days is unfortunately a common observer error. Such fabrications by the observer suggest that other values have also been incorrectly entered. Such entries should be reported to the Divisional office to facilitate correction following secondary validation. They should also be reported to the field supervisor to ensure that such mistakes are not repeated.

Digital records downloaded from the data loggers are also checked for valid station/instrument identification, dates and timings etc.

## 8.3 ENTRY OF WATER LEVELS AT MULTIPLE TIMES A DAY

The layout of the form for water level observations at multiple times a day is as shown in Figure 8.1.

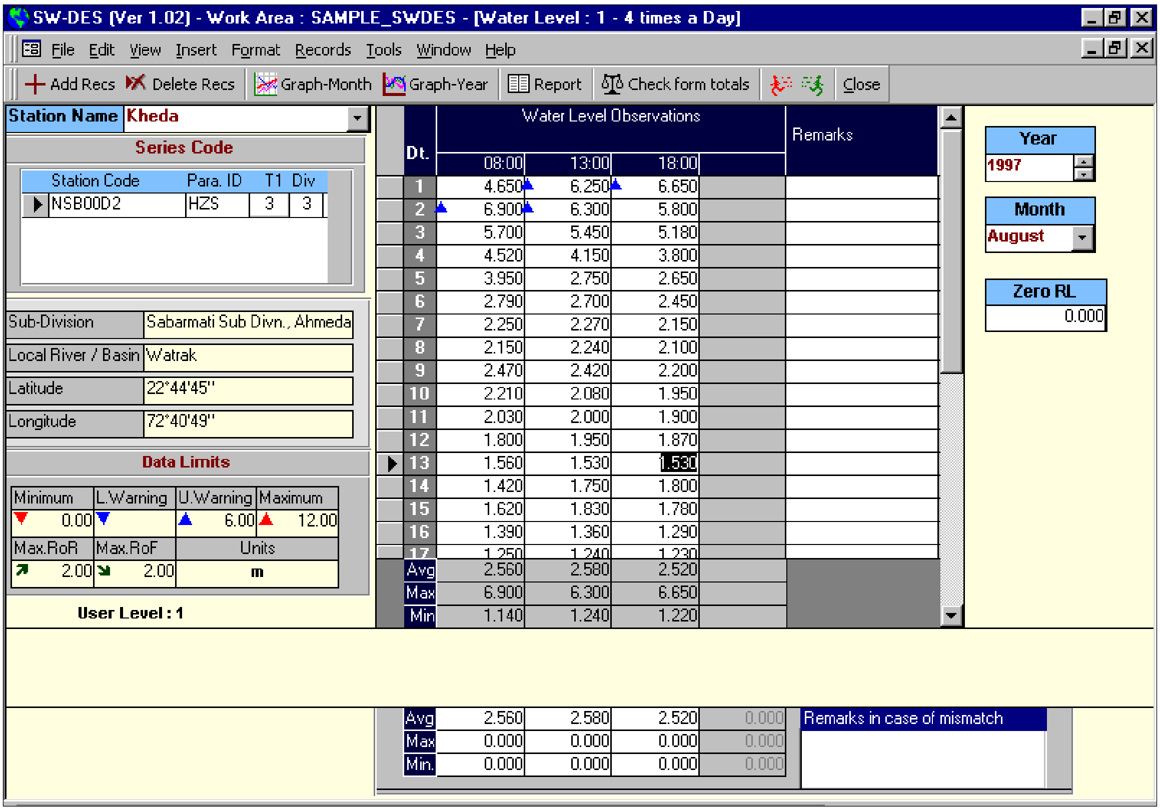



*Figure 8.1: Form for entry of water level data at multiple times a day.*

The station and series to which data are to be entered are selected from a list and the displayed entry form shows the station code, station name, Sub-division, location River/Basin and the reduced level (R.L.) of the gauge zero. Using the mouse or arrow keys, the data processor may scroll through the data to the required date and time.

Facility is available to enter data limits to provide a numerical basis for checking spurious entries or extreme observations. There are six data limits displayed on the screen:

- minimum level
- lower warning level
- upper warning level
- maximum value
- maximum rate of rise
- maximum rate of fall

Once entered these data limits are rarely altered.

The data for a complete month are entered in the tabular form. The rows represent the days in the month and number of column(s) are for each observation in the day. The first column gives the day of the month and is automatically filled up according to the month and year. The data corresponding to each observation in the day is entered by the user. The cursor automatically moves first from observation to observation within a day and then the control moves to the next day. If a remark is to be entered for any day it can be entered by moving to that remark slot using the arrow keys or mouse. At the bottom of the form, for each observation time in the day, the average, maximum and minimum values, as available in the manuscript must be entered and the corresponding computed values from the tabulated entries are automatically filled.

The data processor can draw a graph of the data entered and data limits previously specified may be shown on the graph. There are two options:

a) to plot the data of the whole month for which the entries are being made (Figure 8.2)
b) to plot the data of the entire year for which the data are being entered (Figure 8.3).

Two types of data entry check are performed for water level data at multiple times a day.

a) The entered daily data are compared against minimum value, lower warning level, upper warning level, maximum value, maximum rate of rise and/or minimum rate of rise.
b) A check is carried out to see if there is a proper match between the entered and computed values for the monthly average, maximum and minimum values for each observation in the day. The user is suitably prompted where there is a mismatch so that the entries can be re-checked. Where a mismatch remains (for example due to observer error or unclear readings), a slot is available to make comments to aid subsequent validation.

Scrutinising and checking the water level data month by month in this manner will leave little scope of any data being wrongly entered.

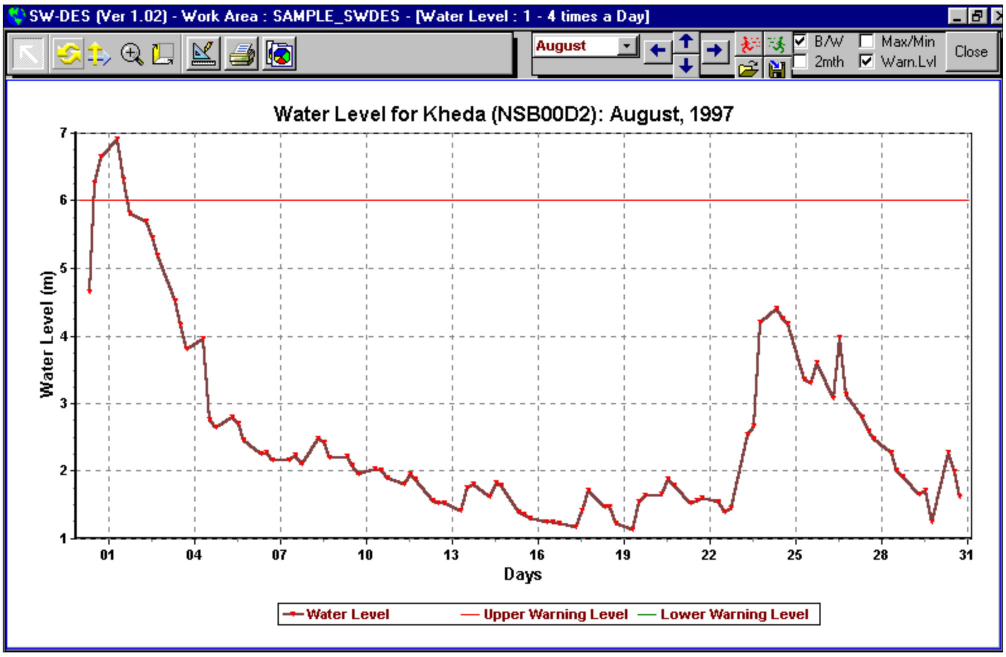



*Figure 8.2: Plot of multiple times a day water level data for a month.*

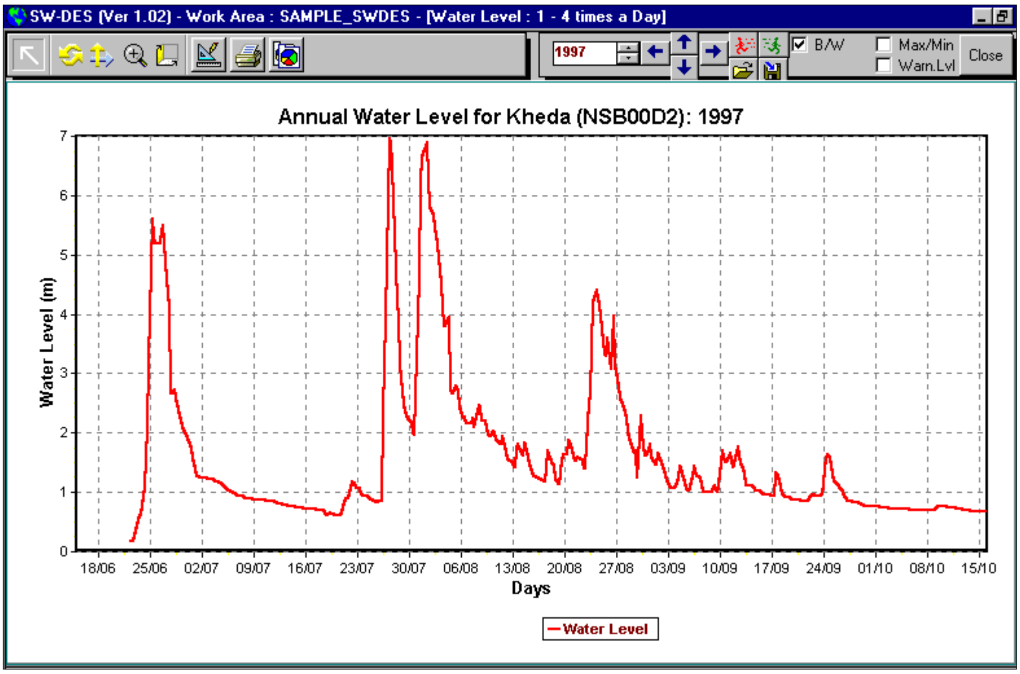
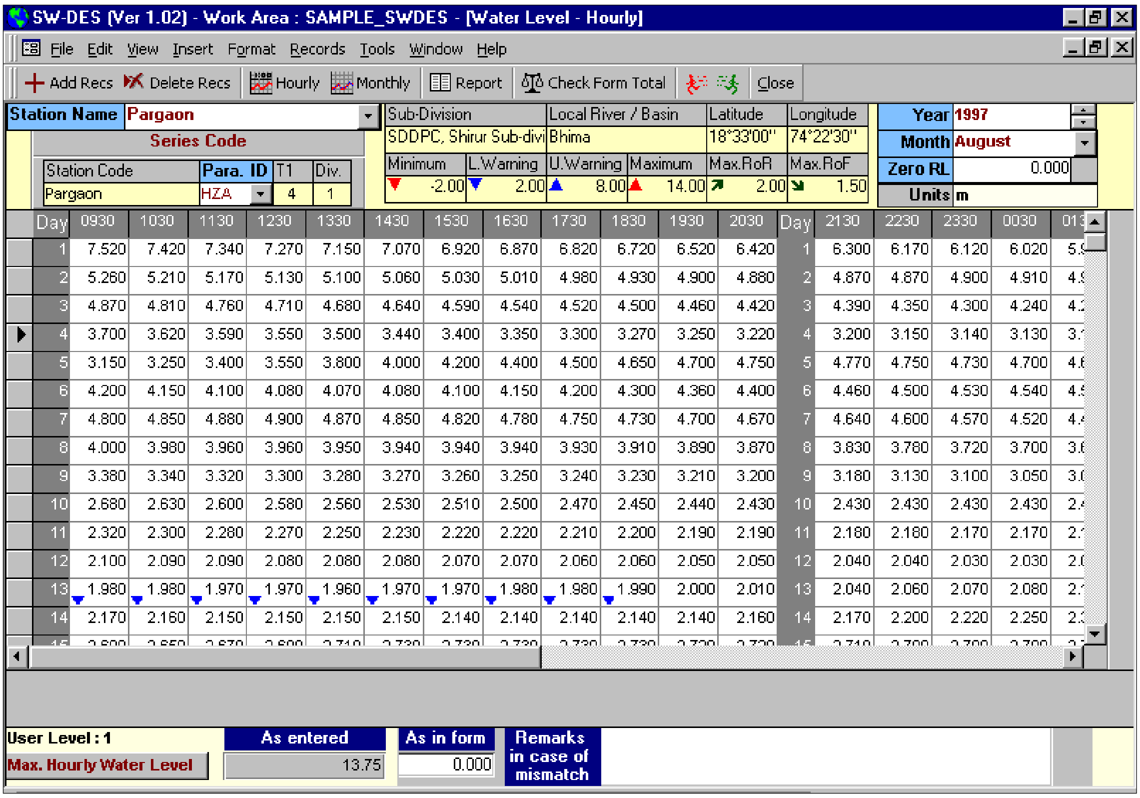



*Figure 8.3: Plot of multiple times a day water level data for a year.*

## 8.4 ENTRY OF HOURLY WATER LEVELS

Hourly water level data are obtained in tabulated form from the chart records of the autographic type recorders. The layout of the hourly water level form is as shown in Figure 6.4:




| Day | 0930 | 1030 | 1130 | 1230 | 1330 | 1430 | 1530 | 1630 | 1730 | 1830 | 1930 | 2030 | Day | 2130 | 2230 | 2330 | 0030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.520 | 7.420 | 7.340 | 7.270 | 7.150 | 7.070 | 6.920 | 6.870 | 6.820 | 6.720 | 6.520 | 6.420 | 1 | 6.300 | 6.170 | 6.120 | 6.020 |
| 2 | 5.260 | 5.210 | 5.170 | 5.130 | 5.100 | 5.060 | 5.030 | 5.010 | 4.980 | 4.930 | 4.900 | 4.880 | 2 | 4.870 | 4.870 | 4.900 | 4.910 |
| 3 | 4.870 | 4.810 | 4.760 | 4.710 | 4.680 | 4.640 | 4.590 | 4.540 | 4.520 | 4.500 | 4.460 | 4.420 | 3 | 4.390 | 4.350 | 4.300 | 4.240 |
| 4 | 3.700 | 3.620 | 3.590 | 3.550 | 3.500 | 3.440 | 3.400 | 3.350 | 3.300 | 3.270 | 3.250 | 3.220 | 4 | 3.200 | 3.150 | 3.140 | 3.130 |
| 5 | 3.150 | 3.250 | 3.400 | 3.550 | 3.800 | 4.000 | 4.200 | 4.400 | 4.500 | 4.650 | 4.700 | 4.750 | 5 | 4.770 | 4.750 | 4.730 | 4.700 |
| 6 | 4.200 | 4.150 | 4.100 | 4.080 | 4.070 | 4.080 | 4.100 | 4.150 | 4.200 | 4.300 | 4.360 | 4.400 | 6 | 4.460 | 4.500 | 4.530 | 4.540 |
| 7 | 4.800 | 4.850 | 4.880 | 4.900 | 4.870 | 4.850 | 4.820 | 4.780 | 4.750 | 4.730 | 4.700 | 4.670 | 7 | 4.640 | 4.600 | 4.570 | 4.520 |
| 8 | 4.000 | 3.980 | 3.960 | 3.960 | 3.950 | 3.940 | 3.940 | 3.940 | 3.930 | 3.910 | 3.890 | 3.870 | 8 | 3.830 | 3.780 | 3.720 | 3.700 |
| 9 | 3.380 | 3.340 | 3.320 | 3.300 | 3.280 | 3.270 | 3.260 | 3.250 | 3.240 | 3.230 | 3.210 | 3.200 | 9 | 3.180 | 3.130 | 3.100 | 3.050 |
| 10 | 2.680 | 2.630 | 2.600 | 2.580 | 2.560 | 2.530 | 2.510 | 2.500 | 2.470 | 2.450 | 2.440 | 2.430 | 10 | 2.430 | 2.430 | 2.430 | 2.430 |
| 11 | 2.320 | 2.300 | 2.280 | 2.270 | 2.250 | 2.230 | 2.220 | 2.220 | 2.210 | 2.200 | 2.190 | 2.190 | 11 | 2.180 | 2.180 | 2.170 | 2.170 |
| 12 | 2.100 | 2.090 | 2.090 | 2.080 | 2.080 | 2.080 | 2.070 | 2.070 | 2.060 | 2.060 | 2.050 | 2.050 | 12 | 2.040 | 2.040 | 2.030 | 2.030 |
| 13 | 1.980 | 1.980 | 1.970 | 1.970 | 1.960 | 1.970 | 1.970 | 1.980 | 1.980 | 1.990 | 2.000 | 2.010 | 13 | 2.040 | 2.060 | 2.070 | 2.080 |
| 14 | 2.170 | 2.160 | 2.150 | 2.150 | 2.150 | 2.150 | 2.140 | 2.140 | 2.140 | 2.140 | 2.140 | 2.160 | 14 | 2.170 | 2.200 | 2.220 | 2.250 |



*Figure 8.4: Form for entry of hourly water level data.*

The form again displays information on station code, station name, sub-division and local river/basin, reduced level of gauge zero and the six data limits: The year and month of the data displayed on the screen are also displayed for reference purpose.

Water level data are entered in a form of a matrix in which the columns are the hourly values for a day and the rows represents different days of the month. The entries for the dates and hours are filled automatically. All the hourly values are entered by navigating horizontally across the day. At the end of each day's entry the cursor moves to the column for entering the daily minimum, maximum and average as available in the manuscript. The corresponding statistics as per the entries made are computed and filled automatically. Remarks, if available in the manuscript, can be entered on a daily basis.

For graphical display of data there are two options:

a) to plot the data of any day from 0100 to 2400 hrs. and

b) to plot the data for the complete month (see Figure 8.5)

The latter option is very useful in comparing the entered data with the autographic chart record. The user can navigate through different days in the month to see the corresponding plots without leaving the graph.

Two types of data entry checks are performed for hourly water level data.

a) The entered hourly data are compared against minimum value, lower warning level, upper warning level, maximum value, maximum rate of rise and/or minimum rate of rise.

b) A check is carried out to see if there is a proper match between the entered and computed values for daily minimum, maximum and average water levels for each day. The user is suitably prompted where there is a mismatch so that the entries can be re-checked.

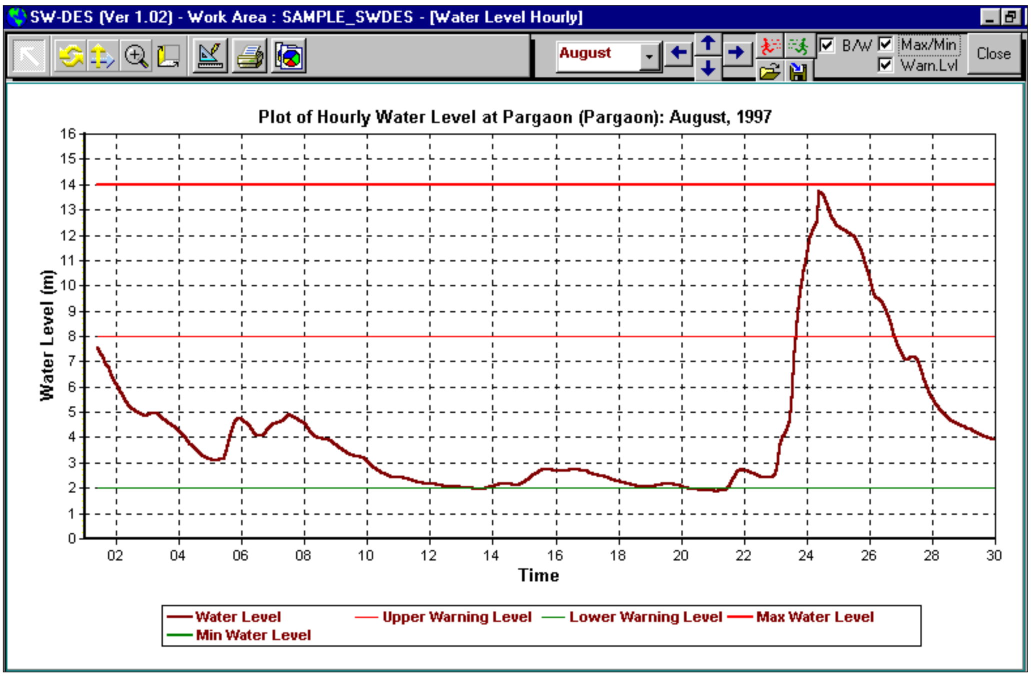



*Figure 8.5: Plot of hourly water level data for a month*

# 9 PRIMARY VALIDATION OF WATER LEVEL DATA

## 9.1 GENERAL

Data validation is the means by which data are checked to ensure that the final figure stored in the HIS is the best possible representation of the true value of the variable at the measurement site at a given time or in a given interval of time. Validation recognises that values observed or measured in the field are subject to errors which may be random, systematic or spurious.

Stage or water level is the elevation of water surface above an established datum; it is the basic measure representing the state of a water body. Records of stage are used with a stage-discharge relation in computing the record of stream discharge. The reliability of the discharge record is dependent on the reliability of the stage record and on the stage discharge relation. Stage is also used to characterise the state of a water body for management purposes like the filling of reservoirs, navigation depths, flood inundation etc. Stage is usually expressed in metres or in hundreds or thousandths of a metre.

Primary validation of water level data will be carried out at the Sub-divisional level using Primary module of dedicated hydrological data processing software and is concerned with data comparisons at a single station:

for a single data series, between individual observations and pre-set physical limits

between two measurements of a variable at a single station, e.g. staff gauges and levels recorded by an automatic or digital water level recorder

Data entry checks will already have been carried out to ensure that there have been no transcription errors from the field sheets to the database. Some doubtful values may already have been flagged.

Where a doubtful or incorrect value is identified, this should be marked with a ‘flag’ to indicate that it is ‘suspect’. In some instances it may be possible to replace this value with a corrected value, in which case the replacement value is flagged ‘corrected’. Otherwise ‘suspect’ values remain flagged for secondary validation. Missing values may be interpolated as stage or as discharge depending on the nature and duration of missing or faulty records and the availability of records on which to base interpolation.

## 9.2 INSTRUMENTS AND OBSERVATIONAL METHODS

The method of measurement or observation influences our view of why data are suspect. To understand the source of errors we must understand the method of measurement or observation in the field and the typical errors of given instruments and techniques.

Data validation must never be considered a purely statistical or mathematical exercise. Staff involved in it must understand the field practice.

Three basic instruments are in use at river gauging stations for measurement of water level.

- Staff gauges
- Autographic water level recorders
- Digital water level recorders

### 9.2.1 STAFF GAUGES

***Instrument and procedure***

The staff gauge is the primary means of measurement at a gauging station, the zero of which is the datum for the station. It is a manually read gauge and other recording gauges which may exist at a station are calibrated and checked against the staff gauge level. Staff gauges are located directly in the river. An additional staff gauge may be situated within the stilling well but this must not be used to calibrate recording instruments as it may be affected by blockage of the intake pipe. Where the staff gauge is the only means of measurement at a station, observations are generally made once a day in the lean season and at multiple times a day during a flood period - even at hourly intervals during flood season on flashy rivers.

***Typical measurement errors***

Staff gauges like other manual measurements, are dependent on the observer's ability and reliability and it must not be assumed that these are flawless. Checking on the performance of the observer is mainly the task of the field supervisor, but the data processor must also be aware of typical errors made by observers.

A common problem to note is the misplacement of decimal point for readings in the range .01 to .10. For example a sequence of level readings on the falling limb of a hydrograph:

4.12, 4.10, 4.9, 4.6, 4.3, 4.1, 3.99 - should clearly be interpreted as:

4.12, 4.10, 4.09, 4.06, 4.03, 4.01, 3.99.

Experience suggests that where the record is maintained by a single observer who is left unsupervised for extended periods of time, that it may contain some 'estimated' readings, fabricated without visiting the station. This may show up as sequences which are hydrologically inconsistent. Typical indicators of such 'estimates' are:

- Abrupt falls or a sudden change in slope of a recession curve.
- Long periods of uniform level followed by a distinct fall.
- Uniform mathematical sequences of observations, for example, where the level falls regularly by 0.05 or 0.10 between readings for extended periods. Natural hydrographs have slightly irregular differences between successive readings and the differences decline as the recession progresses.

In addition, precise water level measurement may be difficult in high flows, due to poor access to the gauge and wave action and, in flood flows the correspondence between staff gauges and recording gauges may not be as good as in low flows. Quality of gauge observations is of course, also affected if the gauge is damaged, bent or washed away. The station record book should be inspected for evidence of such problems.

### 9.2.2 AUTOMATIC WATER LEVEL RECORDERS

***Instrument and procedure***

The vast majority of water level recorders in use in India use a float and pulley arrangement in a stilling well to record the water level as a continuous pen trace on a chart. The chart is changed daily or weekly and the recorder level is set to the current level on the staff gauge, which is also written on the chart at the time of putting on and taking off.

***Typical measurement errors***

Automatic water level recorders are subject to errors resulting from malfunction of the instrument or the stilling well in which it is located. Many of these errors can be identified by reference to the chart trace or to the level figures which have been extracted from it.

The following are typical malfunctions noted on charts and possible sources of the problems.

a) Chart trace goes up when the river goes down

- Float and counterweight reversed on float pulley

b) Chart trace goes up when the river goes down

- Tangling of float and counterweight wires
- Backlash or friction in the gearing
- Blockage of the intake pipe by silt or float resting on silt

c) Flood hydrograph truncated

- Well top of insufficient height for flood flows and float sticks on floorboards of gauging hut or recorder box.
- Insufficient damping of waves causing float tape to jump or slip on pulley.

d) Hydrograph appears OK but the staff gauge and chart level disagree. There are many possible sources including operator setting problems, float system, recorder mechanism or the operation of the stilling well, in addition to those noted above. The following may be considered.

**Operator Problems**

- Chart originally set at the wrong level

**Float system problems**

- Submergence of the float and counterweight line (in floods)
- Inadequate float diameter and badly matched float and counterweight
- Kinks in float suspension cables
- Build up of silt on the float pulley affecting the fit of the float tape perforations in the sprockets

**Recorder problems**

- Improper setting of the chart on the recorder drum
- Distortion and/or movement of the chart paper (humidity)
- Distortion or misalignment of the chart drum
- Faulty operation of the pen or pen carriage

**Stilling well problems**

- Blockage of intake pipe by silt.
- Lag of water level in the stilling well behind that in the river due to insufficient diameter of the intake pipe in relation to well diameter.

e) Chart time and clock time disagree

- Chart clock in error and should be adjusted

In particular it should be noted that the partial blockage of the stilling well or intake pipe will result in a serious systematic error in level measurement.

### 9.2.3 DIGITAL WATER LEVEL RECORDERS

***Instrument and procedure***

Like the chart recorder many DWLRs are still based on a float operated sensor operating in a stilling well. One significant improvement is that the mechanical linkage from the pulley system to the chart is replaced by the shaft encoder which eliminates mechanical linkage errors and the imprecision of a pen trace. The signal from the shaft encoder is logged as level at a selected time interval on a digital logger and the information is downloaded from the logger at regular intervals and returned for processing. The level is set and checked with reference to the staff gauge.

Alternative sensors for the measurement of water level do not require to be placed in still water, notably the pressure transducer. Loggers based on such sensors have the advantage that they do not need to be placed in a stilling well and thus can avoid the associated problems.

***Typical measurement errors***

Measurement except for the sensors noted above is still subject to the errors caused by the float system and by the operation of the stilling well. Many of the same or equivalent checks are therefore necessary to ensure the continuity and accuracy of records. In particular the comparison and noting of staff gauge and logger water levels (and clock time and logger time) at take off and resetting, in the Field Record Book are essential for the interpretation of the record in the office.

Procedures in the office for checking the reliability of the record since the previous data download will depend on the associated logger software but should include a graphical inspection of the hydrograph for indications of malfunction (e.g. flat, stepped or truncated trace). Comparisons as for the chart recorder should be made with the observer’s readings and bad or missing data replaced by manual observations.

## 9.3 SCRUTINY OF TABULAR AND GRAPHICAL DATA - SINGLE RECORD

### 9.3.1 GENERAL DESCRIPTION

The first step in validation is the inspection of individual records from a single recorder or manual measurement for violations of preset physical limits or for the occurrence of sequences of data which represent unacceptable hydrological behaviour.

Screening of some unacceptable values will already have been carried out at the data entry stage to eliminate incorrectly entered values.

Numerical tests of physical limits may be considered in three categories:

a) Absolute maximum and minimum limits
b) Upper and lower warning limits
c) Acceptable rates of rise and fall

### 9.3.2 ABSOLUTE MAXIMUM AND MINIMUM LIMITS

Checking against maximum and minimum limits is carried out automatically and values violating the limits are flagged and listed. The values of the absolute maximum and minimum levels at a particular station are set by the data processor such that values outside these pre-set limits are clearly incorrect. These values are normally set for the full year and do not vary with month or season.

The cross-section plot of the river gauging line in conjunction with the cross section of the control section at higher flow depths provides an appropriate basis for setting these minimum and maximum limits. With respect to minimum values for stage records, since it is normal to set the zero of the gauge at the level at which flow is zero then, for many stations a zero gauge level may be set as the absolute minimum. However, for some natural channels and controls negative stage values may be acceptable if the channel is subject to scour such that flow continues below the gauge zero. Such conditions must be confirmed by inspection of the accompanying Field Record Book.

Similarly, the absolute maximum is set at a value after considering the topography of the flood plains around the control section and also the previously observed maximum at the station. If long term data on water levels is already available (say for 15 –20 years) then the maximum attained in the past can be taken as an appropriate maximum limit.

### 9.3.3 UPPER AND LOWER WARNING LIMITS

Validation of stage data against an absolute maximum limit does not discriminate those unusually high or low values which are less than the maximum limit but which may be incorrect. Less extreme upper and lower warning limits are therefore set such that values outside the warning range are flagged for subsequent scrutiny. The underlying objective while setting the upper and lower warning levels must be that such limits are violated 1–2 times every year by a flood event. This would ensure that on an average the one or two highest flood or deepest troughs are scrutinised more closely for their correctness. These limits may also be worked out using suitable statistics but care must be taken of the time interval and the length of data series under consideration. Statistics like 50% ile value of the collection of peak over the lowest maximum annual values used to set the upper warning level for the case of hourly data series of say 15-20 years. Of course, such statistics will also be subjected to the nature or shape of hydrograph which the station under consideration experiences. And therefore the appropriateness of such limits have to be verified before adopting them.

### 9.3.4 RATES OF RISE AND FALL LIMITS

The method of comparing each data value with immediately preceding and following observations is of particular relevance to parameters exhibiting significant serial correlation such as water level data. The limit is set numerically as the maximum acceptable positive or negative change between successive observations. It should be noted however that what is an acceptable change in level during a rising flood hydrograph during the monsoon may be unacceptable during the dry season. Violations of rise and fall limits are therefore more readily identified from graphical plots of the hydrograph whilst numerical tests provide a relatively coarse screen.

It is a good practice and an essential requirement for an organised data processing activity that the listing of the entered data is obtained as a result of the above checking against various data limits. Such a listing will provide an appropriate medium for recording remarks/comments of the data processing personnel while validating the data. Any glaring deviations of the entered data from the expected one will also be apparent from such a listing.

**Example 9.1:**

Hourly water level data of Pargaon river gauging site in Pargaon catchment is considered during the period of 1995-1997. It is required to set various data limits for the purpose of validation of water level data at this station.

The cross-section of the gauging section is given in Figure 9.1 from which it is apparent that the lowest bed level is about 507 m and the top of the bank is about 520 m. If the zero of the gauge is set at 507 m then the minimum data limit can be easily set at 507 m since it is not expected for water to reach this level even after moderate scouring of the bed. This gauging section happens to be at the bridge location it is therefore not appropriate to consider the cross section details of the same for setting up the maximum limit since the control section may be somewhere downstream of the bridge section and may have different levels at the flood plain levels. Such flood plain levels and the topography around the control section would be governing the levels at the gauging cross section. As a first estimate the top of the cross section at the bridge section can be taken as the maximum limit which is 520 m. An alternative is to use the highest water level ever recorded at the site which is about 519.5 m in the year 1997 (as per the available data). Figure 9.2 (a) to Figure 9.2 (c) shows the application of these two data limits for four years during 1994-97 respectively.

Considering that the objective of setting the upper warning level is to flag 1-2 flood events each year for closer scrutiny, a limit of 513 m as the upper warning levels will be effective. Such limits can also be arrived at using suitable statistics on the data derived for peak over a certain threshold limit.

For limits on maximum rate of rise and rate of fall it is best to use the historical data and obtain the derivative of the hourly water level series. After having seen the rate of change of water levels for a few years the maximum limits on rate of rise and fall can be easily obtained. For this case, limits of 2 and -1 m/hr is set for the maximum rate of rise and rate of fall respectively (Figure 3.3). It may be seen from this plot that a few observations which are clear errors results in abnormal values of rate of rise or falls beyond the set limits even for small lower stages.

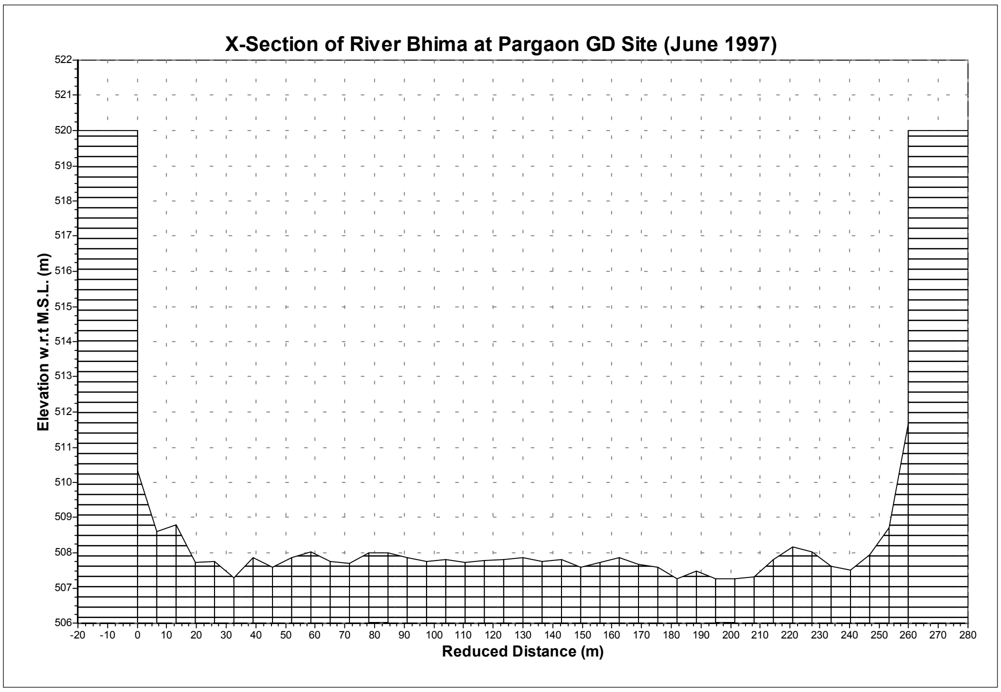



*Figure 9.1: Cross sectional profile of river gauging station at PARGAON.*

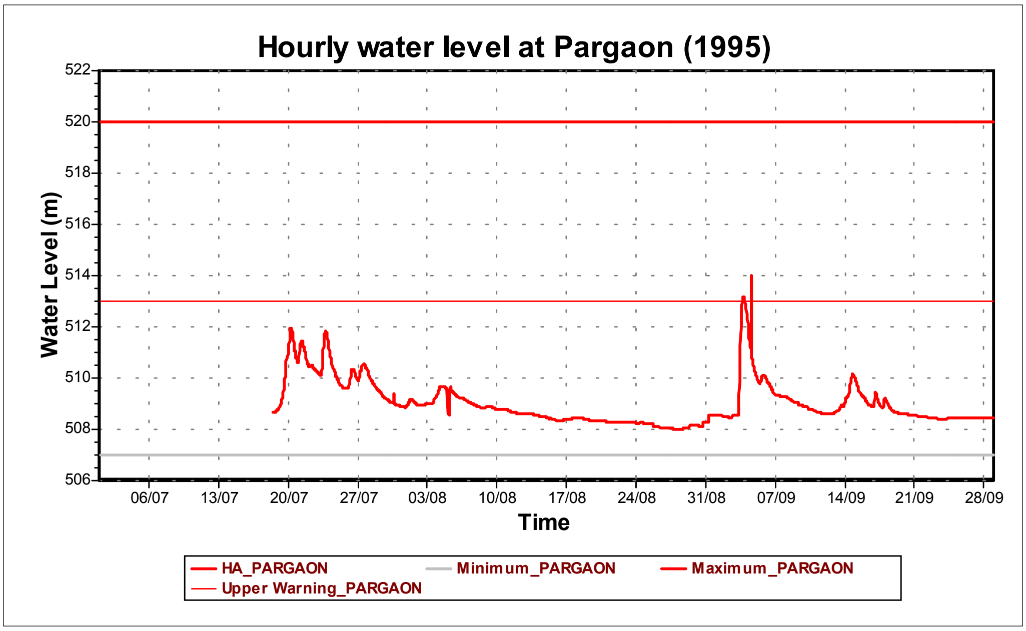



*Figure 9.2(a) Hourly water level data with data limits at PARGAON for 1995*

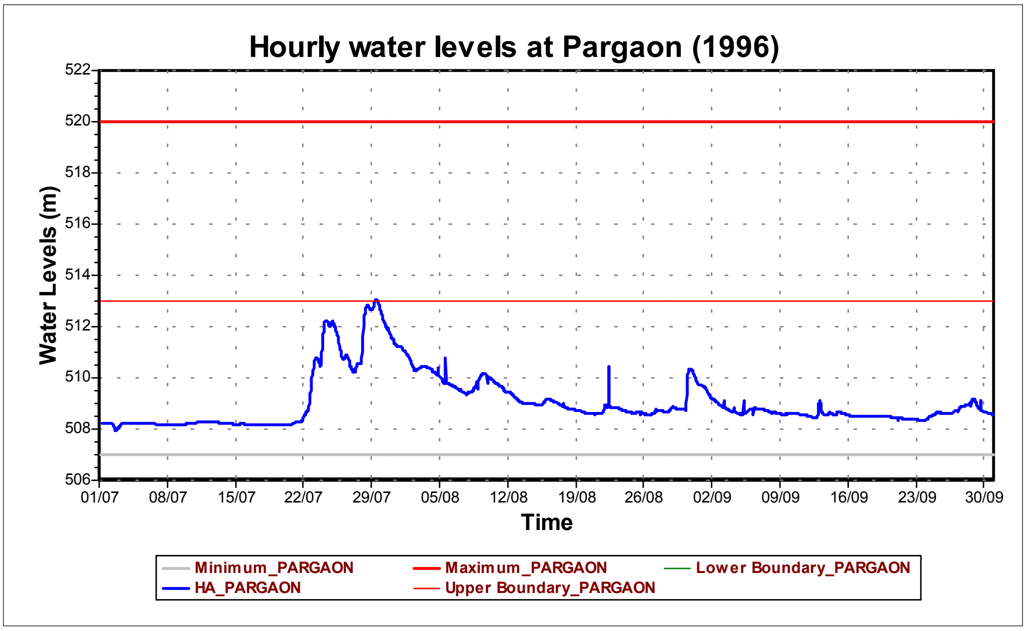



*Figure 9.2(b) Hourly water level data with data limits at PARGAON for 1996*

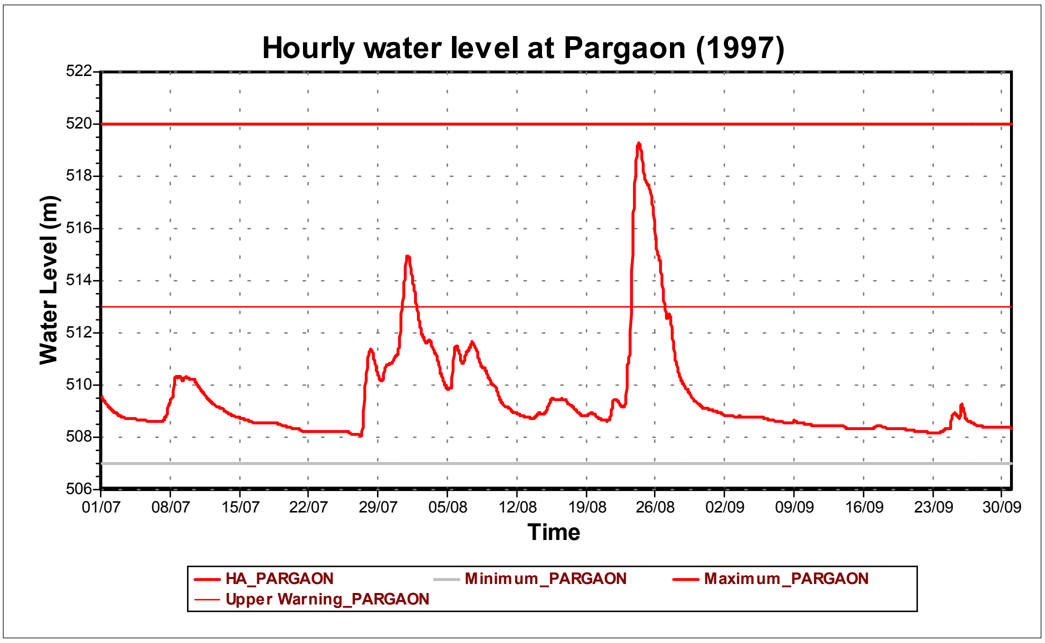



*Figure 9.2(c): Hourly water level data with data limits at PARGAON for 1997*

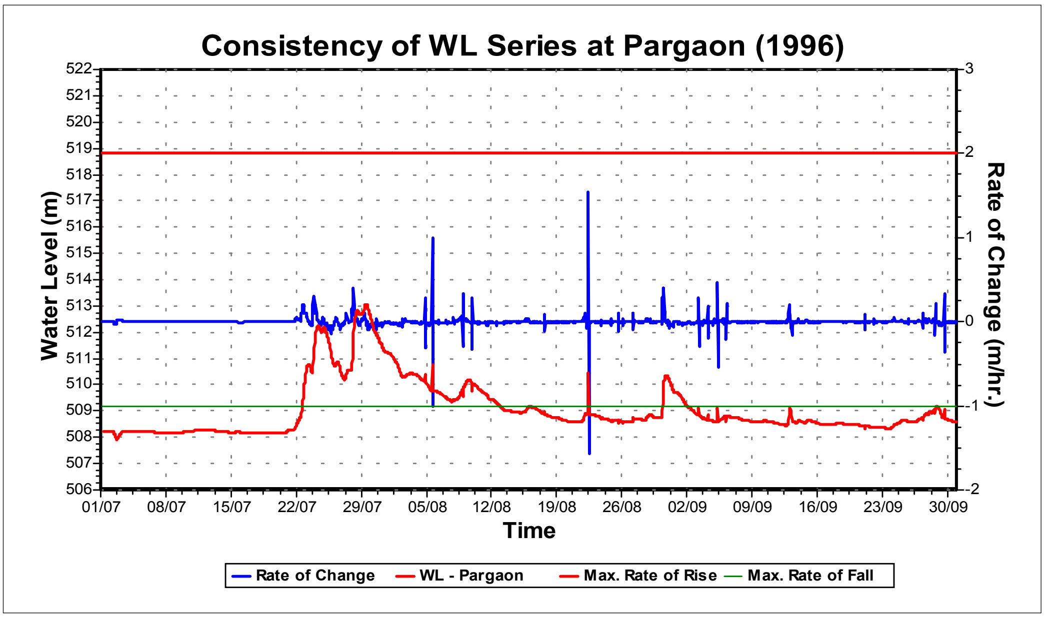



*Figure 9.3: Rate of change in hourly water level data with data limits at PARGAON for 1996*

### 9.3.5 GRAPHICAL INSPECTION OF HYDROGRAPHS

Visual checking of time series data is often a more efficient technique for detecting data anomalies than numerical checking and must be applied to every data set with an inspection of the stage hydrograph on screen. Screen display will also show the maximum and minimum limits and the upper and lower warning levels. Potential problems identified using numerical tests will be inspected and accepted as correct, flagged as spurious or doubtful and corrected where possible. An attempt must be made to interpret identified anomalies in terms of the performance of observer, instruments or station and where this has been possible to communicate this information to field staff for field inspection and correction. A few examples cases are discussed below:

**Case 1**

Case 1 represents a false recording of a recession curve (Figure 9.4) caused by:

a) An obstruction causing the float to remain hung
b) Blockage of the intake pipe
c) Siltation of the stilling well

This also shows where the obstruction was cleared. It may be possible to interpolate a true recession.

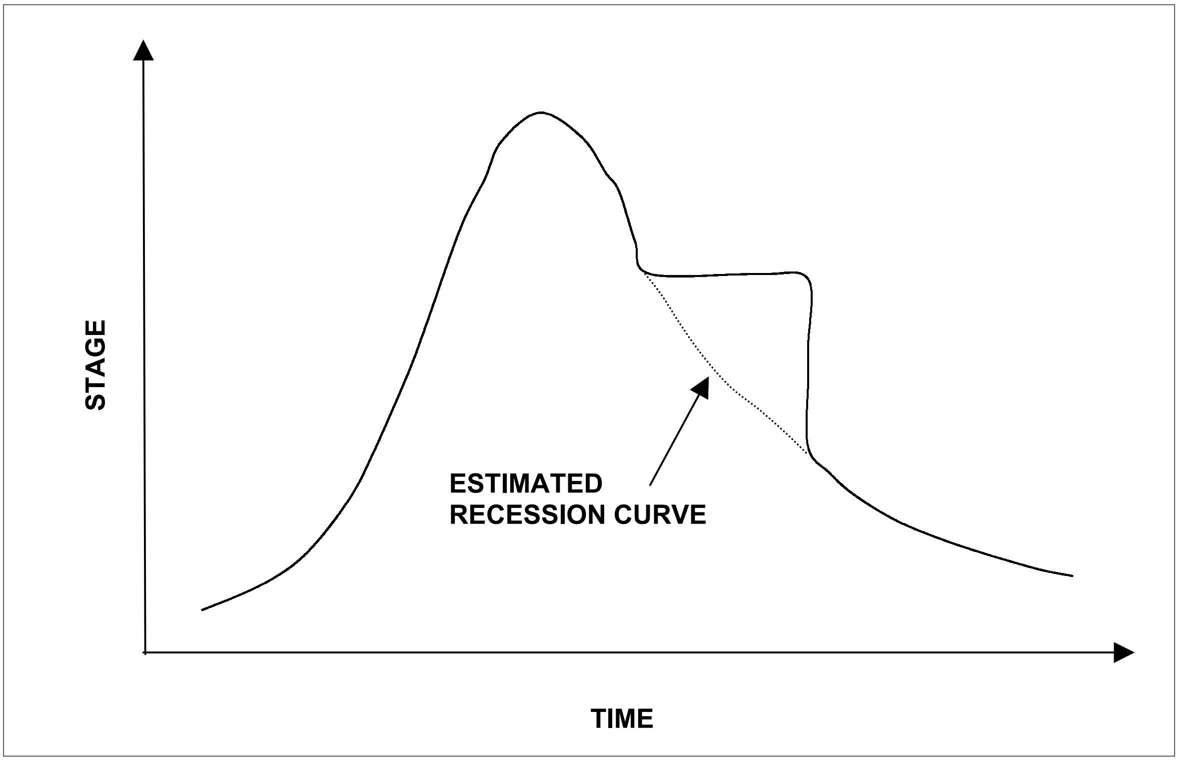



*Figure 9.4: False recording of recession curve*

**Case 2**

Case 2 involves steps in the stage recording because of temporary hanging of the float tape or counterweight as the result of mechanical linkages in the recorder (Figure 9.5). Such deviations can be easily identified graphically and true values can be interpolated.

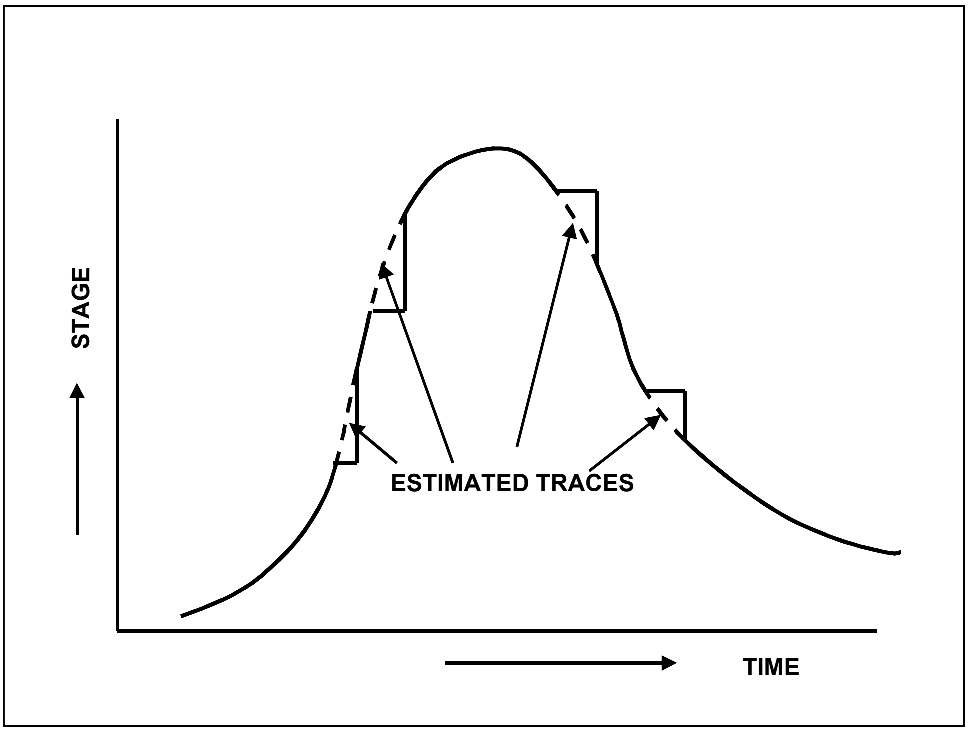



*Figure 9.5: Temporary hanging of the float*

**Case 3**

Spurious peaks and troughs (spikes) in the hydrograph. These may be generated by observer error or occasionally by electronic malfunction of transducers or shaft encoders. It should be noted however that in some instances real variations of a similar nature may be generated:

a) In rivers with small flow, switching on and off of pumps immediately upstream from the observation station will generate rapid changes
b) The building of a bund or obstruction upstream from a station and its subsequent failure or release will generate first a negative spike followed by a positive one. In this case the levels as observed are correct.

### 9.3.6 VALIDATION OF REGULATED RIVERS

Rivers which are unaffected by river regulation and abstraction have a flow pattern which is determined by the rainfall and the transformation and storage of that rainfall on that basin on its way to the outlet. The hydrograph at such stations follows a natural pattern on which errors and inconsistencies can readily be identified.

Such natural rivers are not common in India; they are influenced artificially to a greater or lesser extent. One example is listed above (Case 3) More generally on regulated rivers the natural pattern is disrupted by reservoir releases which may have abrupt onset and termination, combined with multiple abstractions and return flows. The influences are most clearly seen in low to medium flows where in some rivers the hydrograph appears entirely artificial; high flows may still observe a natural pattern. In such rivers validation becomes more difficult and the application of objective rules may result in the listing of many queries where the observations are in fact correct. It is therefore recommended that the emphasis of validation on regulated rivers should be graphical screening by which data entry and observation errors may still be readily recognised.

The officer performing validation should be aware of the principal artificial influences within the basin, the location of those influences, their magnitude, their frequency and seasonal timing, to provide a better basis for identifying values or sequences of values which are suspect.

## 9.4 COMPARISON OF DAILY TIME SERIES FOR MANUAL AND AUTOGRAPHIC OR DIGITAL DATA

### 9.4.1 GENERAL DESCRIPTION

At stations where water level is measured at short durations using an autographic or a digital recorder, a staff gauge reading is always also available. Thus, at such observation stations water level data at daily time interval is available from at least two independent sources. Discrepancies between reading may arise either from the staff gauge readings, the recorder readings or from both. The typical errors in field measurement have been described above and these should be considered in interpreting discrepancies. In addition errors arising from the tabulation of levels at hourly intervals from chart records or from data entry are possible.

### 9.4.2 VALIDATION PROCEDURE

Two or more series representing the same level at a site are plotted on a single graph, where the two lines should correspond. A residual series may also be plotted showing the difference between the two methods of measurement. The following in particular should be noted:

- If there is a systematic but constant difference between staff gauge and recorder, it is probable that the recorder has been set up at the wrong level. Check chart annotations and the field record book. Check for steps in the hydrograph at the time of chart changing. The recorder record should be adjusted by the constant difference from the staff gauge.
- If the comparison is generally good but there are occasional discrepancies, it is probably the result of error in the staff gauge observations by the observer or incorrect extraction from the chart.
- If there is a change from good correspondence to poor correspondence in flood conditions, a failure associated with the stilling well or the recorder should be suspected and the staff gauge record is more likely to be correct and may therefore be used to correct or interpolate missing records in the recorder record.
- A gradual increase in the error may result simply from the recorder clock running fast or slow. This can be easily observed from the graphical plot and the recorder record should be adjusted.

## 9.5 MULTIPLE GRAPHS OF WATER LEVEL AT ADJACENT STATIONS

Comparison of records between stations will normally be carried out as part of secondary validation at Divisional level and will not only be done with respect to discharge but also for stages. However an initial inspection may be done at Sub-divisional level where records for a few neighbouring stations are available. Such stations, especially if on the same river will show a similarity in their stage plot and inspection may help in screening out outliers.

# 10 ENTRY OF FLOW MEASUREMENT DATA

## 10.1 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.

## 10.2 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 Figure 10.1.

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)

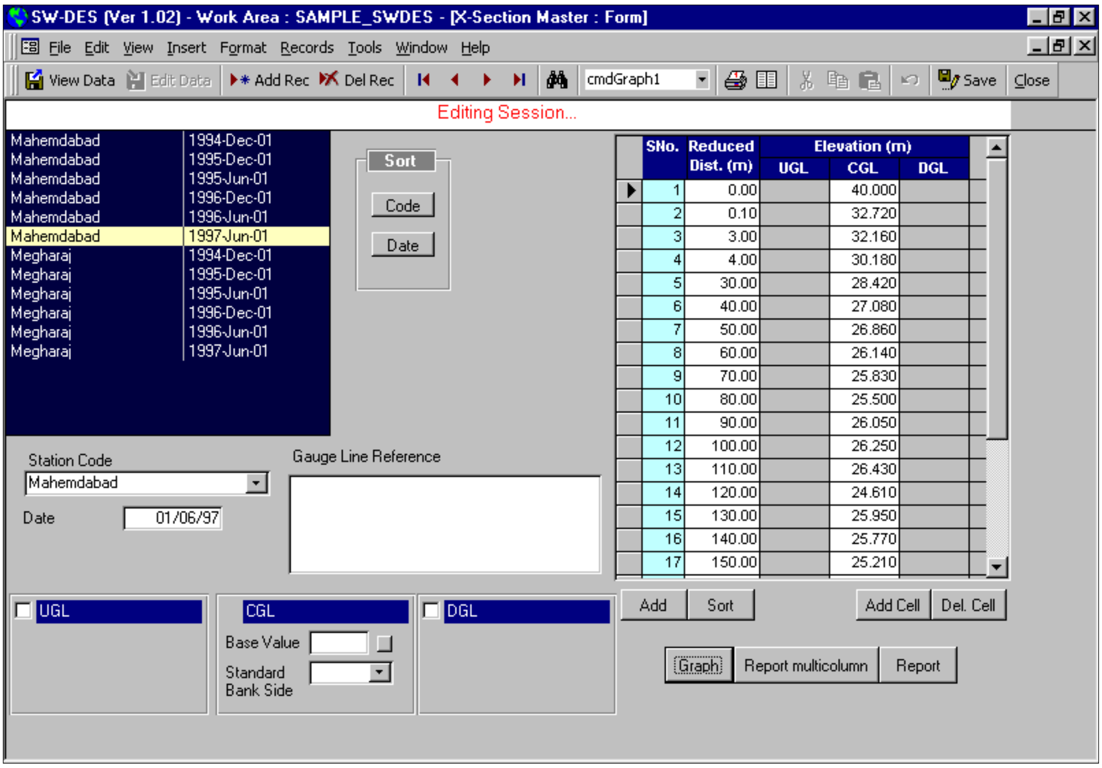



Figure 10.1: Data entry form for cross sectional data

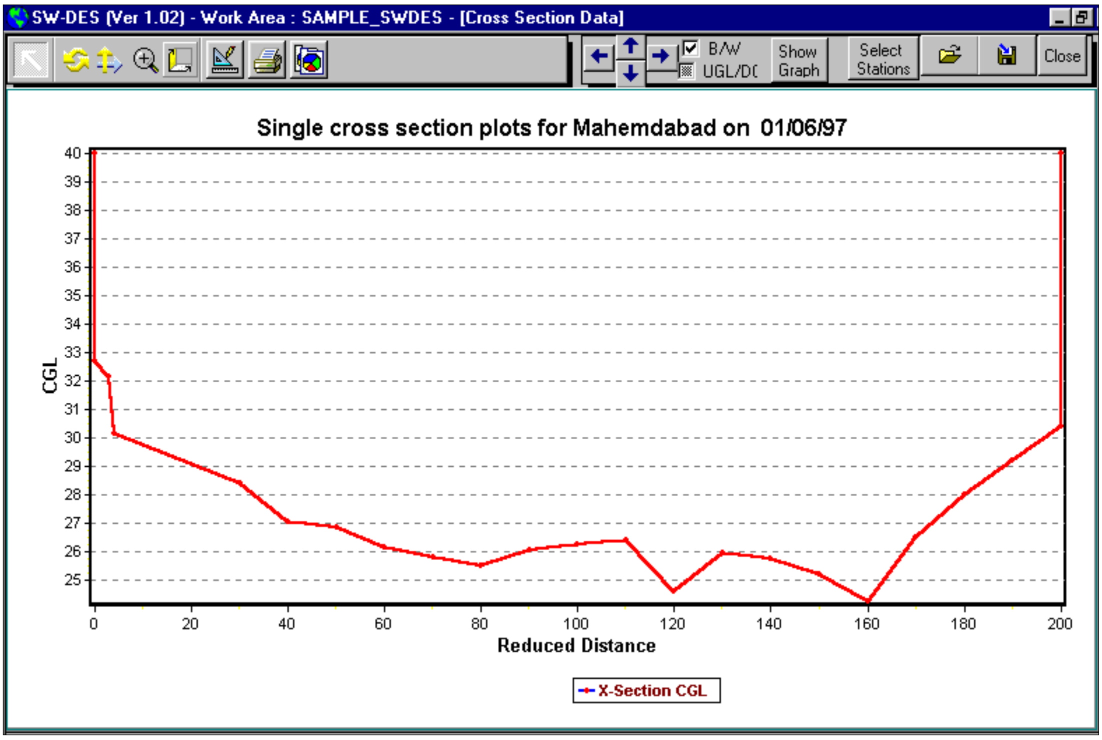



*Figure 10.2: Plot of cross sectional profile*

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 Figure 10.2)

## 10.3 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.

## 10.4 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.

### 10.4.1 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 Figure 10.3.

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 ($^{o}$C)***
- ***Atmospheric temperature ($^{o}$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)***

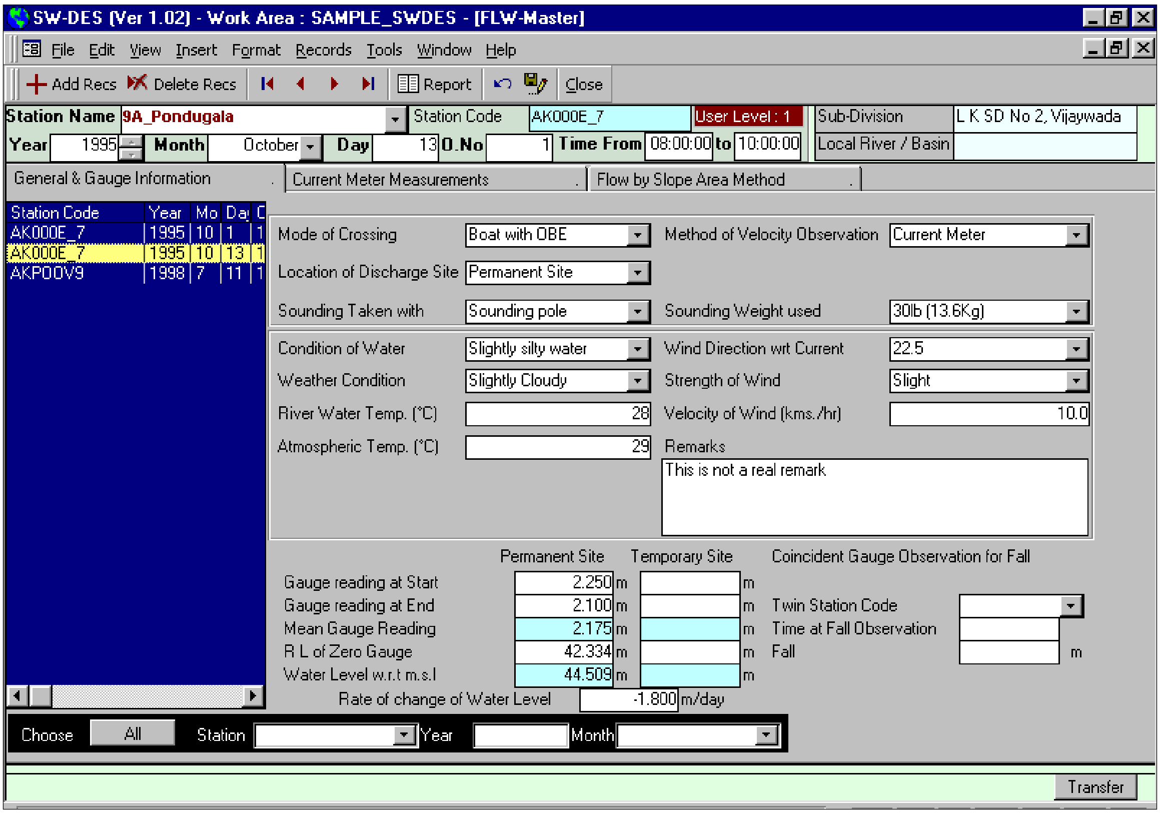



*Figure 10.3: Layout of form for entry of gauge data and reference information for stage-discharge measurements*

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.

### 10.4.2 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. Figure 10.4 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 Figure 10.5.

At the top of the 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.

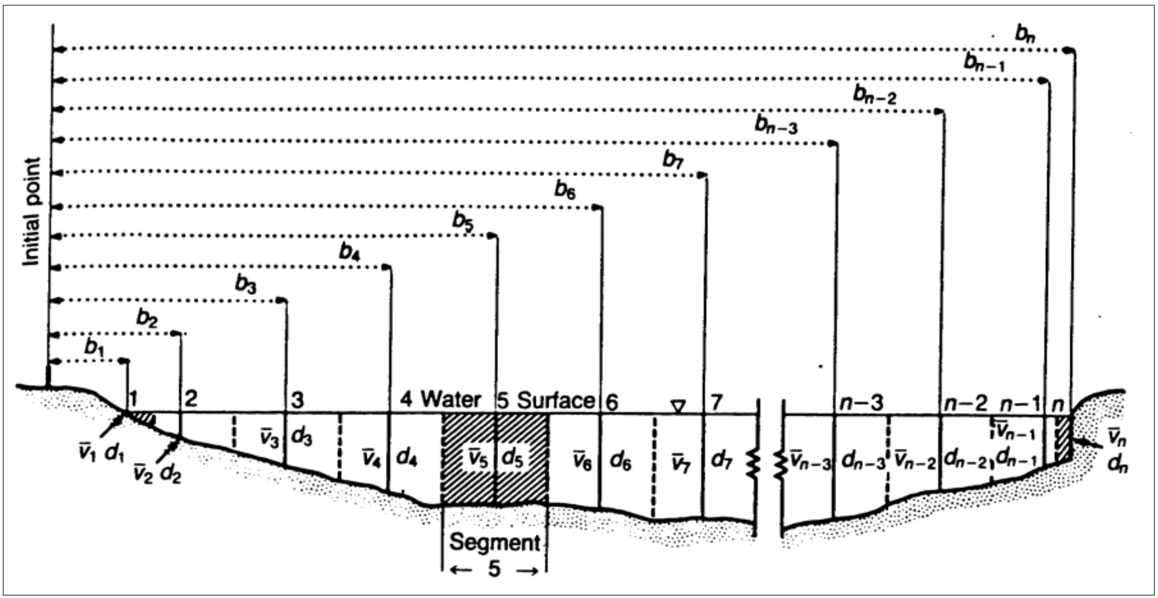



*Figure 10.4: The mid-section method of computing current meter measurements. 1, 2, 3, ….n, number of vertical; b1, b2, b3, …, bn, distance from initial point; d1, d2, d3, …, dn, depth of flow at verticals; $v_1$, $v_2$, $v_3$, .....$v_n$ average velocity in verticals.*

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.

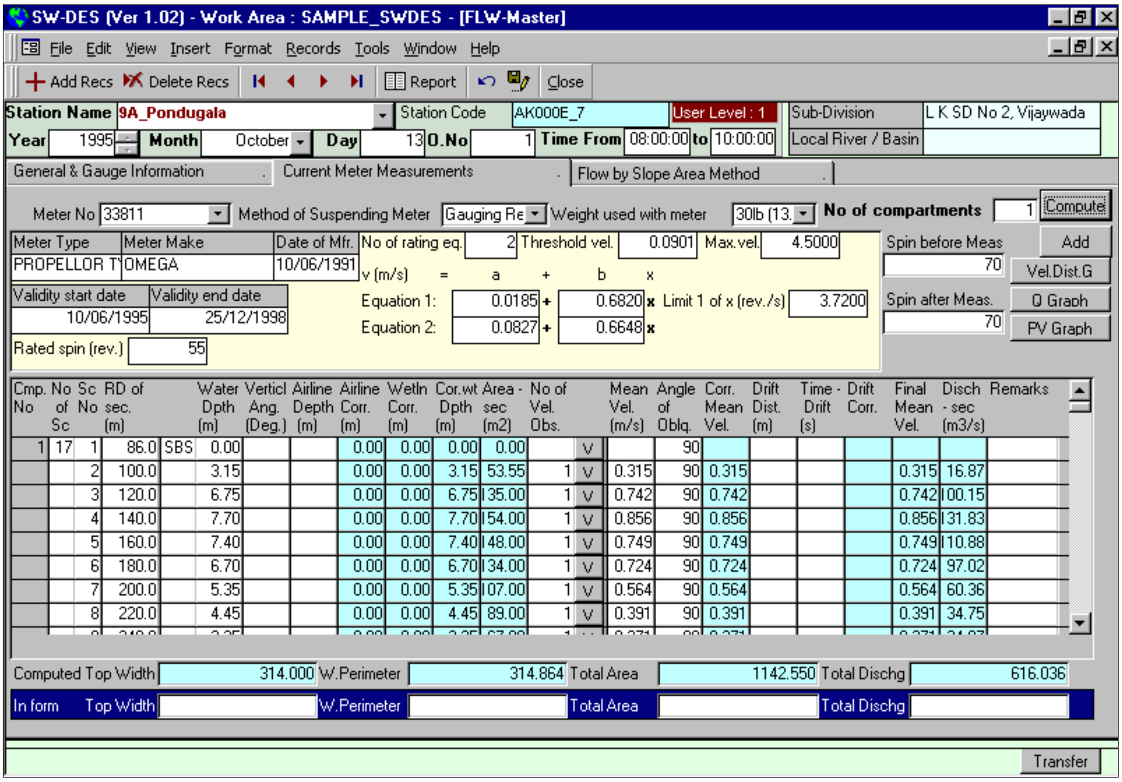



*Figure 10.5: Layout of form for entry of current metering observations.*

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 Figure 10.6. 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 $(\text{Sec}\ \theta - 1)$

and

Wetline correction = Wetline depth * ($\alpha$ /100)

= (Observed water depth - Airline correction) * ($\alpha$ /100)

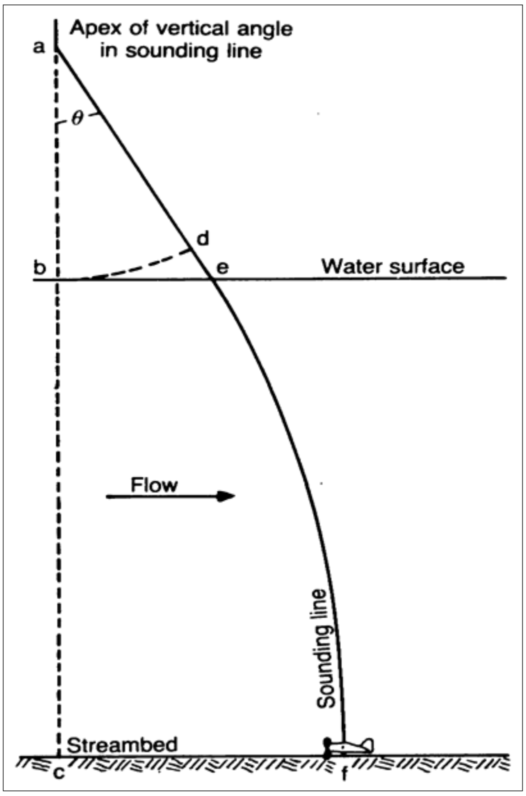



*Figure 10.6:*
*Position taken up by sounding line and weight in deep swift water. Corrections to be made to determine depth, "bc", are air-line correction, "de", and wet line correction as percentage of "ef".*

*Table 10.1: Wet-line correction (Correction given in this table are percentages of wet line depth)*

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

Here, $\theta$ is the vertical angle and $\alpha$ is percent of the wetline depth and is tabulated in Table 10.1 for different values of $\theta$ according to ISO 748-1979 (E), Annex C, Table 2.

***Column 9: Corrected water depth***

The corrected water depth is computed by subtracting the airline and wet line corrections from the observed water depth. This field is also filled automatically by the system itself. The corrected water depth is computed as:

Corrected water depth = (Observed water depth - Airline correction)*(1 - $\alpha$ /100)

***Column 10: Area of section***

Area of section is the area of flow represented by the velocity observations at any section. This is also computed and filled automatically by the system. The computations are based on the mid-section method. The area of section for all sections except the end sections is computed, in m2 , as:

Area of section = (1/2) (R.D. of next section - R.D. of prev. section) (Corrected water depth)

For end sections however, the computations are:

Area of section for SBS end section = (1/2) (R.D. of next section - R.D. of section) (Corrected water depth)

Area of section for OBS end section = (1/2) (R.D. of section - R.D. of previous section) (Corrected water depth)

***Column 11: No. of velocity observations***

At every section, velocity is observed at one or more points. The number of such point velocity observations is entered in this field. A maximum number of three can be entered in this cell.

***Column 12: Details of velocity observations***

When the cursor is placed in the cells of this column, the cell expands in the form of a small pop-up table containing four more columns and as many rows as the number of velocity observations as entered in column 11. This is done to make the entries for each section within one row of the main table. After all the entries are made this pop-up table folds back again into a single cell.

***Column 13: Velocity observed at depth***

This is one of the columns of small pop-up table. The depth at which the point velocities are observed is to be entered in these cells. As per the entry for the no. of velocity observations in column 11, the system fills these cells with default depths. However, the user can overwrite these entries, if need be. The default entries are:

| | |
|---|---|
| For no. of observations as 1: | The default depth is 0.6d |
| For no. of observations as 2: | The default depths are 0.2d and 0.8d |
| For no. of observations as 3: | The default depth is 0.2d, 0.6d and 0.8d |

***Column 14: Coefficient to be used***

For computation of the mean velocity in the vertical section all the point velocities are weighted as per their location in the section. The system fills the entries with the default values which can be overwritten, if desired by the user. The default values for the coefficients are:

| | |
|---|---|
| For the depth as 0.6d : | The default coefficient is 1 |
| For the depths as 0.2d and 0.8d | The default coefficients are 0.5 and 0.5 respectively |
| 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 Figure 8.7), 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:

Corrected mean velocity = Observed mean velocity * Sin($\beta$)

where $\beta$ 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.

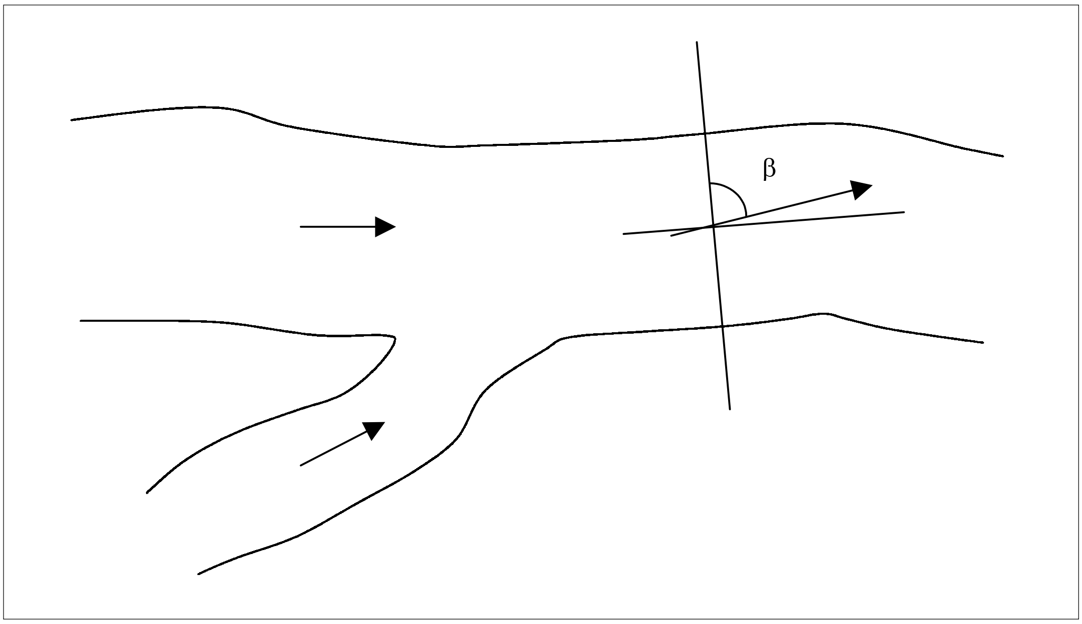



*Figure 10.7: Correction for obliqueness of flow lines with respect to the normal to the gauging section*

***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:

Drift correction = (Drift distance) / (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 = Σ {(R.D. of last section - R.D. of first section) for each compartment}

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

Wetted perimeter = Σ {(sum of corrected water depth at first and last section) + [(difference in R.D. of successive sections)$^2$ + (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 Figure 10.8)
c) graph for distribution of discharge giving the histogram of discharge flowing through each sectional area in percentage and absolute form (see Figure 10.9).

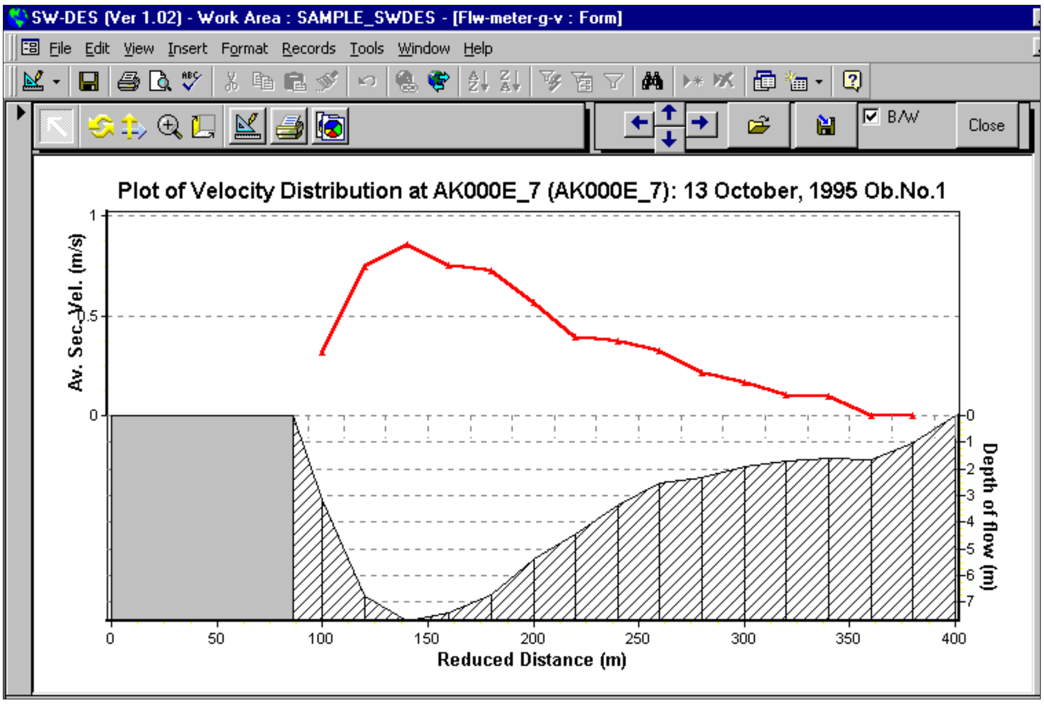



*Figure 10.8: Plot of mean velocity profile along the gauging section*

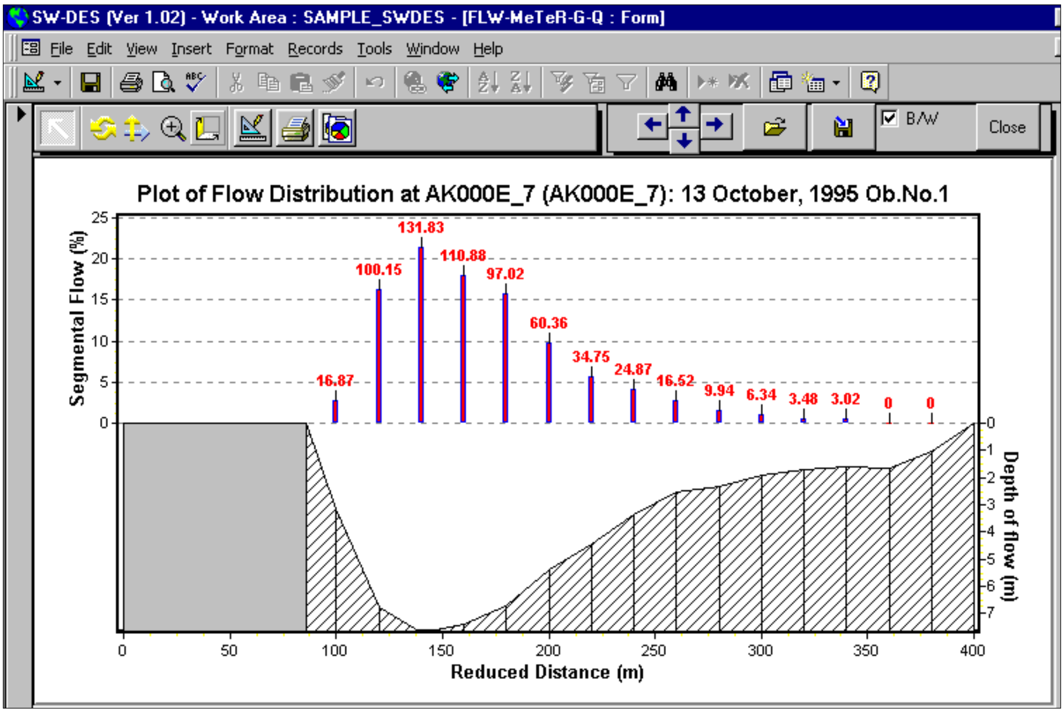



*Figure 10.9: Plot of flow passing through various segmental areas*

### 10.4.3 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 Figure 10.10.

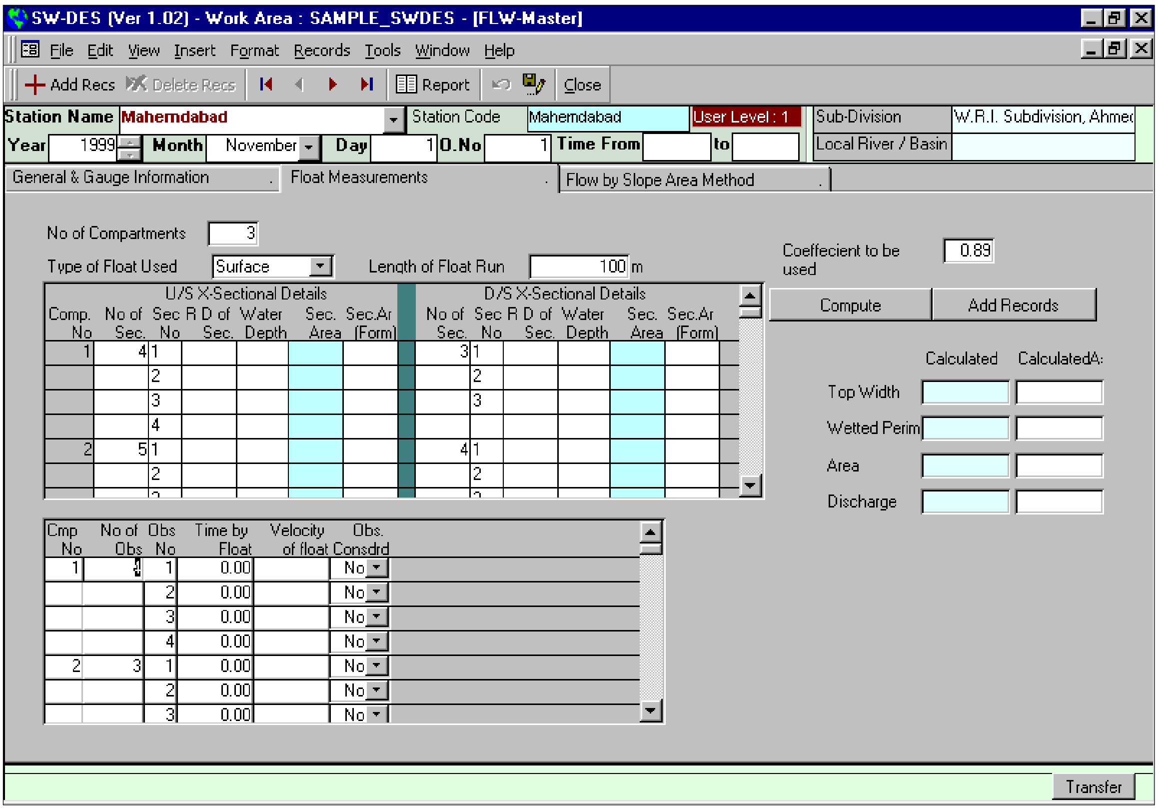



*Figure 10.10: Layout of form for entry of velocity observations using floats.*

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

a) type of float
b) length of float run
c) 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. Figure 10.11 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.

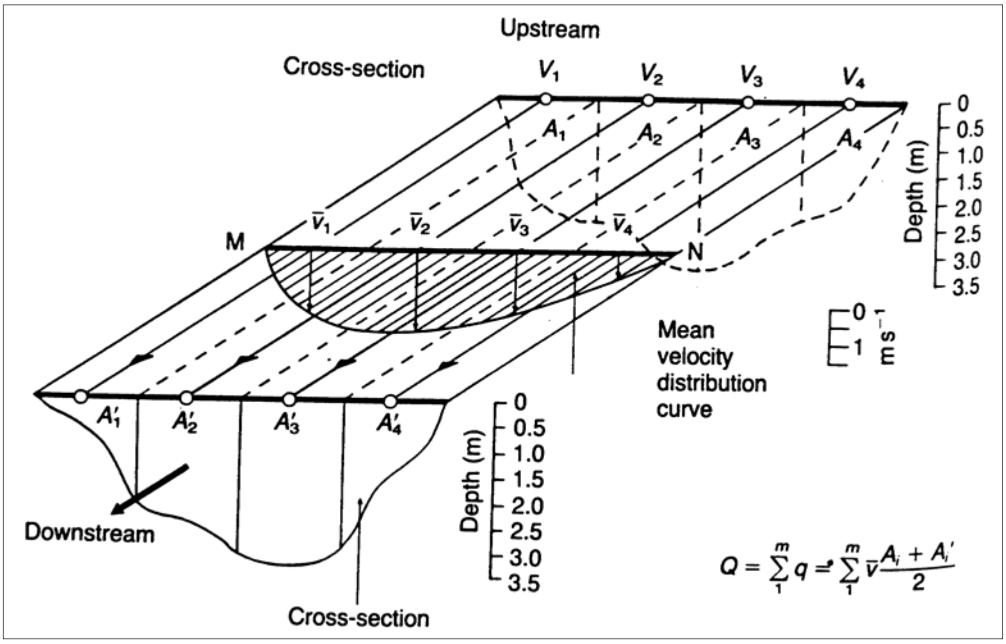



*Figure 10.11: Computation of discharge from float measurement. $v_1$, $v_2$, $v_3$ .....$v_n$ are the mean velocities in each of the four panels*

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 form the tabular entries in exactly the same way as explained for the current metering observations.

### 10.4.4 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 Figure 10.12.

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.

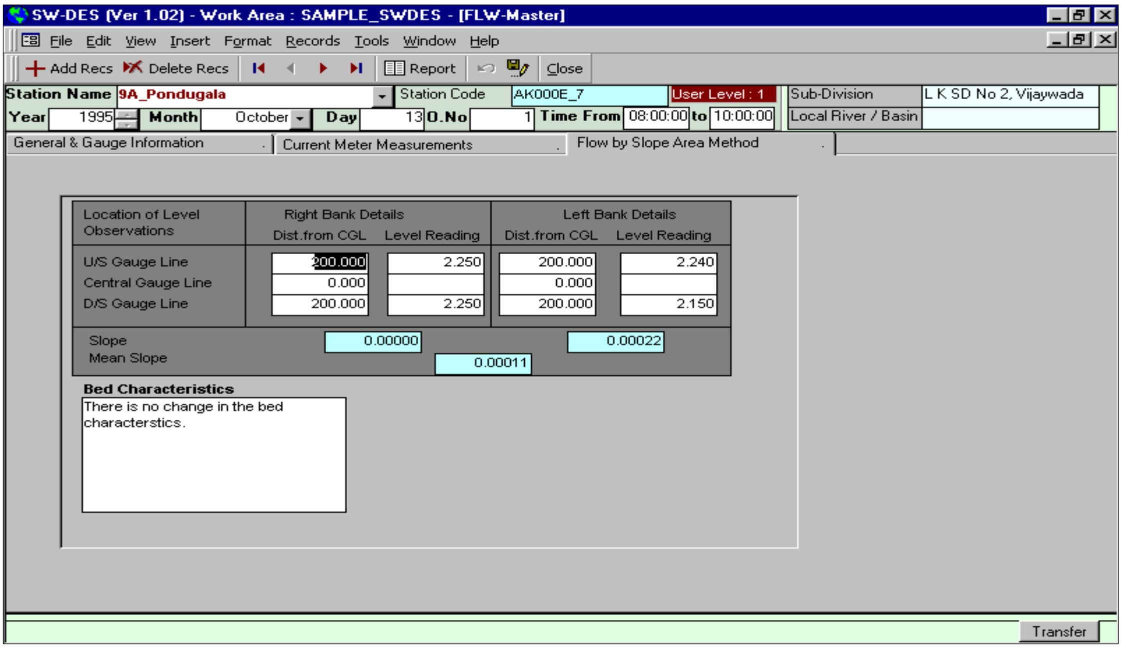



*Figure 10.12: Layout of form for entry of slope observations for discharge estimation using slope-are method.*

### 10.4.5 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 Figure 10.13a and 10.13b.

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.

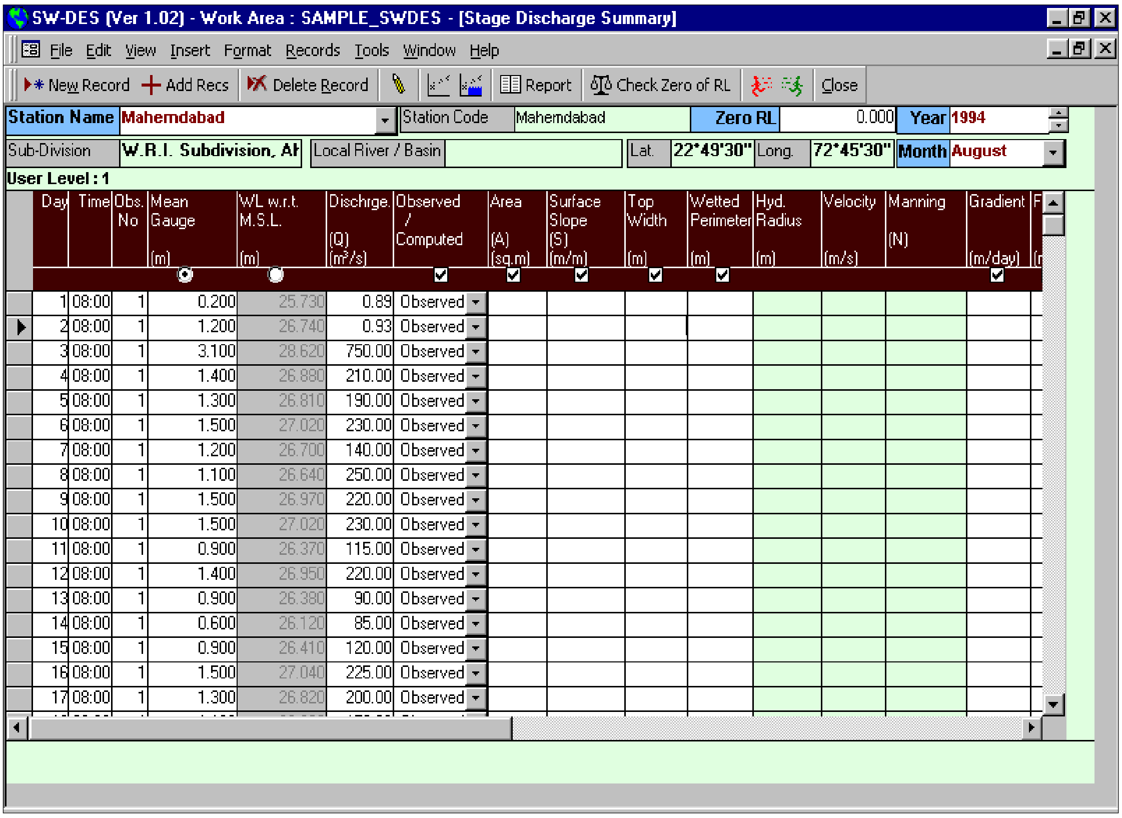



*Figure 10.13a: Form for entry of stage-discharge summary data*

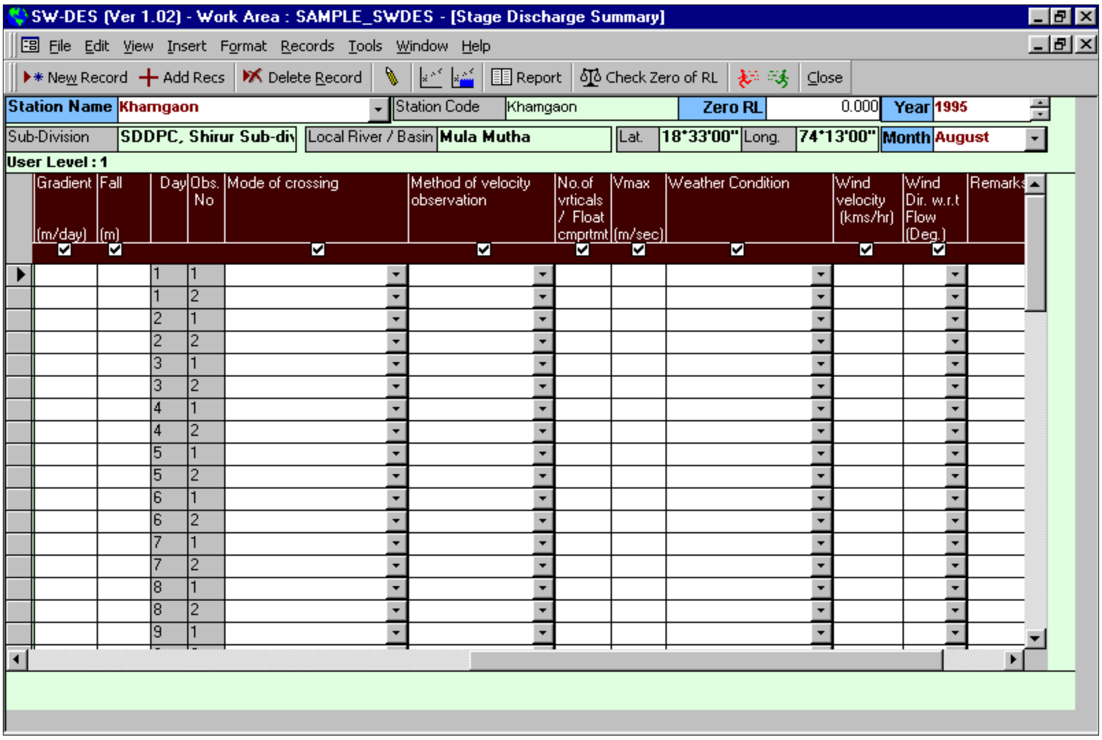



*Figure 10.13b: Form for entry of stage-discharge summary data*

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 Figure 10.14).

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.

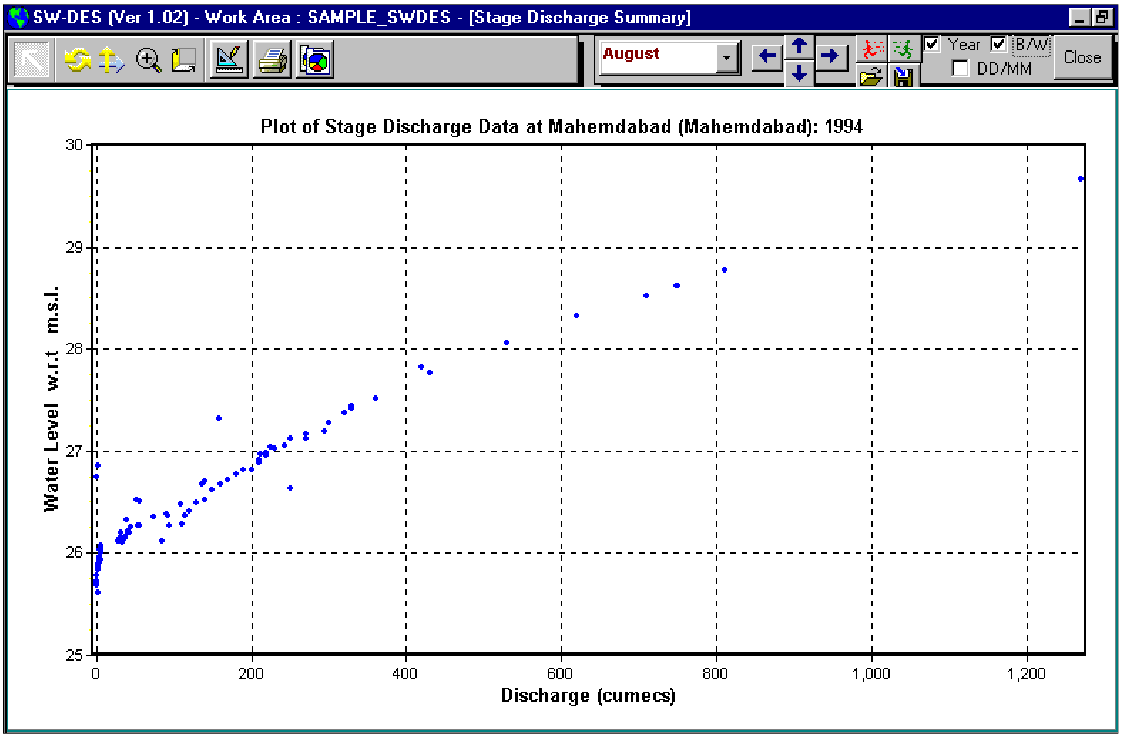



*Figure 10.14: Plot of observed discharge against water level with respect to mean sea level*

# 11 PRIMARY VALIDATION OF STAGE-DISCHARGE DATA

## 11.1 GENERAL

Flow measurement in this module refers to individual measurements of discharge made by current meter which are used in the plotting and fitting of a stage discharge relationship or rating curve.

Initial calculation is carried out in the field and the completed field sheets are returned monthly to the Sub-divisional office where they are entered to computer using Primary module of dedicated hydrological data processing system (SWDES) and the discharge recomputed.

Primary validation consists of:

- inspection of field sheets and Field Record Book
- comparison of field and office computed discharge
- comparison of computed discharge with existing rating curve
- comparisons of cross sectional and velocity profiles

## 11.2 INSPECTION OF FIELD SHEETS AND FIELD RECORD BOOK

Each current meter measurement of discharge contains multiple observations or calculations of width, depth, velocities, slope, areas, flows, etc., and the information is entered to the standard "Discharge Measurement Sheet" (Figure 11.1). Before checking the arithmetic calculations, it is necessary to check ancillary information on the form and in the Field Record Book to ensure that it is complete and that any change at the station which may have influenced the relationship between stage and discharge is available for interpretation of the computed discharge. Information which may be relevant includes:

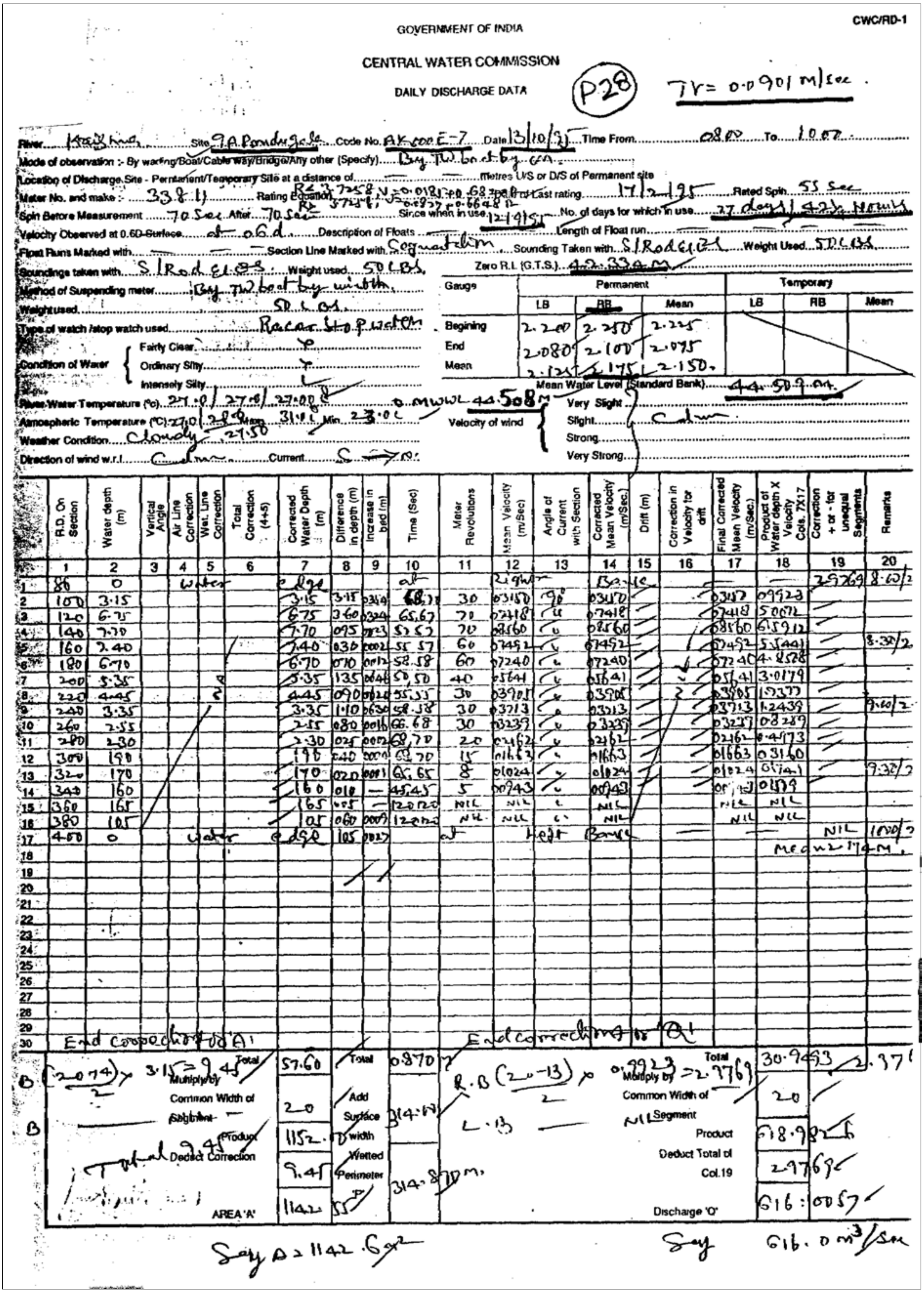
- rates of rise and fall in level during measurement (possible unsteady flow effect)
- backwater due to very high stages (i.e. flooding) in receiving river or contributing tributary downstream of gauging station
- flood in deposition or scour of the channel at the gauge or at the downstream control, based on observer observations.
- gravel extraction at the station or downstream
- bunding or blockage in the downstream channel
- weed growth in the channel
- change in datum at the station, adjustment or replacement of staff gauges.

The stage recorded at the beginning and end and during the gauging must be compared with the hourly or other stage observation by recorder or manually. Any discrepancy must be investigated by reference to the field supervisor. The error may be in the continuous record or in the observation during current meter gauging; if the latter then the mean stage in the summary form for the current meter measurement must be amended.

## 11.3 COMPARISON OF FIELD AND OFFICE COMPUTED DISCHARGE

The calculation of discharge from current meter measurements is initially carried out in the field by the gauging team. On receipt in the office, individual observations made during the measurement are entered to computer and the discharge is re-computed. If the total discharge determined from the two calculations differs, the source of the difference must be identified and correction made. In particular line by line comparisons of the two calculations should be made to identify data entry errors to computer. If none are found, arithmetic errors should be sought in the field calculation. Other potential sources of discrepancy are in the use of the wrong current meter rating in one of the calculations or incorrect entry of current meter rating parameters to the ratings datafile.

Any errors in the field computation should be notified to the field supervisor.


CWC/RD-1

GOVERNMENT OF INDIA

CENTRAL WATER COMMISSION

DAILY DISCHARGE DATA

P28 Tr = 0.0901 m/sec.

River: Krishna Site: 9.A.Pondugala Code No. AK 00E-7 Date 13/10/95 Time From 08.00 To 10.00

Mode of observation :- By wading/Boat/Cable way/Bridge/Any other (Specify) By TW boat by CA

Location of Discharge Site - Permanent/Temporary Site at a distance of ...... Metres U/S or D/S of Permanent site

Meter No. and make :- 338.11 Rating Equation ... Last rating 17/2/95 Rated Spin 55 Sec

Spin Before Measurement 70 Sec After 70 Sec Since when in use 12/4/95 No. of days for which in use 27 days

Velocity Observed at 0.6D-Surface at 0.6d Description of Floats ...... Length of Float run ......

Float Runs Marked with ...... Section Line Marked with Segmentalim Sounding Taken with S.I.Rod & L.B.L. Weight Used 50 LBS.

Soundings taken with S.I.Rod & L.B.S. Weight used 50 LBS. Zero R.L (G.T.S.) 42.330 m

Method of Suspending meter By TW boat by width

Weight used 50 LBS.

Type of watch/stop watch used Racer stop watch

Condition of Water: Fairly Clear / Ordinary Silty / Intensely Silty

River Water Temperature (°c) 27.0 / 27.0 / 27.0 MWL 44.508 m

Atmospheric Temperature (°C) 27.0 / 28.0 Max. 31.0 Min. 23.0

Weather Condition Cloudy 27.50

Direction of wind w.r.t. Calm Current S → N

| Gauge | Permanent LB | Permanent RB | Permanent Mean | Temporary LB | Temporary RB | Temporary Mean |
|---|---|---|---|---|---|---|
| Begining | 2.200 | 2.250 | 2.225 | | | |
| End | 2.080 | 2.100 | 2.095 | | | |
| Mean | 2.120 | 2.175 | 2.150 | | | |

Mean Water Level (Standard Bank) 44.509 m

Velocity of wind: Very Slight / Slight Calm / Strong / Very Strong

| | R.D. On Section | Water depth (m) | Vertical Angle | Air Line Correction | Wet Line Correction | Total Correction (4+5) | Corrected Water Depth (m) | Difference in depth (m) | Increase in bed (m) | Time (Sec) | Meter Revolutions | Mean Velocity (m/Sec) | Angle of Current with Section | Corrected Mean Velocity (m/Sec) | Drift (m) | Correction in Velocity for drift | Final Corrected Mean Velocity (m/Sec.) | Product of Water depth X Velocity Cols. 7X17 | Correction + or - for unequal Segments | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 1 | 80 | 0 | | water | | | edge | | | at | | right | | Bank | | | | | .29769 | 8.00/2 |
| 2 | 100 | 3.15 | | | | | 3.15 | 3.15 | .0319 | 68.71 | 30 | .03150 | 90 | .03150 | | | .03150 | .09923 | | |
| 3 | 120 | 6.75 | | | | | 6.75 | 3.60 | .0324 | 65.67 | 70 | .07418 | | .07418 | | | .07418 | .50072 | | |
| 4 | 140 | 7.70 | | | | | 7.70 | .095 | .0023 | 55.52 | 70 | .08560 | | .08560 | | | .08560 | .65912 | | |
| 5 | 160 | 7.40 | | | | | 7.40 | .030 | .0002 | 55.57 | 60 | .07452 | | .07452 | | | .07452 | 5.5441 | | 8.30/2 |
| 6 | 180 | 6.70 | | | | | 6.70 | .070 | .0012 | 58.58 | 60 | .07240 | | .07240 | | | .07240 | 4.8528 | | |
| 7 | 200 | 5.35 | | | | | 5.35 | .135 | .0048 | 50.50 | 40 | .05641 | | .05641 | | | .05641 | 3.0179 | | |
| 8 | 220 | 4.45 | | | | | 4.45 | .090 | .0024 | 55.55 | 30 | .03905 | | .03905 | | | .03905 | 1.9377 | | |
| 9 | 240 | 3.35 | | | | | 3.35 | .110 | .0030 | 58.58 | 30 | .03713 | | .03713 | | | .03713 | 1.2439 | | 9.00/2 |
| 10 | 260 | 2.55 | | | | | 2.55 | .080 | .0016 | 66.68 | 30 | .03239 | | .03239 | | | .03239 | .08289 | | |
| 11 | 280 | 2.30 | | | | | 2.30 | .025 | .0002 | 68.70 | 20 | .02162 | | .02162 | | | .02162 | .04973 | | |
| 12 | 300 | 1.90 | | | | | 1.90 | .040 | .0004 | 68.70 | 15 | .01663 | | .01663 | | | .01663 | .03160 | | |
| 13 | 320 | 1.70 | | | | | 1.70 | .020 | .0001 | 66.65 | 8 | .01024 | | .01024 | | | .01024 | .01741 | | 9.32/2 |
| 14 | 340 | 1.60 | | | | | 1.60 | .010 | — | 45.45 | 5 | .00943 | | .00943 | | | .00943 | .01509 | | |
| 15 | 360 | 1.65 | | | | | 1.65 | .005 | — | 120.20 | NIL | NIL | | NIL | | | NIL | NIL | | |
| 16 | 380 | 1.05 | | | | | 1.05 | .060 | .0009 | 120.20 | NIL | NIL | | NIL | | | NIL | NIL | | |
| 17 | 400 | 0 | | water | | | edge | 1.05 | .0027 | at | | left | | Bank | | | | | NIL | 10.00/2 |
| 18 | | | | | | | | | | | | | | | | | | | Mean 2.174 m | |
| 19 | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | | | | | | |
| 30 | | End correction of A | | | | | | | | | | End correction of Q | | | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| L.B (20-7.4)/2 × 3.15 = 9.45 | Total 57.60 | Total .08707 | R.B (20-13)/2 × .09923 = .29769 | Total | 30.9453 | 2.37 |
| Multiply by Common Width of Segment | 20 | Add Surface width 314.87 | L.B | Multiply by Common Width of Segment NIL | 20 | |
| Product | 1152.17 | Wetted | | Product | 618.906 | |
| Total 9.45 Deduct Correction | 9.45 | Perimeter | 314.870 m. | Deduct Total of Col.19 | .29769 | |
| AREA 'A' | 1142.55 | | | Discharge 'Q' | 616.00057 | |

Say A = 1142.6 m² Say 616.0 m³/sec

Figure 11.1: Specimen "discharge measurement sheet"

## 11.4 COMPARISON OF COMPUTED DISCHARGE WITH EXISTING RATING CURVE

Validated gaugings are entered to the stage-discharge summary data file in a form suitable for graphical plotting and inspection. The new gauging can then be compared graphically with existing rating curve and the previous current meter gaugings (Figure 11.2); a table can also be obtained of the actual and percentage deviation of the gauging from the previously established rating.

Deviations may be due to:

- the reliability of the individual gauging
- the general accuracy with which measurements can be made at a station
- actual changes in the stage discharge relationship

It is important to distinguish the difference. Early identification is necessary so that gauging practice can be adjusted or, in the case of rating changes, so that gauging can be intensified to establish a new relationship.

The percentage deviation of a gauging which requires further action will depend on the physical characteristics of the station and the assumed accuracy with which individual measurements can be made. For example in a station with sensitive control and a regular gauging section and error of ± 5% may be achieved but at irregular sections with erratic velocity distribution an error of ± 10% may be acceptable. In general the individual gauging should be investigated further if the deviation from the previous rating exceeds 10% or, if a sequence of gaugings shows persistent positive or negative deviations from the established rating.

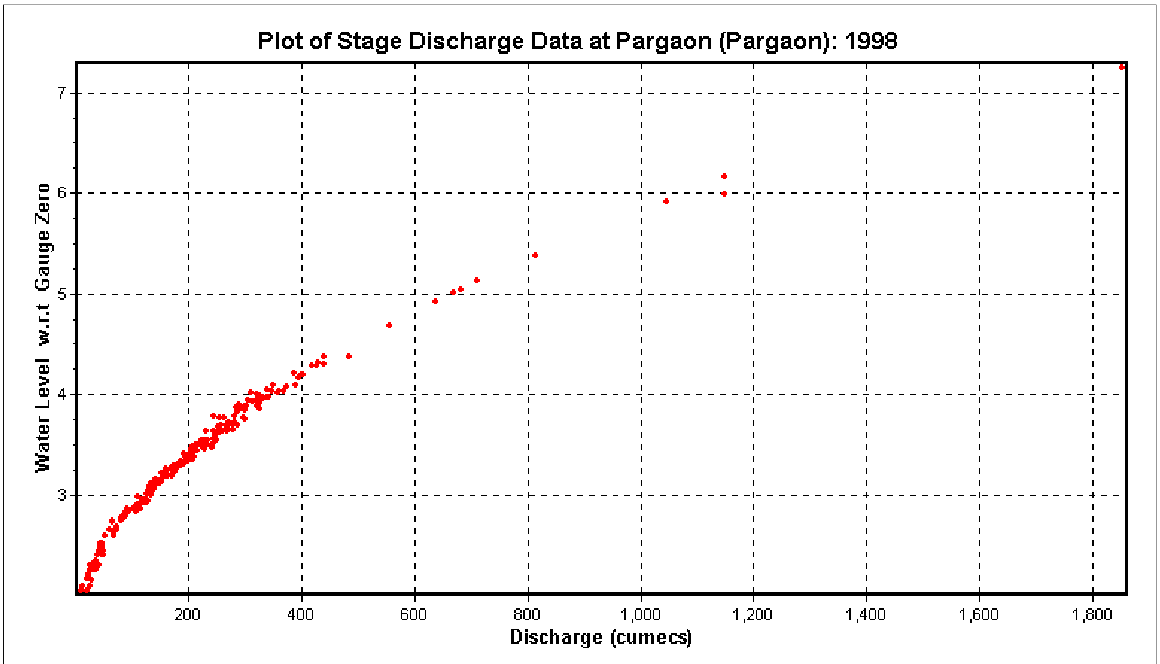



*Figure 11.2: Scatter plot of stage-discharge data*

### 11.4.1 DEVIATIONS DUE TO RELIABILITY OF INDIVIDUAL GAUGINGS

The individual gauging may be unreliable due, for example, to:

a) an inadequate number of verticals taken to define total area and mean velocity
b) very low velocities in the section not measured accurately by available equipment
c) no air/wet line corrections made to depth measurement in high flow
d) no angle correction for gaugings taken oblique to the flow
e) a faulty current meter

Items (a) to (d) can be identified from the tabulated gauging. The use of a faulty current meter (e) cannot be so identified but may be identified from field inspection or by persistent differences between the results from the specified meter and other meters at the same station. A plot of cross sectional velocity can be made for individual gaugings and a comparison made between gaugings at the same stage

### 11.4.2 DEVIATIONS DUE TO PHYSICAL PROPERTIES OF GAUGING SECTION

The general accuracy with which gaugings can be made at a station depends to a large extent of the regularity of the bed and banks at the gauging cross section and approach conditions - both bed roughness and the existence of a bend - whether or not these are subject to change. These control the velocity distribution across the section and how it differs from a smooth trapezoidal channel. Irregularities may result in deviation from a typical logarithmic velocity profile in the vertical so that neither 0.6d nor (0.2d + 0.8d)/2 represent the mean flow. They may also cause rapid velocity variations across the section such that the number of verticals chosen may not be an adequate sample to represent the mean flow.

The velocity distribution in the cross section may be investigated by plotting velocity contours or velocity vectors across the cross section if sufficient observations have been made.

### 11.4.3 DEVIATIONS DUE TO ACTUAL CHANGES IN THE STAGE DISCHARGE RELATIONSHIP

Deviation from a simple power relationship at a gauging station may arise for a number of reasons including the following:

- Unsteady flow causing hysteresis with rising and falling floods. This can be identified by plotting the rate of rise (+) of fall (-) during gauging alongside the plotted point on the stage discharge graph. Higher flow for given level may be expected in rising flows when the energy slope is greater but is generally only evident in reaches with low channel slope. In such cases an unsteady flow rating should be adopted.
- Changes in cross section at the control section due to natural scour or deposition or gravel extraction. Such changes may be identified by plotting sequential cross-sections for the control section where available but otherwise for the gauging section. It is changes in the control section which are critical, but these are often accompanied by changes in cross section at the station also and these can give an indication of the existence of scour or deposition At least two cross sections are conducted each year before and after the monsoon period. These may be compared. In addition, a cross sectional profile is available from each current meter gauging and these may also be compared and may indicate the presence of scour or deposition at the station. Reference should be made to gauging notes and to the Field Record Book for observations of field staff. Introduction of a new rating or the use of the shift procedure should be considered.

- Discharge for given level may also be affected by downstream bed changes even if no change is found at the station itself. In channels of low slope the control may extend to many kilometres downstream for which no cross sectional information exists. Comparison of mean velocity between sequential gaugings across the width of the channel at the gauging section will help to identify such changes (though backwater may exhibit the same effect - see below). Scour or gravel extraction downstream will result in increased velocity for given gauge level; bunding and blockage will result in a decrease. Reference should again be made to gauging notes. Introduction of a new rating or the use of the shift procedure should be considered.
- Similarly discharge for given level may be affected by downstream backwater conditions caused for example by a confluence or by tidal effects. The effect may also be illustrated by comparison of velocity profiles. Unlike the effects of downstream bed changes, the effect may not persist from one gauging to the next. For stations affected by backwater, rating curves with backwater corrections should be applied.
- Weed growth at or downstream from the station may also be identified by changes in the mean velocity profile across the section. Weed growth decreases the velocity for a given level. Reference should be made to gauging notes. If weed growth causes significant variation from the mean rating, the introduction of the shift procedure should be considered.
- Where bed profile and mean velocity profiles remain sensibly constant from one gauging to another but the plotted point deviates from the previous rating, then a change in the datum or a shift in the staff gauges should be suspected. Reference should be made to the Field Record Book and gauging notes. Field staff should be requested to carry out a check survey of the staff gauges. If necessary a new rating can be introduced with a simple change in the ‘a’ parameter.

# 12 ENTRY OF SEDIMENT DATA

## 12.1 GENERAL

Two types of sediment data are considered in the HIS:

- Suspended sediment data, and
- Bed material data.

The suspended sediment data comprise of the concentrations of coarse (> 0.2 mm), medium (0.075-0.2 mm) and fine (< 0.075 mm) material in combination with water level and discharge data. The suspended sediment concentrations are obtained from samples by the Punjab bottle sampler taken at 0.6 of the water depth in a number of verticals in the cross-section. Per fraction a discharge weighted average concentration is computed in the field laboratory and entered in the field data sheet, see Table 12.1. These data are transferred to the sub-Division together with the hydrometric data. The entry of suspended sediment data is discussed in Section 12.2 and its scrutiny in 12.3.

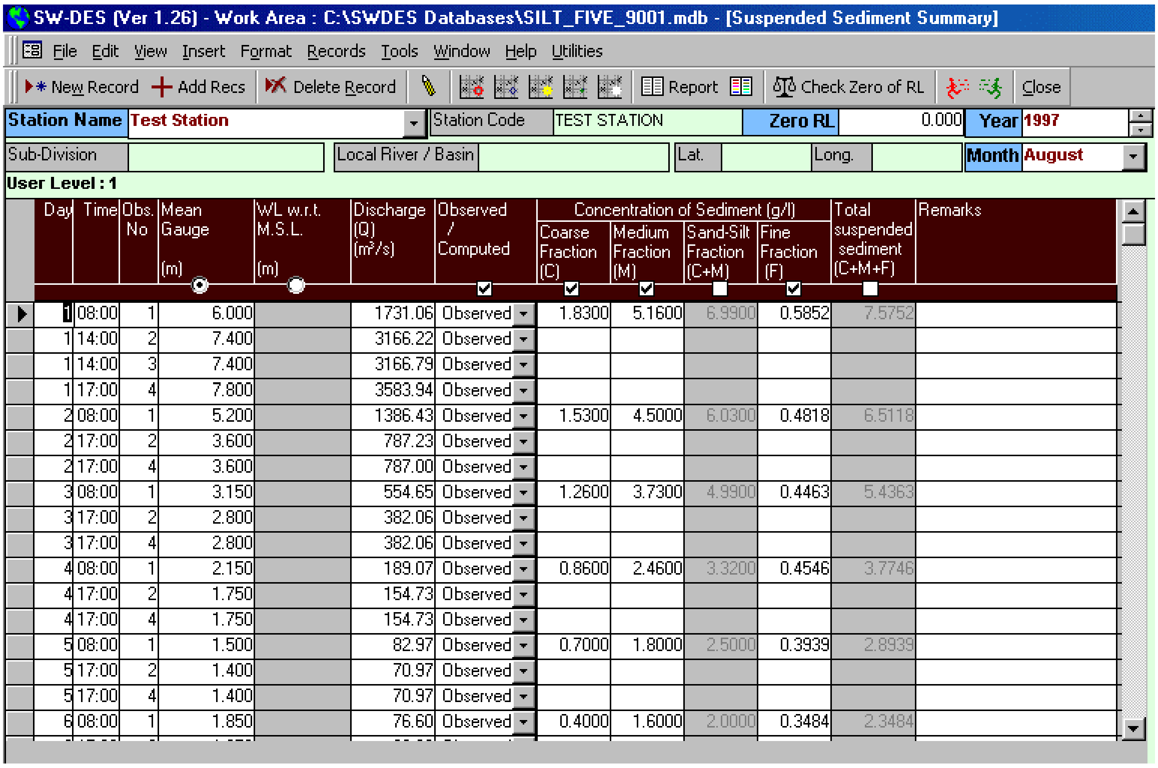
Bed material samples are generally collected thrice in a water year: pre-monsoon, monsoon and post-monsoon. The samples are analysed in the Water Quality Laboratory in two ways:

- for particle sizes > 0.6 mm by dry sieving, and
- for particle sizes < 0.6 mm by siltometer.

The appropriate data entry forms and data entry procedure for bed material data in SWDES are dealt with in Section 12.4.

## 12.2 ENTRY OF SUSPENDED SEDIMENT DATA

To enter the suspended data from the field data sheet in an easy manner in SWDES, the data entry table in SWDES is made similar to the field data sheet, see Figure 12.1.


SW-DES (Ver 1.26) - Work Area : C:\SWDES Databases\SILT_FIVE_9001.mdb - [Suspended Sediment Summary]

File Edit View Insert Format Records Tools Window Help Utilities

New Record | Add Recs | Delete Record | Report | Check Zero of RL | Close

Station Name: Test Station | Station Code: TEST STATION | Zero RL: 0.000 | Year: 1997

Sub-Division | Local River / Basin | Lat. | Long. | Month: August

User Level : 1

| Day | Time | Obs. No | Mean Gauge (m) | WL w.r.t. M.S.L. (m) | Discharge (Q) (m³/s) | Observed / Computed | Concentration of Sediment (g/l): Coarse Fraction (C) | Medium Fraction (M) | Sand-Silt Fraction (C+M) | Fine Fraction (F) | Total suspended sediment (C+M+F) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 08:00 | 1 | 6.000 | | 1731.06 | Observed | 1.8300 | 5.1600 | 6.9900 | 0.5852 | 7.5752 | |
| 1 | 14:00 | 2 | 7.400 | | 3166.22 | Observed | | | | | | |
| 1 | 14:00 | 3 | 7.400 | | 3166.79 | Observed | | | | | | |
| 1 | 17:00 | 4 | 7.800 | | 3583.94 | Observed | | | | | | |
| 2 | 08:00 | 1 | 5.200 | | 1386.43 | Observed | 1.5300 | 4.5000 | 6.0300 | 0.4818 | 6.5118 | |
| 2 | 17:00 | 2 | 3.600 | | 787.23 | Observed | | | | | | |
| 2 | 17:00 | 4 | 3.600 | | 787.00 | Observed | | | | | | |
| 3 | 08:00 | 1 | 3.150 | | 554.65 | Observed | 1.2600 | 3.7300 | 4.9900 | 0.4463 | 5.4363 | |
| 3 | 17:00 | 2 | 2.800 | | 382.06 | Observed | | | | | | |
| 3 | 17:00 | 4 | 2.800 | | 382.06 | Observed | | | | | | |
| 4 | 08:00 | 1 | 2.150 | | 189.07 | Observed | 0.8600 | 2.4600 | 3.3200 | 0.4546 | 3.7746 | |
| 4 | 17:00 | 2 | 1.750 | | 154.73 | Observed | | | | | | |
| 4 | 17:00 | 4 | 1.750 | | 154.73 | Observed | | | | | | |
| 5 | 08:00 | 1 | 1.500 | | 82.97 | Observed | 0.7000 | 1.8000 | 2.5000 | 0.3939 | 2.8939 | |
| 5 | 17:00 | 2 | 1.400 | | 70.97 | Observed | | | | | | |
| 5 | 17:00 | 4 | 1.400 | | 70.97 | Observed | | | | | | |
| 6 | 08:00 | 1 | 1.850 | | 76.60 | Observed | 0.4000 | 1.6000 | 2.0000 | 0.3484 | 2.3484 | |

*Figure 12.1: Data entry form for suspended sediment data*

From left to right the entries consist of:

- Column 1: day and time of measurement
- Column 2: time of measurement
- Column 3: observation number within the day
- Column 4: gauge height in m, with respect to gauge zero
- Column 6: discharge in m$^3$/s,
- Column 7: whether the discharge in Column 6 is observed or calculated
- Column 8: concentration of sediment in grams/litre of coarse fraction
- Column 9: concentration of sediment in grams/litre of medium fraction
- Column 11: concentration of sediment in grams/litre of fine fraction

# RECORD OF SUSPENDED SEDIMENT SUMMARY DATA

## <*Agency*: *{e.g., State Water Data Centre, I & CAD Department, A.P.}* >

**Sub-Division** : …………………………..  **Division** : …………………………..

**Station Name** : ……………………………..  **Station Code :** ……………………………

**Independent River :** ……………………..……….  **Local River** : ..………………………..…

**District** : …………………………..…  **Latitude :** ….° ….′ ….″  **Longitude :** ….° ….′ ….″

**R.L. of Gauge Zero :** …………… (m+m.s.l)  **Year** : …………**Month** : ………..…

| Date | Time of observation | Gauge Reading (m) | Water Level (m) | Total Discharge (cumec) | Suspended sediment Concentration (g/l) | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Coarse Fraction | Medium Fraction | Fine Fraction | Total | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |
| 16 | | | | | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | | | | | |
| 19 | | | | | | | | | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |
| 25 | | | | | | | | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | | | | | | | | |
| 29 | | | | | | | | | |
| 30 | | | | | | | | | |
| 31 | | | | | | | | | |

**Observer's remarks :** ……………………..…………………………………………………………………

………………………………………………………………………………………………………………

| Form filled by: | Manuscript checked: | Data entered & checked by: | Primary validation done by: |
|---|---|---|---|
| **Observer** | **Supervisor/J.E.** | **DPC Assistant** | **Assistant Hydrologist** |

*Table 12.1 Example of data sheet for suspended data*

SWDES determines based on your entries the water level w.r.t. M.S.L (Column 5), the sand-silt fraction (Column 10) as the sum of the coarse and medium fractions and the total suspended sediment concentration (Column 12).

## 12.3 SCRUTINY OF SUSPENDED SEDIMENT DATA

The data should immediately after entry be verified on typing errors by comparison of the computed total suspended sediment concentration (see Table 12.1) against the data sheet. A difference may mean that in one or more of the concentrations of a particular day typing errors have been made. It may also be due to a wrong calculation in the field laboratory. In the latter case feed-back has to be given to the field station, as it may hint on a transcription error from the field note book into the summary sheet.

# Listing of Suspended Sediment Summary Data

**Station Code: Mahemdabad** **Station Name: Mahemdabad**

**Local River/Basin: Watrak** **Sub-Division: W.R.I. Subdivision, Ahmedabad**

**August, 1997**

| Day | Time | Obs. No. | Mean Gauge | WL w.r.t. M.S.L. (m) | Discharge ($m^3/s$) (Q) | Observed / Computed | Concentration of Sediment (g/l) Coarse (C) | Medium (M) | Sand+Silt (C+M) | Fine (F) | Total suspended sediment (C+M+F) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 08:00 | 1 | 6.000 | 31.520 | 1731.06 | Observed | 1.8300 | 5.1600 | 6.9900 | 0.5852 | 7.5752 |
| 2 | 08:00 | 1 | 5.200 | 30.720 | 1386.43 | Observed | 1.5300 | 4.5000 | 6.0300 | 0.4818 | 6.5118 |
| 3 | 08:00 | 1 | 3.150 | 28.670 | 554.65 | Observed | 1.2600 | 3.7300 | 4.9900 | 0.4463 | 5.4363 |
| 4 | 08:00 | 1 | 2.150 | 27.670 | 189.07 | Observed | 0.8600 | 2.4600 | 3.3200 | 0.4546 | 3.7746 |
| 5 | 08:00 | 1 | 1.500 | 27.020 | 82.97 | Observed | 0.7000 | 1.8000 | 2.5000 | 0.3939 | 2.8939 |
| 6 | 08:00 | 1 | 1.850 | 27.370 | 76.60 | Observed | 0.4000 | 1.6000 | 2.0000 | 0.3484 | 2.3484 |
| … | | | | | | | | | | | |
| … | | | | | | | | | | | |
| … | | | | | | | | | | | |
| 28 | 08:00 | 1 | 1.950 | | 277.05 | Observed | 0.5000 | 1.8000 | 2.3000 | 0.4327 | 2.7327 |
| 29 | 08:00 | 1 | 1.200 | | 93.14 | Observed | 0.1000 | 1.2000 | 1.3000 | 0.2856 | 1.5856 |
| 30 | 08:00 | 1 | 1.250 | | 169.22 | Observed | 0.2000 | 1.3000 | 1.5000 | 0.3125 | 1.8125 |
| 31 | 08:00 | 1 | 1.050 | | 107.84 | Observed | 0.1000 | 1.0000 | 1.1000 | 0.2182 | 1.3182 |

*Table 12.2 Example of Report of SWDES on suspended sediment data*

To further verify the entries graphs should be made of the various concentrations against discharge:

- Coarse fraction against discharge
- Medium fraction against discharge and
- Fine fraction against discharge.

Though a log-log scale is often suitable for analysis purposes of sediment data, here a linear scale for the concentration with a linear or logarithmic scale for the discharge is more appropriate as particular attention is to be given to zero concentration entries. Some example plots are presented in Figures 12.2 to 12.7. Also plots should be produced of Coarse + Medium and of Total sediment concentration; the latter is shown in Figure 12.8.

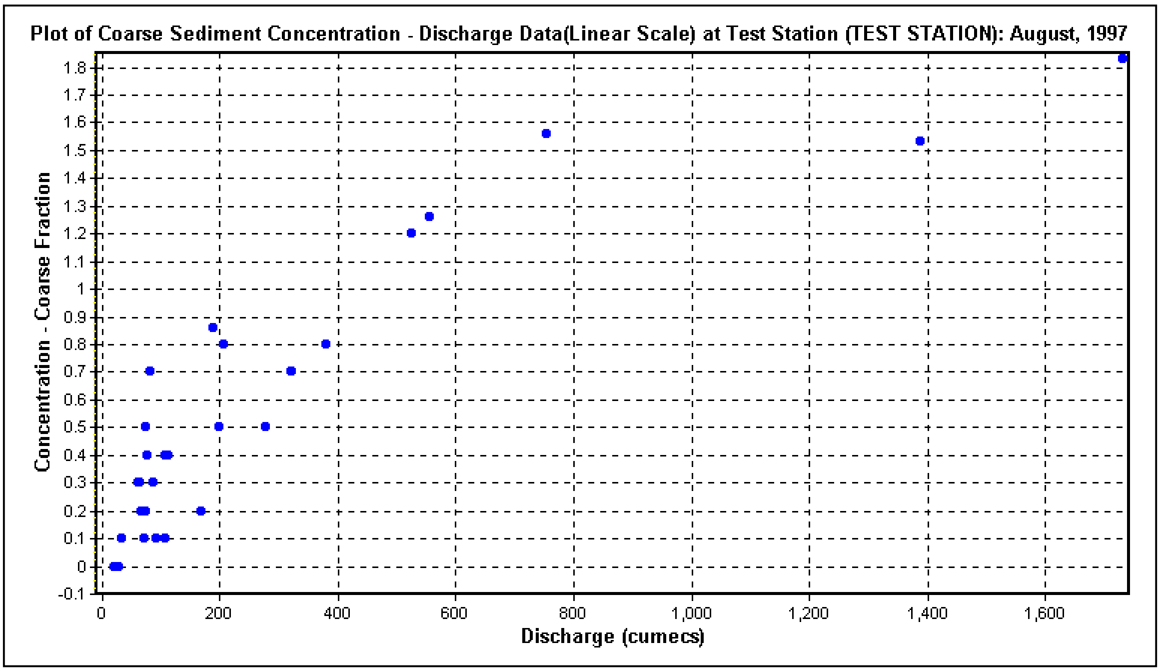



*Figure 12.2: Linear plot of concentration of coarse suspended sediment against discharge*

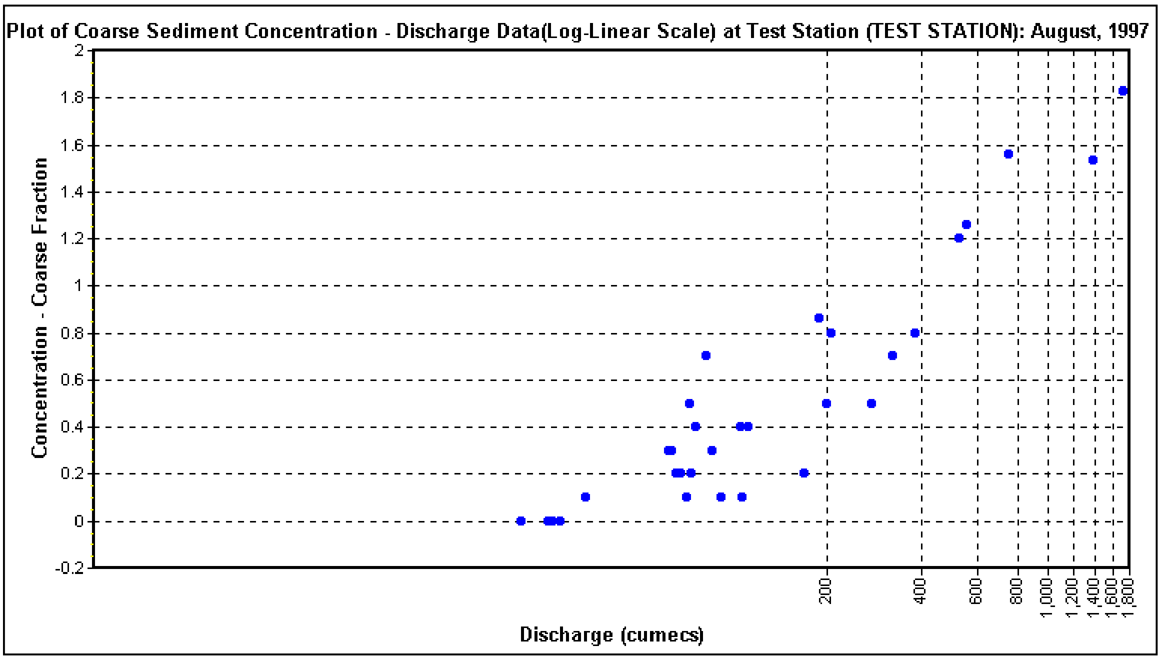



*Figure 12.3: Semi-log plot of concentration of coarse suspended sediment against discharge*

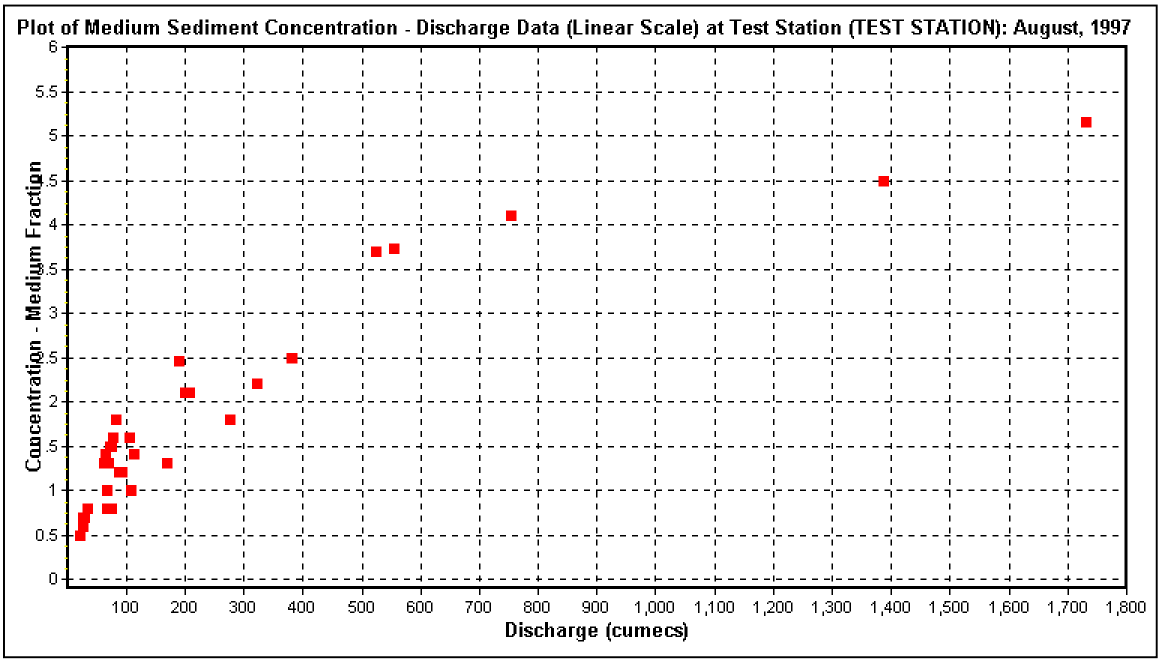



*Figure 12.4: Linear plot of concentration of medium fractioned suspended sediment against discharge*

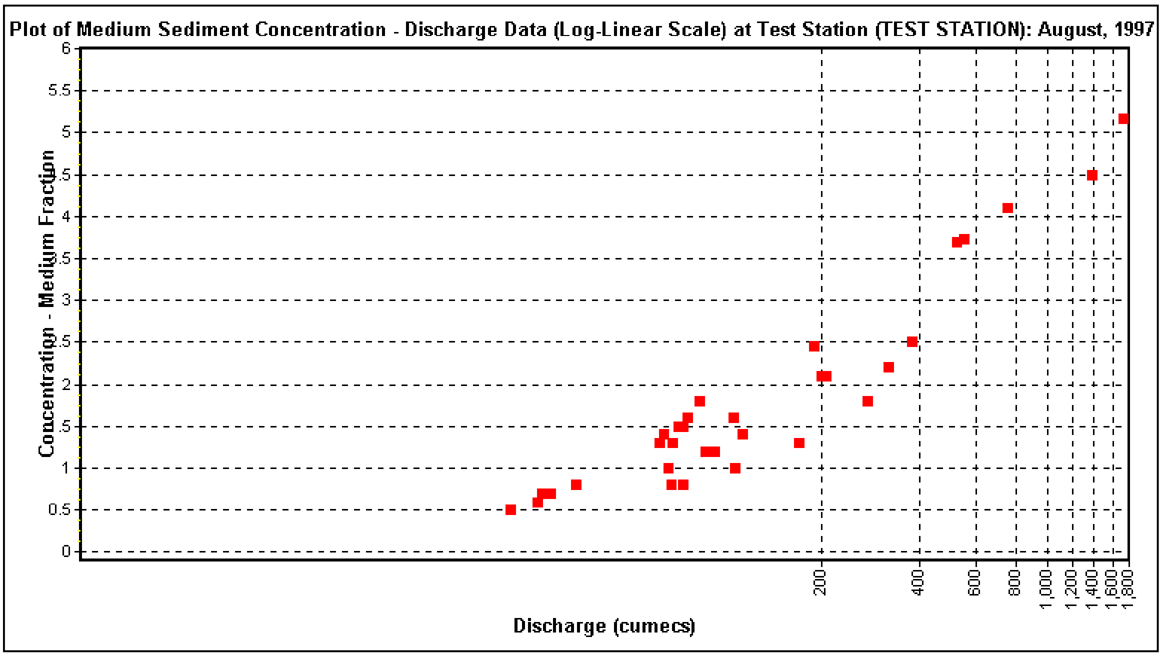



*Figure 12.5: Semi-log plot of concentration of medium fractioned suspended sediment against discharge*

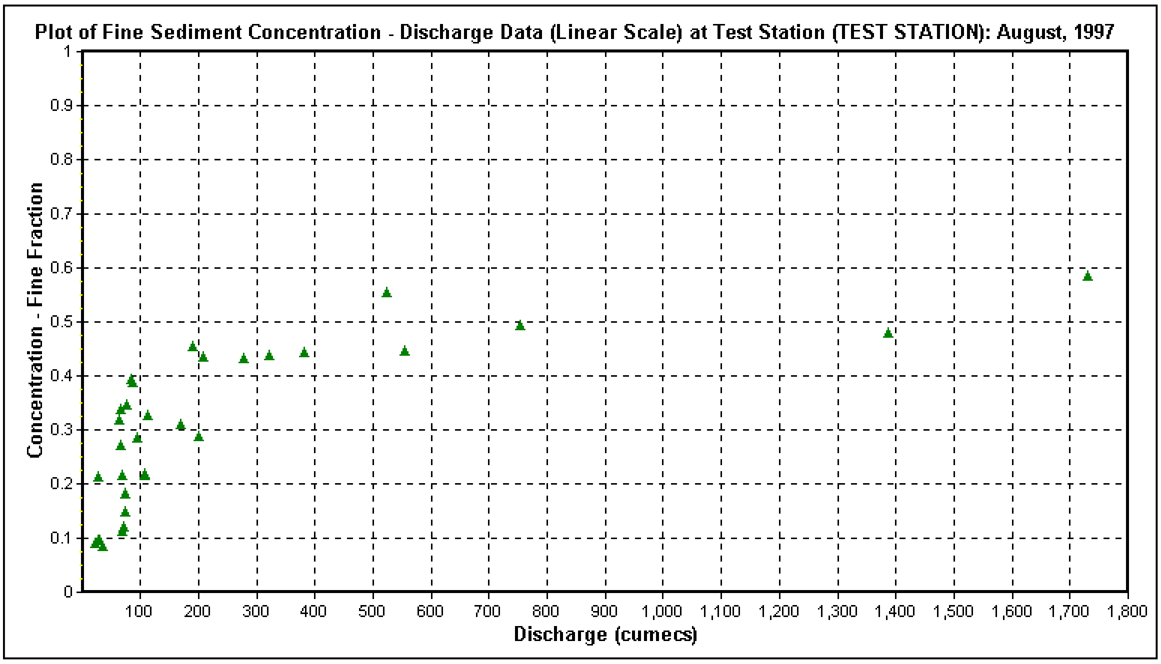



*Figure 12.6: Linear plot of concentration of fine suspended sediment against discharge*

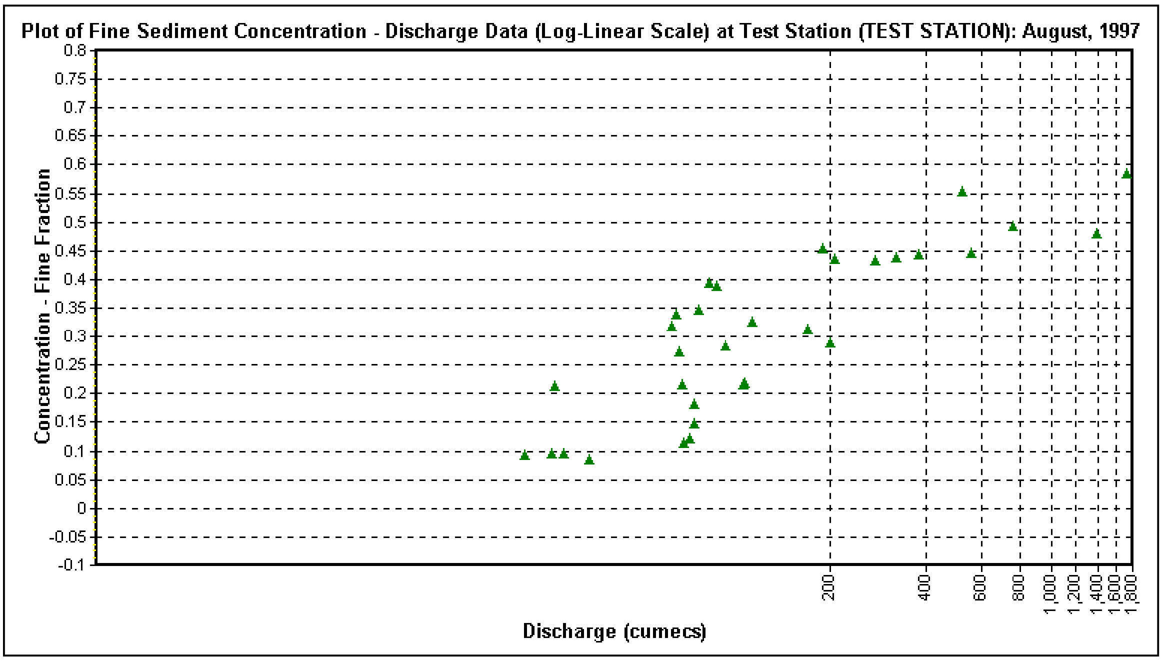



*Figure 12.7: Semi-log plot of concentration of fine suspended sediment against discharge*

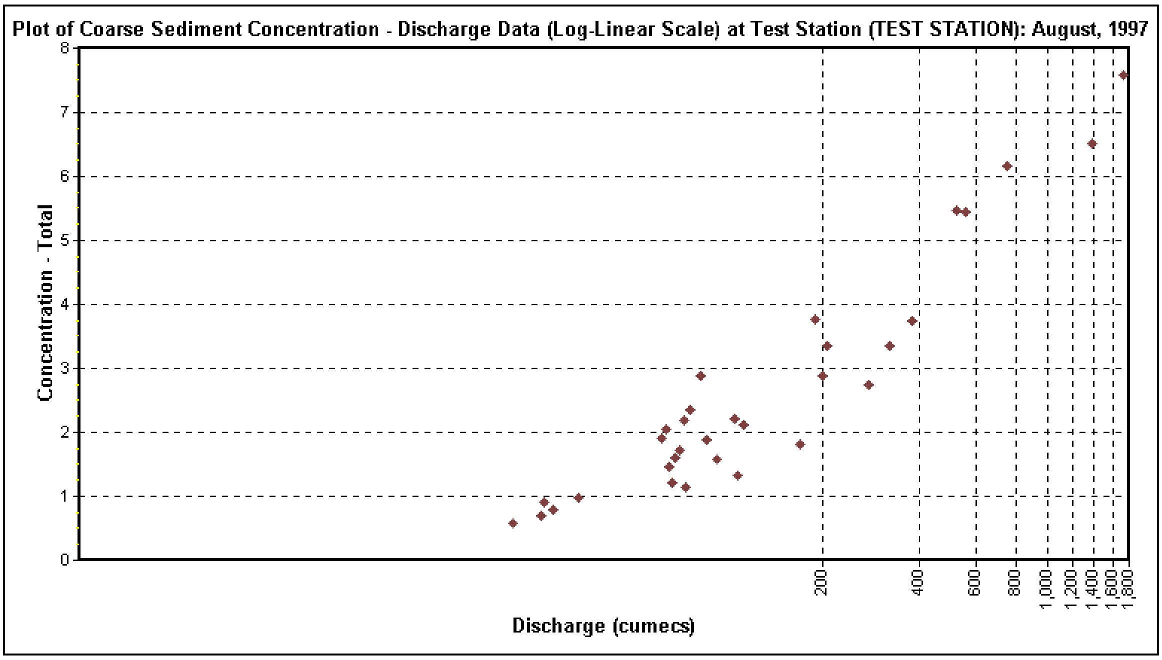



*Figure 12.8: Semi-log plot of concentration of total suspended sediment against discharge*

From the above figures it is found that the suspended sediment concentration of whatever fraction, shows a much wider variation than is the case with discharge against water level. Before one investigates the concentrations the discharge data should be verified, for which reference is made to the previous chapters.

## 12.4 ENTRY OF BED MATERIAL DATA

***Particle size distribution***

The analysis of bed material comprises the determination of its grain size distribution. The distribution of grain sizes found in nature is generally approximately log-normal. It follows that the logarithm of the diameter will be approximately be normally distributed. Hence, the particle size distribution is generally graphically presented with the diameter plotted on a logarithmic horizontal axis against a normal probability scale on the vertical. The latter is stretching the lower and upper tails of the distribution. In spreadsheet the latter is difficult to establish, but instead the reduced normal variate can be plotted conveniently by transforming the non-exceedance frequencies into reduced variate values, see the Annex to Part III of Volume 8 on Data Processing for the details of the normal and log-normal distribution.

By sieving and with the siltometer a detailed grain size distribution will be obtained. In view of the fact that the distribution is approximately log-normal some characteristic values of the distribution are only maintained, sufficient to reproduce the real important features of the distribution. For this the following characteristic particle sizes are defined:

- The **mean** diameter $D_m$:

$$D_m = \frac{\sum p_i D_i}{\sum p_i} \qquad (12.1)$$

where: $D_i$ = arithmetic mean diameter of particles in class i

$p_i$ = the percentage of mass of the sample in the $i^{th}$ class interval

- The **median** $D_{50}$ = the median particle size, which is not exceeded by 50% of the sample mass
- $D_{10}$ = the particle size, which is not exceeded by 10% of the sample mass
- $D_{16}$ = the particle size, which is not exceeded by 16% of the sample mass
- $D_{35}$ = the particle size, which is not exceeded by 35% of the sample mass
- $D_{65}$ = the particle size, which is not exceeded by 65% of the sample mass
- $D_{84}$ = the particle size, which is not exceeded by 84% of the sample mass
- $D_{90}$ = the particle size, which is not exceeded by 90% of the sample mass

For an approximately log-normal distribution one further defines:

- **Geometric mean** diameter $D_g$:

$$D_g = 10^{\frac{\sum p_i \log D_i}{\sum p_i}} \tag{12.2}$$

- **Geometric standard deviation** $\sigma_g$:

$$\sigma_g = \frac{1}{2}\left(\frac{D_{84}}{D_{50}} + \frac{D_{50}}{D_{16}}\right) \tag{12.3}$$

In view of the log-normal particle size distribution the following relations approximately hold:

$$\begin{aligned} D_{10} &= \sigma_g^{-1.3} D_{50} \\ D_{16} &= \sigma_g^{-1} D_{50} \\ D_{84} &= \sigma_g D_{50} \\ D_{90} &= \sigma_g^{1.3} D_{50} \end{aligned} \tag{12.4}$$

The reduced normal variate to which the non-exceedance frequency 10, 16, 35, 50, 65, 84 and 90% refer to are presented in Table 12.3.

Examples of particle size distributions are depicted in Figures 12.9 and 12.10 for the same data set (see Table 12.4). In both cases a logarithmic scale is used for the particle diameter. The difference is in the vertical scale: in Figure 12.9 the diameter is plotted against a linear non-exceedance frequency (% finer) and in Figure 12.10 against a normal probability scale expressed in a reduced variate. In case the particle size distribution would be log-normal in the last graph a straight line should have been observed.

| Non-exceedance probability % | Reduced normal variate | Non-exceedance probability % | Reduced normal variate |
|---|---|---|---|
| 10 | -1.282 | 65 | 0.385 |
| 16 | -0.994 | 84 | 0.994 |
| 35 | -0.385 | 90 | 1.282 |
| 50 | 0 | | |

*Table 12.3: Relation between non-exceedance probability and reduced variate*

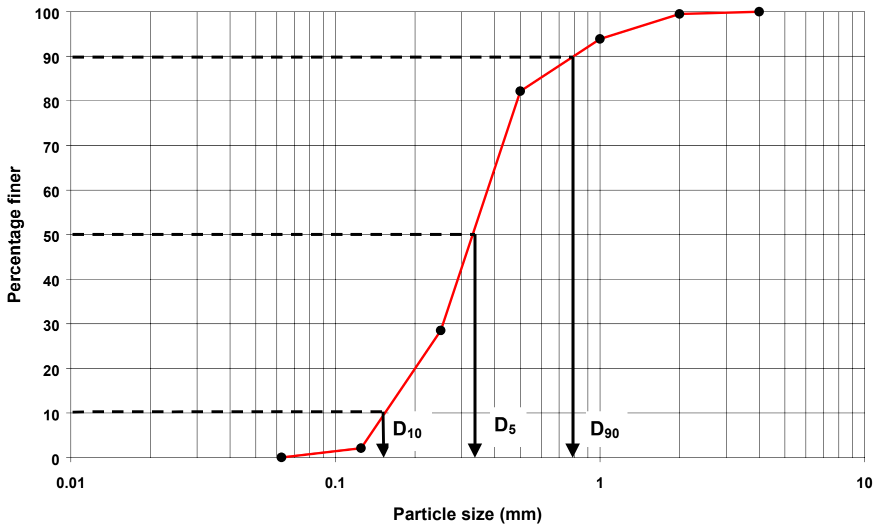



*Figure 12.9: Particle size distribution with linear probability scale*

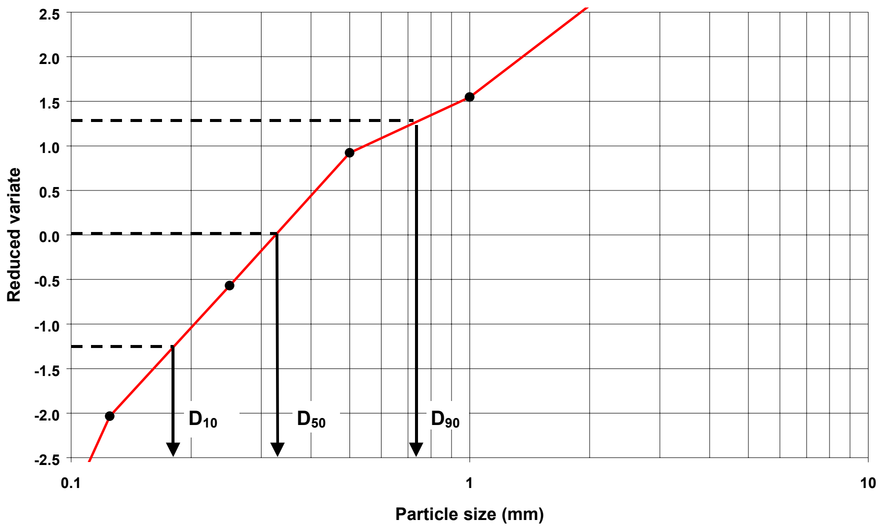



*Figure 12.10: Particle size distribution on log-normal paper*

In the following the characteristic diameters of the sample will be elaborated. For this, first Table 12.4 is observed.

| Size | Percentage of mass of sample $p_i$ retained | $D_i$ | $p_iD_i$ | log $D_i$ | $p_i$ log $D_i$ |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 4 | 0.0 | - | - | - | - |
| 2 | 0.5 | 3 | 1.5000 | 0.4771 | 0.2386 |
| 1 | 5.6 | 1.5 | 8.4000 | 0.1761 | 0.9861 |
| 0.5 | 11.7 | 0.75 | 8.7750 | -0.1249 | -1.4618 |
| 0.25 | 53.7 | 0.375 | 20.1375 | -0.4260 | -22.8745 |
| 0.125 | 26.4 | 0.1875 | 4.9500 | -0.7270 | -19.1928 |
| 0.0625 | 2.1 | 0.09375 | 0.1969 | -1.0280 | -2.1589 |
| Totals | 100.0 | | 43.9594 | | -44.4633 |

*Table 12.4: Results of grain size distribution analysis and determination of mean and geometric mean value*

From the data of Table 12.4 column 4 and 2 it follows for the mean value $D_m$ according to equation (12.1):

$$D_m = \frac{\sum p_i D_i}{\sum p_i} = \frac{43.9594}{100} = 0.44 \text{ mm}$$

For the geometric mean $D_g$ according to (12.2) one obtains from column 6 and column 2:

$$D_g = 10^{\frac{\Sigma p_i \log D_i}{\Sigma p_i}} = 10^{\frac{-44.4633}{100}} = 10^{-0.445} = 0.36\text{mm}$$

The other characteristic particle sizes are determined by interpolation. Keeping in mind that in case of a log-normally distributed grain size the logarithm of the particle size versus the reduced variate will produce a straight line. Hence by interpolation from observed values the characteristic particle sizes are determined as follows. Use is made of Table 12.3 and Table 12.5, where the non-exceedance frequencies are shown together with their reduced variates.

| Row nr | Size | Log $D_i$ | Percentage of mass of sample $p_i$ retained | Acc. percentage finer | Reduced variate |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 4 | 0.60206 | 0.00 | 100.00 | 3.000* |
| 2 | 2 | 0.30103 | 0.50 | 99.50 | 2.576 |
| 3 | 1 | 0 | 5.60 | 93.90 | 1.546 |
| 4 | 0.5 | -0.30103 | 11.70 | 82.20 | 0.923 |
| 5 | 0.25 | -0.60206 | 53.70 | 28.50 | -0.568 |
| 6 | 0.125 | -0.90309 | 26.40 | 2.10 | -2.034 |
| 7 | 0.0625 | -1.20412 | 2.10 | 0.00 | -3.000* |

*) assumed values for plotting purposes only, as basically these values should be ∞ and -∞

*Table 12.5: Scheme for computation of characteristic particle sizes*

Any characteristic $D_x$ is determined by interpolation from its surrounding known values:

$$\log D_x = \left(\frac{rv_x - rv_i}{rv_{i+1} - rv_i}\right)(\log D_{i+1} - \log D_i) + \log D_i$$
$$D_x = 10^{\log D_x} \qquad (12.5)$$

Where: i = index of value just below x

i+1 = index of value just above x

rv = reduced variate

For the median $D_{50}$, (12.5) is used with x = 50. According to Table 12.3, $rv_{50}$ = 0. Hence from Table 12.5, column 5, and equation (12.5) it follows with i = row 5 and i+1 = row 4:

$$\log D_{50} = \left(\frac{0-(-0.568)}{0.923-(-0.568)}\right)(-0.30103-(-0.60206)) + (-0.60206) = -0.487$$
$$D_{50} = 10^{-0.487} = 0.33 \text{ mm}$$

Similarly for the other characteristics it follows:

$$\log D_{10} = \left(\frac{-1.282-(-2.034)}{-0.568-(-2.034)}\right)(-0.60206-(-0.90309))+(-0.90309) = -0.749$$

$$D_{10} = 10^{-0.749} = 0.18\,\text{mm}$$

$$\log D_{16} = \left(\frac{-0.994-(-2.034)}{-0.568-(-2.034)}\right)(-0.60206-(-0.90309))+(-0.90309) = -0.689$$

$$D_{16} = 10^{-0.689} = 0.20\,\text{mm}$$

$$\log D_{35} = \left(\frac{-0.385-(-0.568)}{0.923-(-0.568)}\right)(-0.30103-(-0.60206))+(-0.60206) = -0.565$$

$$D_{35} = 10^{-0.565} = 0.27\,\text{mm}$$

$$\log D_{65} = \left(\frac{0.385-(-0.568)}{0.923-(-0.568)}\right)(-0.30103-(-0.60206))+(-0.60206) = -0.410$$

$$D_{65} = 10^{-0.410} = 0.39\,\text{mm}$$

$$\log D_{84} = \left(\frac{0.994-0.923}{1.546-0.923}\right)(0.00000-(-0.30103))+(-0.30103) = -0.267$$

$$D_{84} = 10^{-0.267} = 0.54\,\text{mm}$$

$$\log D_{90} = \left(\frac{1.282-0.923}{1.546-0.923}\right)(0.00000-(-0.30103))+(-0.30103) = -0.128$$

$$D_{90} = 10-0.128 = 0.75\,\text{mm}$$

For the standard deviation $\sigma_g$ it follows according to equation (12.3):

$$\sigma_g = \frac{1}{2}\left(\frac{0.54}{0.33}+\frac{0.33}{0.20}\right) = 1.64$$

Since in the above example all values constituting $\sigma_g$ are in the same interval in Table 12.5, with equations (12.4) using $\sigma_g$ and $D_{50}$ the values for $D_{16}$ and $D_{84}$ are exactly reproduced. For $D_{10}$ and $D_{90}$ one would get with equation (12.4) 0.18 and 0.62 mm respectively.

***Types of data***

Three types of data are to be entered in SWDES for bed material:

1. Sampling date, location and type of sampler
2. Results of sieve analysis for grain sizes > 0.6 mm
3. Results of siltometer analysis for grain sizes < 0.6 mm

***Sampling date, location and type of sampler***

Bed material samples are generally collected in the pre-monsoon, monsoon and post-monsoon. The date of sampling is to be entered in SWDES as well as the location, i.e.:

- the location of the cross-section
- the location in the cross-section with respect to the river bank.

Standard practice adopted by CWC is that the number and location of samples in the cross-section depends on the river width. The following guideline exists:

| Width of river (m) | Sampling points as fraction of width from left bank |
|---|---|
| 0-200 | 1/4,2/4,3/4 |
| 200-400 | 1/6,2/6,3/6,4/6,5/6 |
| 400-800 | 1/7,2/7,3/7,4/7,5/7,6/7 |
| >800 | 1/8,2/8,3/8,4/8,5/8,6/8,7/8 |

*Table 12.6: Location of sampling points*

In addition to this two samples from either bank are also collected in some cases.

Finally, the type of sampler has to be entered, as this is needed for further interpretation of the results.

***Results of sieve analysis***

For particle sizes > 0.6 mm the distribution is determined by dry sieving. The following data are entered:

1. total weight of the sample $W_s$ used in the sieve analysis
2. weight of the quantity $W_i$ retained by each sieve with aperture i,
3. weight of sample part passing the sieve with aperture 0.6 mm = $W_m$.

The total weight of the sample follows from:

$$W_s = \sum_{i=1}^{N} W_i + W_m \tag{12.6}$$

where: N = total number of sieves used

By comparing the weighed $W_s$ with the computed $W_s$ a check is obtained on the calculations.

The results of the sieving are noted in the following form, see Table 12.7.

| **RESULTS OF SIEVING** | |
|---|---|
| Location<br>Sub-division<br>River: width: m<br>Site: | Location in cross-section<br>Sampler type<br>Date<br>Sample number |
| Aperture in mm | Quantity retained (gram) |
| 20.00 | |
| 12.50 | |
| 6.30 | |
| 4.75 | |
| 4.00 | |
| 3.35 | |
| 2.80 | |
| 2.36 | |
| 2.00 | |
| 1.40 | |
| 1.00 | |
| 0.60 | |
| Passing 0.60 = $W_m$ (gram) | |
| **Total = $W_s$ (gram)** | |

*Table 12.7 Data entry form for sieve analysis*

***Results of analysis by siltometer***

Next to the sieve analysis the distribution of the sediments passing the 0.60 mm aperture sieve of which a total of $W_m$ (gram) is available. From this $W_m$ (gram) a quantity of $W_a$ of exactly **10** gram is taken for further analysis in the siltometer. The siltometer contains 20 pockets, in which sediment of a specific fraction is caught based on its fall velocity, by rotating the device according to prescribed time intervals, see the Field Manual of Volume V on Sediment Transport Measurements. The size of the material caught in a certain pocket depends on the temperature, as listed in Table 12.8. The pocket content is subsequently dried and weighed. Let the sum of the weight of the caught quantities in the 20 pockets be $W_p$. The difference: $W_a – W_p = W_f$ grams, which is called the loss, is the quantity having a size **less** than the lowest size measurable with the siltometer. This lower limit is a function of the water temperature, see last column in Table 12.8

| ***T* °*C*** | ***Time (s)*** | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***26*** | ***30*** | ***34*** | ***38*** | ***42*** | ***46*** | ***50*** | ***54*** | ***58*** | ***62*** | ***66*** | ***70*** | ***86*** | ***96*** | ***106*** | ***136*** | ***166*** | ***196*** | ***376*** | ***556*** |
| **10** | 618 | 541 | 483 | 438 | 401 | 371 | 346 | 325 | 307 | 291 | 277 | 249 | 227 | 209 | 195 | 165 | 146 | 131 | 91 | 74 |
| **11** | 612 | 536 | 478 | 433 | 397 | 367 | 342 | 322 | 303 | 287 | 274 | 246 | 224 | 207 | 193 | 163 | 144 | 130 | 90 | 73 |
| **12** | 606 | 530 | 473 | 429 | 393 | 363 | 339 | 317 | 300 | 284 | 271 | 243 | 221 | 204 | 190 | 161 | 142 | 128 | 88 | 72 |
| **13** | 600 | 525 | 468 | 427 | 389 | 360 | 335 | 314 | 297 | 281 | 268 | 240 | 219 | 202 | 188 | 159 | 140 | 126 | 87 | 71 |
| **14** | 594 | 520 | 464 | 421 | 385 | 356 | 332 | 311 | 294 | 278 | 265 | 237 | 217 | 200 | 186 | 157 | 138 | 125 | 86 | 70 |
| **15** | 588 | 515 | 459 | 416 | 381 | 352 | 328 | 308 | 290 | 275 | 262 | 235 | 214 | 198 | 184 | 155 | 137 | 123 | 85 | 69 |
| **16** | 583 | 510 | 455 | 412 | 378 | 349 | 325 | 305 | 287 | 272 | 259 | 232 | 212 | 196 | 182 | 153 | 135 | 122 | 84 | 68 |
| **17** | 577 | 505 | 451 | 408 | 374 | 346 | 322 | 302 | 285 | 270 | 256 | 230 | 209 | 193 | 180 | 152 | 134 | 120 | 83 | 67 |
| **18** | 572 | 501 | 446 | 404 | 370 | 342 | 319 | 299 | 282 | 267 | 254 | 228 | 207 | 191 | 178 | 150 | 132 | 119 | 82 | 66 |
| **19** | 567 | 496 | 443 | 400 | 367 | 339 | 315 | 296 | 279 | 264 | 251 | 225 | 205 | 189 | 176 | 148 | 130 | 118 | 81 | 66 |
| **20** | 562 | 492 | 438 | 397 | 363 | 336 | 312 | 293 | 276 | 262 | 249 | 223 | 203 | 187 | 174 | 147 | 129 | 116 | 80 | 65 |
| **21** | 557 | 487 | 435 | 393 | 360 | 333 | 310 | 290 | 274 | 259 | 246 | 221 | 201 | 185 | 172 | 145 | 127 | 115 | 79 | 64 |
| **22** | 553 | 484 | 431 | 390 | 357 | 330 | 307 | 288 | 271 | 257 | 244 | 219 | 199 | 183 | 171 | 144 | 126 | 114 | 78 | 63 |
| **23** | 548 | 480 | 428 | 386 | 354 | 327 | 304 | 285 | 268 | 254 | 242 | 217 | 197 | 182 | 169 | 142 | 125 | 113 | 77 | 63 |
| **24** | 544 | 476 | 424 | 383 | 351 | 324 | 302 | 282 | 266 | 252 | 240 | 215 | 195 | 180 | 167 | 141 | 124 | 112 | 76 | 62 |
| **25** | 540 | 472 | 421 | 380 | 348 | 321 | 299 | 280 | 264 | 250 | 237 | 213 | 193 | 178 | 166 | 139 | 122 | 110 | 76 | 61 |
| **26** | 535 | 468 | 417 | 377 | 345 | 319 | 296 | 278 | 261 | 247 | 235 | 211 | 192 | 177 | 164 | 138 | 121 | 109 | 75 | 60 |
| **27** | 531 | 465 | 414 | 374 | 342 | 316 | 294 | 275 | 259 | 245 | 233 | 209 | 190 | 175 | 163 | 136 | 120 | 108 | 74 | 60 |
| **28** | 527 | 461 | 411 | 371 | 339 | 313 | 291 | 273 | 257 | 243 | 231 | 207 | 188 | 173 | 161 | 135 | 119 | 107 | 73 | 59 |
| **29** | 522 | 458 | 407 | 368 | 337 | 311 | 289 | 271 | 255 | 241 | 229 | 205 | 186 | 172 | 160 | 134 | 118 | 106 | 72 | 59 |
| **30** | 518 | 454 | 404 | 365 | 334 | 308 | 287 | 268 | 253 | 239 | 227 | 203 | 185 | 170 | 158 | 133 | 116 | 105 | 72 | 58 |
| **31** | 515 | 451 | 401 | 362 | 331 | 306 | 284 | 266 | 251 | 237 | 225 | 202 | 183 | 169 | 157 | 131 | 115 | 104 | 71 | 57 |
| **32** | 511 | 447 | 398 | 359 | 329 | 304 | 282 | 264 | 249 | 235 | 224 | 200 | 182 | 167 | 156 | 130 | 114 | 103 | 70 | 57 |
| **33** | 507 | 444 | 395 | 357 | 326 | 301 | 280 | 262 | 247 | 233 | 222 | 198 | 180 | 166 | 154 | 129 | 113 | 102 | 70 | 56 |
| **34** | 503 | 441 | 392 | 354 | 324 | 299 | 278 | 260 | 245 | 231 | 220 | 197 | 179 | 164 | 153 | 128 | 112 | 101 | 69 | 56 |
| **35** | 500 | 437 | 389 | 351 | 321 | 297 | 276 | 258 | 243 | 230 | 218 | 195 | 177 | 163 | 151 | 127 | 111 | 100 | 68 | 55 |

*Table 12.8: Particle size in μm as a function of temperature and time in a 2 m tube after Puri*

Hence the entries from the siltometer analysis are as follows, see Table 12.9:

- The temperature of the water used in the tube of the siltometer.
- Weight of the sediment applied to the siltometer ($W_a$ = 10 grams)
- Dry weight of the sediments caught in each of the 20 pockets, summing up to $W_p$.

The weight of fine sediments $W_f$ is subsequently determined from $W_a – W_p$ in the table, which is to be compared with the value computed in SWDES. Given the temperature of the water in the siltometer analysis in SWDES automatically the size of the fraction is determined for each pocket, by making use of Table 12.8.

Thereafter, to bring the results back in line with the results of the sieve analysis, all weights from the siltometer analysis are multiplied in SWDES with $W_m/W_a$. Next the quantity of each fraction as a percentage of the total is determined, and finally the percentage finer, starting off from the largest particle size in the sample, putting it at 100%.

Next, based on the observed quantity in each fraction, the characteristic particle sizes $D_{10}$, $D_{16}$, $D_{35}$, $D_{50}$, $D_m$, $D_g$, $D_{65}$, $D_{84}$, $D_{90}$ and $\sigma_g$ are determined by SWDES. The results are presented in table and graphical form, shown in Example 12.1.

| RESULTS OF SILTOMETER ANALYSIS | | |
|---|---|---|
| Location<br>Sub-division<br>River: width: m<br>Site: | Location in cross-section<br>Sampler type<br>Date<br>Sample number | |
| Water temperature in tube °C | | |
| Quantity passing 0.60 mm, $W_m$ | $W_m$ | |
| Quantity applied $W_a$ | | $W_a$ |
| Pocket number | Weight (gram) | |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | | |
| 14 | | |
| 15 | | |
| 16 | | |
| 17 | | |
| 18 | | |
| 19 | | |
| 20 | | |
| Total weight in pockets: $W_p$ | Sum | $W_p$ = Sum |
| Weight of fines: $W_f = W_a - W_p$ | | $W_f = W_a - W_p$ |

*Table 12.9 Entries for siltometer analysis*

**Example 12.1**

From a site Pulaman a sample was obtained, which sowed the following results after sieving

| **RESULTS OF SIEVING** | |
|---|---|
| Location<br>Sub-division: SWRD<br>River: Pulamikodu width: 100 m<br>Site: Pulaman | Location in cross-section: xx<br>Sampler type: yy<br>Date: zzz<br>Sample number: AAA |
| Aperture in mm | Quantity retained (gram) |
| 20.00 | 0 |
| 12.50 | 3 |
| 6.30 | 50 |
| 4.75 | 20 |
| 4.00 | 67 |
| 3.35 | 7 |
| 2.80 | 13 |
| 2.36 | 8 |
| 2.00 | 91 |
| 1.40 | 62 |
| 1.00 | 110 |
| 0.60 | 121 |
| Passing 0.60 = $W_m$ (gram) | 275 |
| **Total = $W_s$** (gram) | 827 |

*Table 12.10: Results of sieve analysis Pulaman site*

The results of the siltometer analysis are shown in the second and third column of Table 12.11.

| **RESULTS OF SILTOMETER ANALYSIS** | | |
|---|---|---|
| Location<br>Sub-division<br>River: width: m<br>Site: | Location in cross-section<br>Sampler type<br>Date<br>Sample number | |
| Water temperature in tube $^oC$ | 28.0 | |
| Quantity passing 0.60 mm, $W_m$ | 275.0 | |
| Quantity applied $W_a$ | 10 | 10.000 |
| Pocket number | Weight (gram) | |
| 1 | 5.029 | |
| 2 | 1.150 | |
| 3 | 0.980 | |
| 4 | 0.784 | |
| 5 | 0.549 | |
| 6 | 0.392 | |
| 7 | 0.261 | |
| 8 | 0.209 | |
| 9 | 0.157 | |
| 10 | 0.078 | |
| 11 | 0.052 | |
| 12 | 0.052 | |
| 13 | 0.026 | |
| 14 | 0.026 | |
| 15 | 0.026 | |
| 16 | 0.013 | |
| 17 | 0.000 | |
| 18 | 0.000 | |
| 19 | 0.000 | |
| 20 | 0.000 | |
| Total weight in pockets: $W_p$ | 9.784 | 9.784 |
| Weight of fines: $W_f = W_a - W_p$ | | 0.216 |

*Table 12.11: Results of siltometer analysis*

From Table 12.11 it is observed that the water temperature in the siltometer tube during the analysis was 28.0 $_o$C. Hence the corresponding sizes of the particles caught in the pockets 1, 2,….,20 are respectively according to Table 12.8: 0.527, 0.461, …., 0.059 mm.

Next the results of the sieve analysis and of the siltometer analysis are combined in Table 12.12 to get the final grain size distribution, see Figure 12.11. From this the characteristic particle sizes $D_{10}$, etc. are be determined as described in the beginning of this section, equations 12.1, 12.2, 12.3 and 12.5.

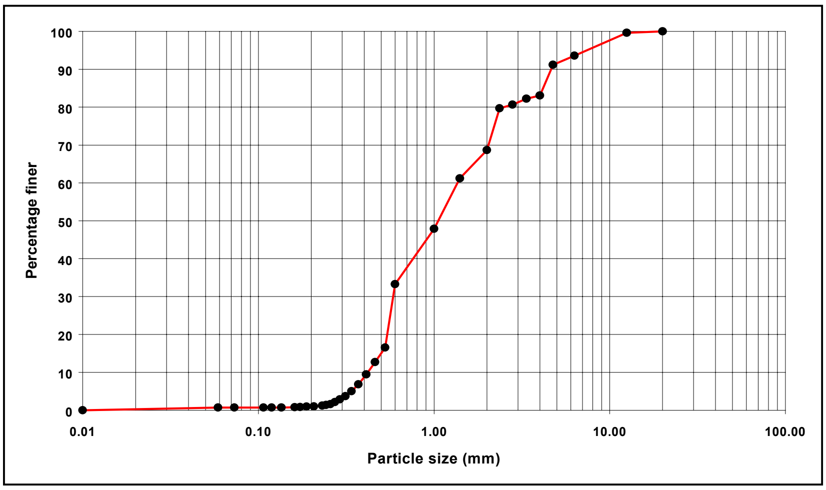



*Figure 12.11: Particle size distribution, with linear frequency scale*

| Row | Diameter (mm) | Sieve analysis (g) | Siltometer analysis (g) | Siltometer adjusted (g) | Retained (g) | Retained (%) | % finer | Reduced variate |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | 20.000 | 0 | | | 0.00 | 0.00 | 100.00 | 3.000* |
| 2 | 12.500 | 3 | | | 3.00 | 0.36 | 99.64 | 2.685 |
| 3 | 6.300 | 50 | | | 50.00 | 6.05 | 93.59 | 1.521 |
| 4 | 4.750 | 20 | | | 20.00 | 2.42 | 91.17 | 1.351 |
| 5 | 4.000 | 67 | | | 67.00 | 8.10 | 83.07 | 0.957 |
| 6 | 3.350 | 7 | | | 7.00 | 0.85 | 82.22 | 0.924 |
| 7 | 2.800 | 13 | | | 13.00 | 1.57 | 80.65 | 0.865 |
| 8 | 2.360 | 8 | | | 8.00 | 0.97 | 79.69 | 0.830 |
| 9 | 2.000 | 91 | | | 91.00 | 11.00 | 68.68 | 0.487 |
| 10 | 1.400 | 62 | | | 62.00 | 7.50 | 61.19 | 0.284 |
| 11 | 1.000 | 110 | | | 110.00 | 13.30 | 47.88 | -0.053 |
| 12 | 0.600 | 121 | | | 121.00 | 14.63 | 33.25 | -0.433 |
| 13 | 0.527 | | 5.029 | 138.298 | 138.30 | 16.72 | 16.53 | -0.973 |
| 14 | 0.461 | | 1.150 | 31.625 | 31.63 | 3.82 | 12.71 | -1.140 |
| 15 | 0.411 | | 0.980 | 26.950 | 26.95 | 3.26 | 9.45 | -1.314 |
| 16 | 0.371 | | 0.784 | 21.560 | 21.56 | 2.61 | 6.84 | -1.488 |
| 17 | 0.339 | | 0.549 | 15.098 | 15.10 | 1.83 | 5.01 | -1.643 |
| 18 | 0.313 | | 0.392 | 10.780 | 10.78 | 1.30 | 3.71 | -1.785 |
| 19 | 0.291 | | 0.261 | 7.178 | 7.18 | 0.87 | 2.84 | -1.904 |
| 20 | 0.273 | | 0.209 | 5.748 | 5.75 | 0.69 | 2.15 | -2.024 |
| 21 | 0.257 | | 0.157 | 4.318 | 4.32 | 0.52 | 1.63 | -2.138 |
| 22 | 0.243 | | 0.078 | 2.145 | 2.15 | 0.26 | 1.37 | -2.207 |
| 23 | 0.231 | | 0.052 | 1.430 | 1.43 | 0.17 | 1.19 | -2.259 |
| 24 | 0.207 | | 0.052 | 1.430 | 1.43 | 0.17 | 1.02 | -2.319 |
| 25 | 0.188 | | 0.026 | 0.715 | 0.72 | 0.09 | 0.93 | -2.352 |

| Row | Diameter (mm) | Sieve analysis (g) | Siltometer analysis (g) | Siltometer adjusted (g) | Retained (g) | Retained (%) | % finer | Reduced variate |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 26 | 0.173 | | 0.026 | 0.715 | 0.72 | 0.09 | 0.85 | -2.388 |
| 27 | 0.161 | | 0.026 | 0.715 | 0.72 | 0.09 | 0.76 | -2.427 |
| 28 | 0.135 | | 0.013 | 0.358 | 0.36 | 0.04 | 0.72 | -2.448 |
| 29 | 0.119 | | 0.000 | 0.000 | 0.00 | 0.00 | 0.72 | -2.448 |
| 30 | 0.107 | | 0.000 | 0.000 | 0.00 | 0.00 | 0.72 | -2.448 |
| 31 | 0.073 | | 0.000 | 0.000 | 0.00 | 0.00 | 0.72 | -2.448 |
| 32 | 0.059 | | 0.000 | 0.000 | 0.00 | 0.00 | 0.72 | -2.448 |
| 33 | <0.059 | | 0.216 | 5.940 | 5.94 | 0.72 | 0.00 | -3.000* |
| 34 | Total | 552 | 10.000 | 275.000 | 827.00 | 100.00 | | |
| D10 (mm) | D16 (mm) | D35 (mm) | D50 (mm) | D65 (mm) | D84 (mm) | D90 (mm) | $\sigma_g$ | $D_m$ (mm) |
| | | | | | | | | |

*) assumed values for plotting purposes

*Table 12.12: Summary of results of particle size analysis*

The particle size distribution plotted against the reduced variate is shown in figure 12.12. It is observed that the distribution shows a fairly straight line with the normal probability scale on the vertical and the logarithm of the particle diameter on the horizontal axis.

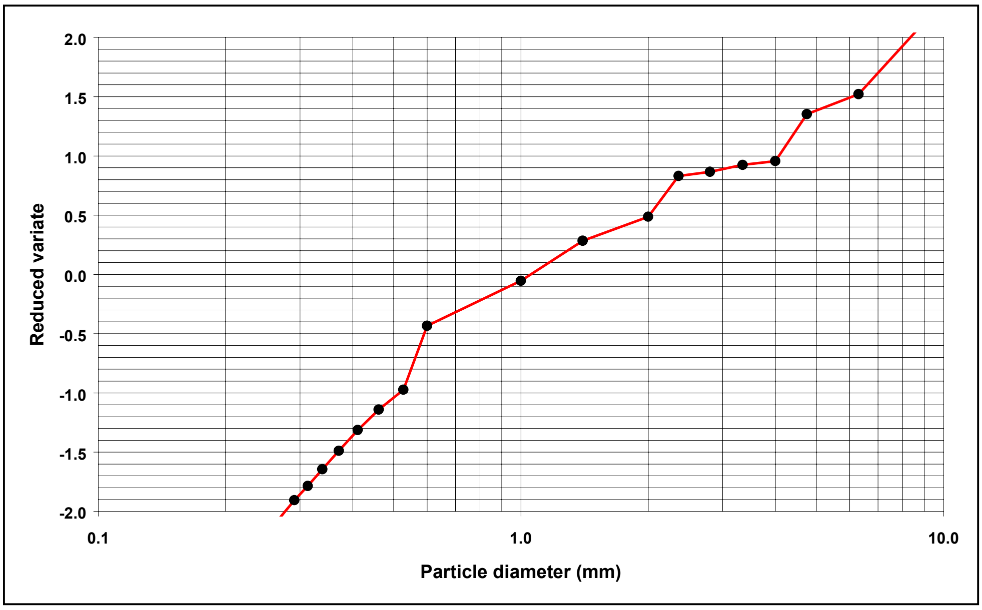



*Figure 12.12: Particle size distribution against reduced variate*

# 13 PRIMARY VALIDATION OF SEDIMENT DATA

## 13.1 SUSPENDED SEDIMENT DATA

The primary validation of suspended sediment data comprises the following steps:

Inspection of inconsistency in zero concentration entries. Particularly for the coarse and medium fractions, annually a number of times zero concentrations will occur when the flow velocities are very low. However, if the zero entries also occur when the flow velocities are significant either the entry in the field was wrong or the entry in the office. Zero's should only be observed below a certain threshold value. This is easily observed from a semi-log plot of concentration versus discharge, particularly if this is done for a particular month in comparison with the data for the whole year. Make sure in your plot that the concentration scale starts with a negative value to make the zero entries clearly visible. An example is given in the Figures 13.1 and 13.2.

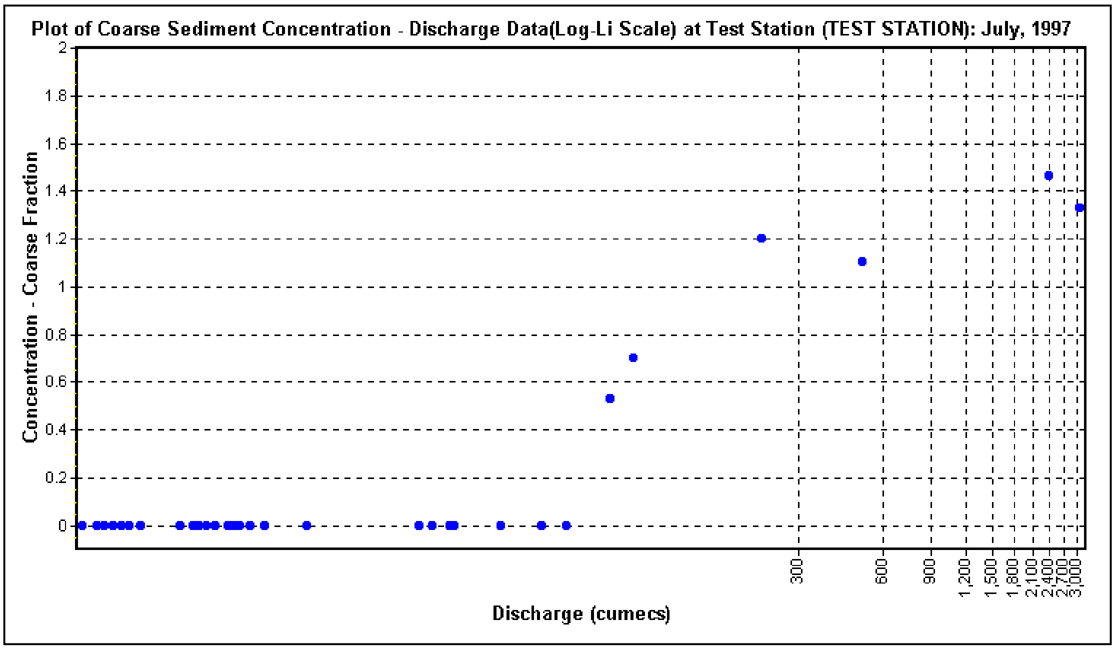



*Figure 13.1: Plot of concentration of Coarse sediment against discharge for July*

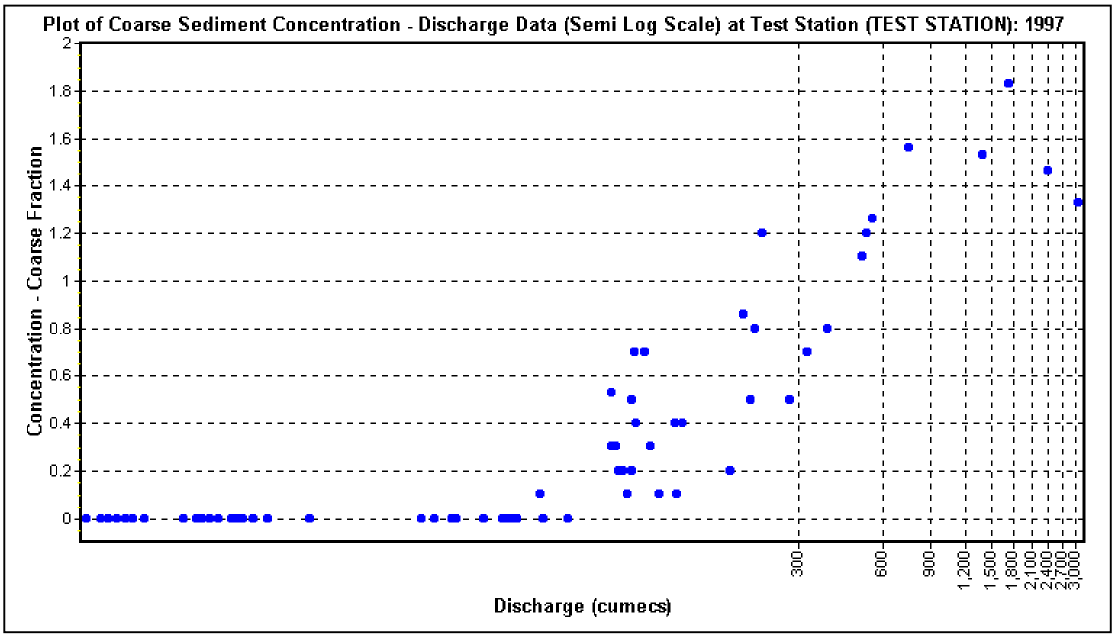



*Figure 13.2: Plot of concentration of Coarse sediment against discharge for the year*

Investigation of any anomaly in the concentration versus discharge plot, as shown in Figures 12.2 to 12.8. This is to be carried out for all fractions separately and subsequently for C+M (sand and silt) and C+M+F (total). Various scales have to be applied as shown in Chapter 12.Though it is generally difficult to detect anomalies, in view of the high scatter these graphs show, extreme outliers still can easily be detected, see Figure 13.3.

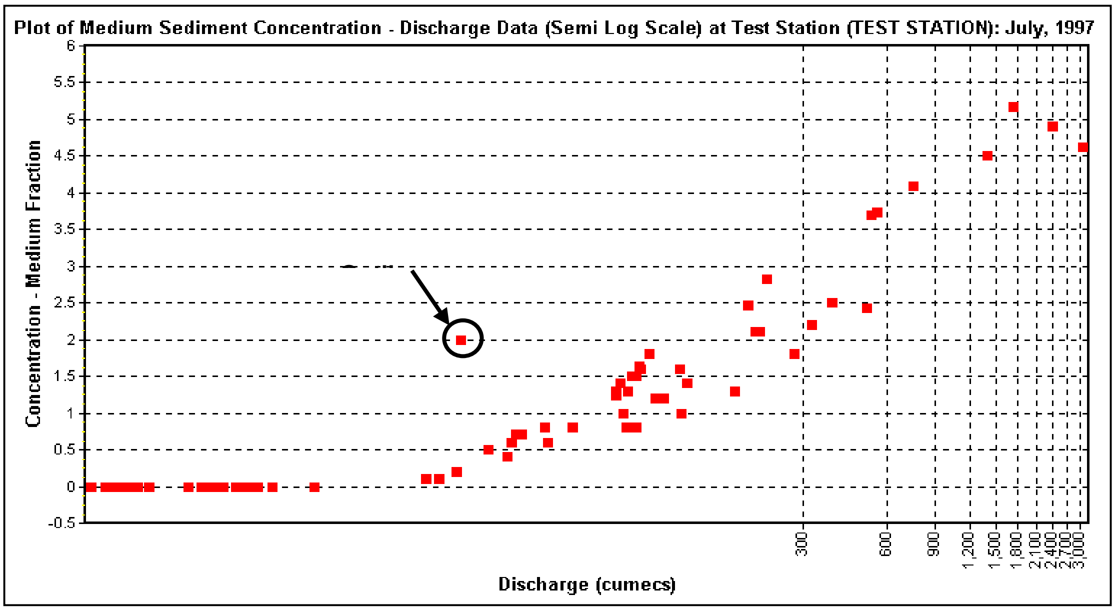



*Figure 13.3: Example of an outlier in the data set of medium fraction*

Outliers should be marked and checked against the field data sheet or field note book. When found erroneous the entry is to be eliminated from the data set. However, one should be very careful in this respect with the fine sediments as the concentrations may vary with the season. When the rains start, their concentrations will be high as the first rains bring a lot of sediment from the catchment into the river and their concentration is fairly independent of the flow velocity. At the end of the rainy period (end of monsoon) their concentration is generally much less as supply dried out. This is seen by comparison of the Figures 13.4 and 13.5.

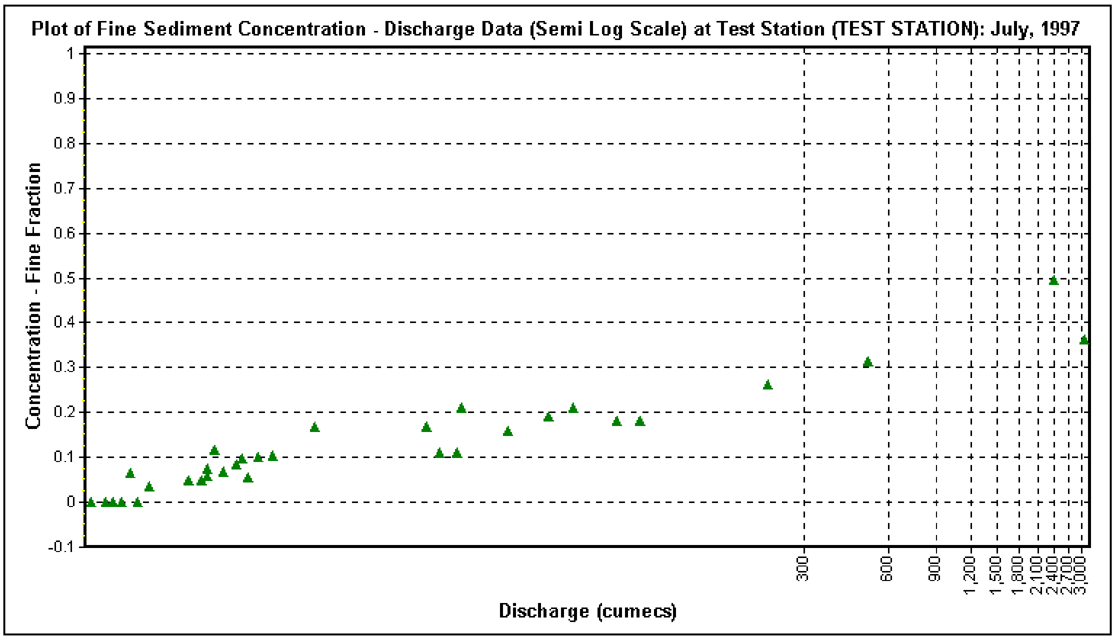



*Figure 13.4: Concentration of Fine suspended sediment in July, 1997*

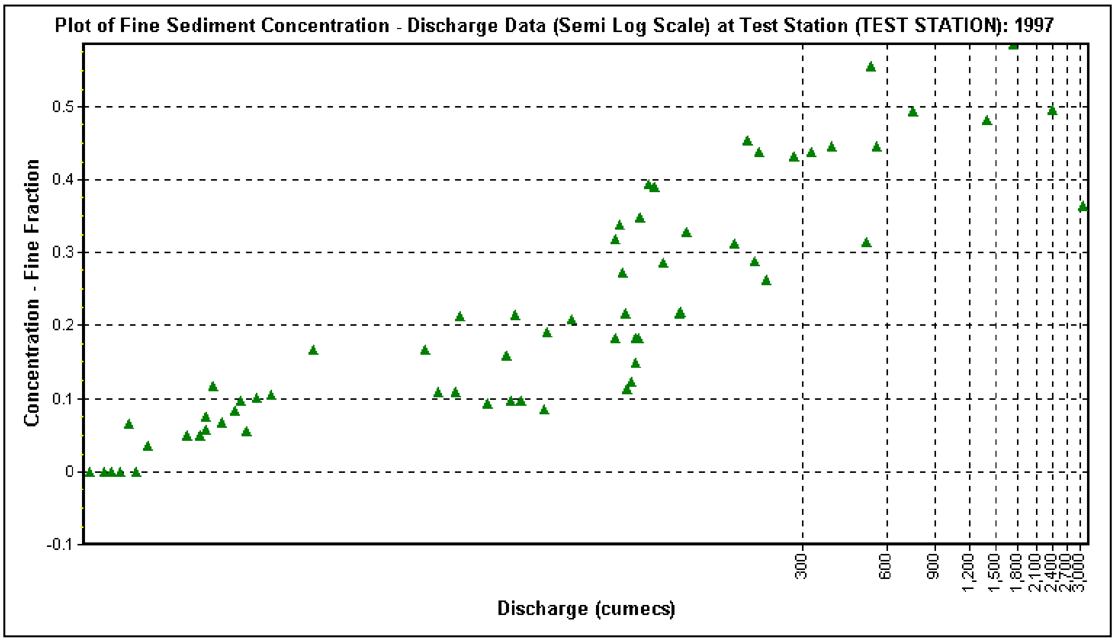



*Figure 13.5: Concentration of Fine suspended sediment in the year 1997*

## 13.2 BED MATERIAL DATA

For bed material data the following steps are to be executed for primary processing of data in the Water Quality Laboratory:

1. Weight of the total sample as measured should comply with the sum of the weight of the various fractions retained by the sieves and passing the 0.60 mm sieve, as computed by SWDES.
2. Verify the weight of the sample passing the 0.60 mm sieve as entered in the data sheet for the siltometer analysis
3. Verify the totals as shown in the final result with their actual measured values; reference is made to Table 12.12.
4. Compare the results of samples taken in the same cross-section at different distances from the bank. Where the flow velocities are highest, the particle sizes will be highest. This should be reflected in the characteristic particle sizes. Note that in a river bend a clear difference should be visible between the grain sizes along the outer bend en the inner bend: along the outer bend the bed material will be coarser.
5. Compare the results for the same location in the cross-section for different moments of time. Samples taken during the monsoon are likely to be coarser than thereafter, whereas the finest samples will be found before the onset of the monsoon, as in the lean season many fines may have settled in almost stagnant water.

# 14 ENTRY OF WATER QUALITY DATA

## 14.1 GENERAL

Observations of water quality mainly refer to concentrations of dissolved constituents in the water in terms of physical (like turbidity, conductivity etc.), chemical (like sodium, potassium, cadmium etc.) and biological parameters (like algae, bacteria etc.). Data on water quality requires collection of a water sample followed by analysis (measurement) for specific water quality parameters. These water quality parameters can be measured at site, the so-called ‘field parameters’, or in a laboratory. Laboratories of different levels are distinguished under HP. Level I laboratories are small laboratories located at or near the sampling location. These were originally established for determination of sediment load only, but now can also be used for determination of the water quality field parameters.

Higher level laboratories (levels II and II+) are usually located in major cities and provide analytical capacity to a larger region covering more sampling locations.

A total of 68 water quality parameters are considered to be the 'Standard HP Water Quality Parameters'. These parameters include many trace contaminants such as heavy metals and organic pollutants which can only be analysed at Level II+ labs. The main information about these 68 parameters is already included in the SWDES water quality database. Information about additional parameters can be added by a laboratory.

#### 14.1.1 WHAT WATER QUALITY DATA ARE ENTERED IN SWDES

Results of the field and laboratory analyses for water quality parameters are entered into the data system using the SWDES software. In addition to analytical results, the software is also designed for entry of relevant information on sample collection, water quality parameters (units, detection limits, method of analysis), and laboratories (capabilities, analytical methods used). Each laboratory is expected to indicate the analytical method used for each parameter that is analysed and entered into the database. Also, substantial attention is given to the recording of details with respect to collection of the sample.

The SWDES can store an unlimited number of water quality *parameters*. A basic set of parameters is supposed to be entered in a fixed order, format and unit. Moreover, it is possible to customise a form containing (additional) parameters in a user-defined order. The units of measurement for each parameter entered in SWDES, are in conformity with the units prescribed in Volume 7. For the sake of uniformity in reporting and comparability of the data, it is important that the data reported by all the laboratories are in the same unit. **Thus, no laboratory is allowed to change the unit of measurement for any of the standard HP water quality parameters.**

The physical parameters, like total suspended solids, may also be measured along with gauge-discharge observations at level 1 laboratories. The results are entered in the computer under the heading "Entry of hydrological and sediment data".

Water quality data for a sampling location can only be entered into the SWDES, when the *sampling location* is present in the database. Generally most of the water quality monitoring stations are the same as hydrologic observation stations. Thus, the station may already exist in the database, entered by Hydrological Observation Group. In case the water quality monitoring station does not exist in the database, it has to be added to the list of stations by the laboratory personnel.

The *frequency* of water quality sampling may vary, depending on the objective(s) of sampling, the agency or the nature of the river (perennial/seasonal). Mostly sampling frequencies vary between trice a month to once every 2 months. However, it is possible to enter the results of up to 1000 sample within a single day, which might be useful in semi-continuous field measurements. Water quality data are stored together with the date of collection in what is called 'non-equidistant time series'.

The SWDES is also suitable for storing water quality data collected under programmes other than HP monitoring plans, such as surveys for specific objective, that collect data for sediments or biota.

#### 14.1.2 WHO ENTERS WATER QUALITY DATA, AND WHERE

The SWDES for entering water quality data is installed in each HP (level II and II+) laboratory, and the laboratory staff will enter the water quality data (i.e. the results of their water quality analyses).

The data entry forms are organised laboratory-wise as well as location-wise. Each laboratory is expected to indicate the analytical method used for every parameter in the database. Also, substantial attention is given to the recording of details with respect to collection of the sample.

### 14.1.3 ADDITIONAL FUNCTIONALITY OF SWDES FOR WATER QUALITY

The SWDES data entry software is primarily for entering the analytical results for water quality parameters. In addition, the software has some extra functionality:

- Calculating certain water quality parameters based on results of other parameters
- Validating the water quality data
- Graphing water quality data
- Preparing reports of water quality results, including comparing water quality results with drinking water and irrigation water standards

Data, after validation, can be transferred to HYMOS for data analysis and reporting, to be done in the data centers.

A Water Quality switchboard in SWDES displays menu items for water quality data, as shown in Figure 14.1. All of the water quality data entry forms are reached via this switchboard.

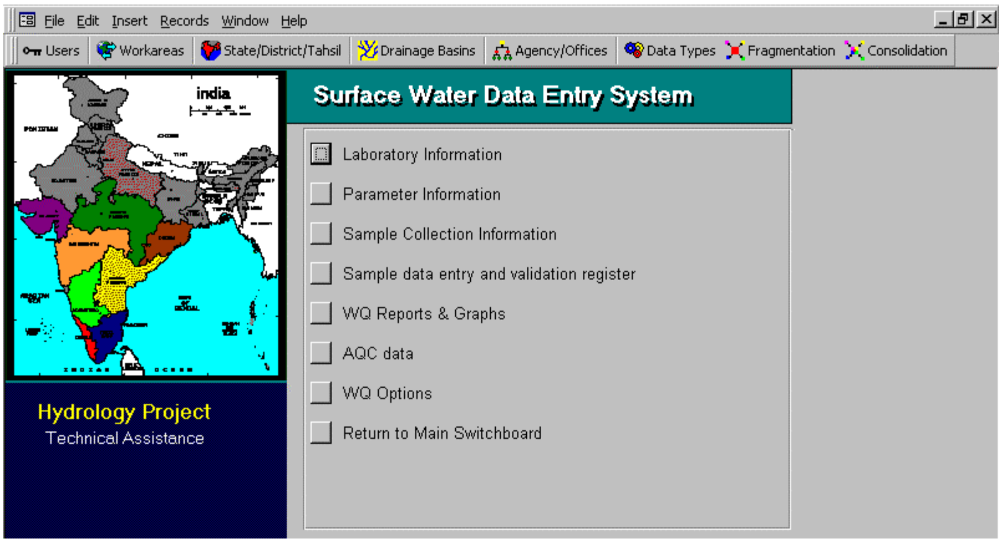



*Figure 14.1: Water Quality switchboard, displaying menu items for water quality data*

This switchboard gives access to the all the data entry forms:

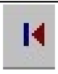
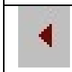
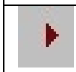
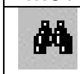
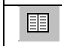
- Laboratory Information
- Parameter Information
- Sample Collection Information
- Sample Data Entry and Validation Register
- WQ Report & Graphs
- AQC Data
- WQ Options

For all the water quality data entry options, the user is required to click on "Water Quality" on the main switchboard. The user then sees a secondary switchboard. The user then sees a secondary switchboard displaying menu items for water quality data, as shown in Figure 12.2.

With each form, a toolbar is displayed. In this toolbar, buttons are available for common functions as explained.

***Toolbar***

Each of the above first 4 forms contains the following buttons on toolbar:

| | |
|---|---|
| <br>View Data Button | Button puts the form in 'view mode' and prevents editing. The importance of view mode is that no entry will get modified by mistake when looking at the records in the form. On opening, most forms are in viewing mode and this button is inactive. If the form is in another mode (e.g. edit-mode) this button is active and can bring the form back to view mode. The button is provided in the above first three forms. |
| <br>Edit Record button | Button puts the form in 'edit mode' and allows editing. Only after the form is in edit mode, modifications in the existing records or addition of new record or deletion of existing record is possible. This button can only be clicked when not already in edit mode. The button is provided in the above first three forms. |
| <br>Add Record button | Button adds a new record. Button is only active when the form is in edit mode, after the "Edit Record" button is clicked. The button is provided in the above first three forms. |
| <br>Delete Record button | Button deletes the currently displayed record. Button is only active when the form is in edit mode, after the "Edit Record" button is clicked. The button is provided in the above 1st and 3rd forms |
| <br>Move First button | Button navigates to the first record in the form. It is one of the four buttons for the purpose of navigation through the available records. |
| <br>Move Previous button | Button navigates to the previous record in the form. Inactive when first record is displayed. It is one of the four buttons for the purpose of navigation through the available records. |
| <br>Move Next button | Button navigates to the next record in the form. Inactive when last record is displayed. It is one of the four buttons for the purpose of navigation through the available records. |
| <br>Move Last button | Button navigates to the last record in the form. It is one of the four buttons for the purpose of navigation through the available records. |
| <br>Search button | This button is used to search the record with the desired entry in this field from all the available records. Usual options, like searching all the fields, setting the search direction, multiple search instances, matching the case type etc., are also available. |
| <br>Report button | The report button invokes an input box to *make* selection of fields to be reported in tabular form. Suitable queries can be built using conditions and the output can be grouped and sorted in the desired form. This is available on most forms. |
| <br>Print button | To print a single record along with the screen layout. |
| Note<br>• some specific buttons available on toolbar of specific form are explained in respective Sections.<br>• the toolbar of Data Entry and Validation Register form has some different features. There is a button for organising the data station-wise in alphabetical (ascending or descending) order or date-wise (ascending or descending) order. There is another button provided to prompt station-wise data entry. The details of the use of these buttons in respective cases are explained in the following sections. | |

## 14.2 ENTRY OF LABORATORY INFORMATION

### 14.2.1 GENERAL

Each laboratory can enter and edit all the relevant information about the laboratory as per the form depicted in Figure 14.2. An agency may enter information on multiple laboratories coming under its jurisdiction. This form also registers the number of parameters the laboratory can analyse along with the method of analysis. The Laboratory Information form allows the customisation of the data entry form as well. For example, if in a particular project the laboratory is analysing only a few parameters, the laboratory can customise the data entry form for those parameters.

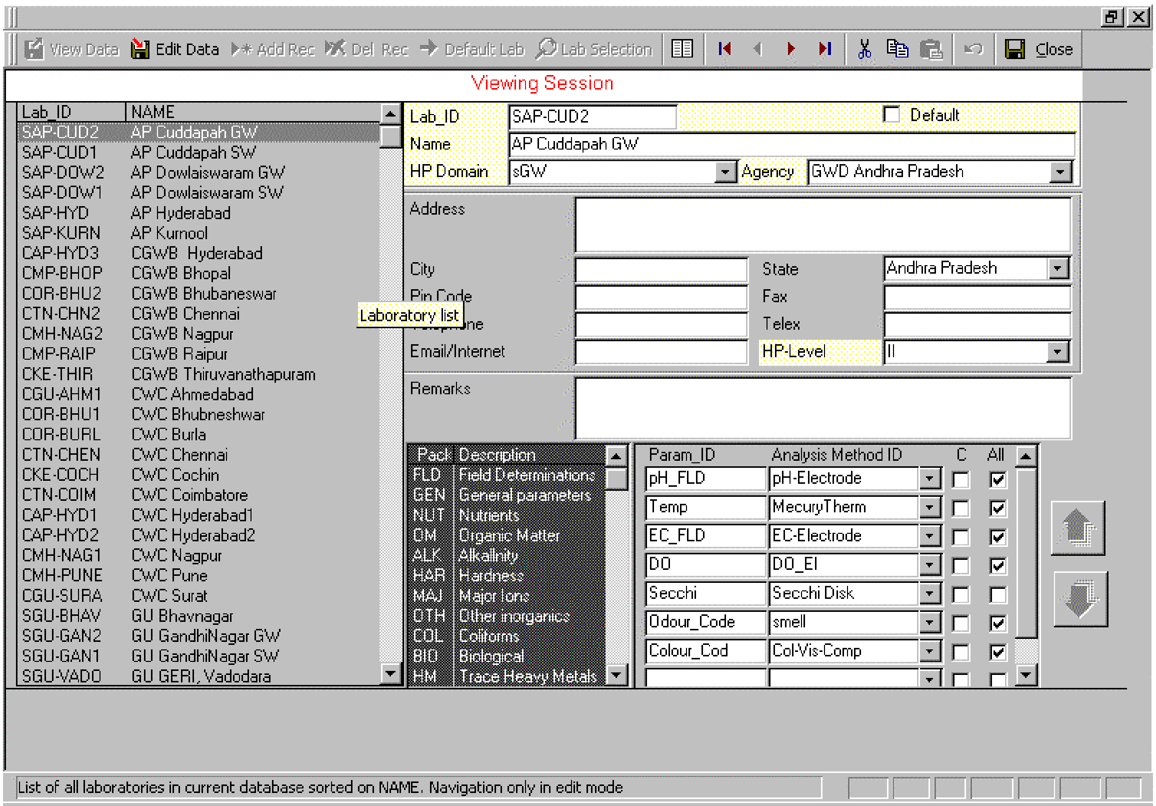



*Figure 14.2: Layout of Laboratory Information Form*

### 14.2.2 LABORATORY INFORMATION TO ENTER

The data entry form shows all the HP laboratories that are registered in the database, including a unique identification code (Lab ID) along with its name (Lab Name). Laboratories are listed alphabetically according to their names.

The individual laboratories have to complete the following information:

***Lab ID and Lab Name (mandatory)***

The Lab ID is a unique eight-character code which identifies each laboratory. The Lab Name is unique name given for each laboratory. The logic followed in the eight-character Lab ID code is as follows:

- Pos 1 ‘C’ for central or ‘S’ for state organisations
- Pos 2 and 3 State code (e.g. AP for Andhra Pradesh and MH for Maharastra etc.)

- Pos 4 Separation sign '-'
- Pos 5 to 8 Abbreviation for the city where the laboratory is located (e.g. NASK for Nashik or HYD1 for Hyderabad). In case there are two laboratories located in the same town one each of surface water and ground water then the 8$^{th}$ pos is numerically presented as 1 for surface water laboratory and 2 for ground water laboratory.

The name of the laboratory includes the state code (for state organisations) or CWC followed by the city in which the laboratory is located. Note that sorting of the laboratories is based on their name.

***HP Domain (mandatory)***

HP domain classifies the laboratory with respect to the types of agencies involved in surface water quality sampling as listed. Possible options for the HP domain are:

- CWC: all Central Water Commission laboratories
- sSW: all laboratories affiliated with a State Surface Water Department
- sG&SW: all laboratories affiliated with a State Groundwater Department, where the laboratory is also carrying out analyses for surface water department.
- non HP laboratory: all other laboratories that use SWDES

***Agency ID (mandatory)***

The Agency ID is the name of the agency to which the laboratory belongs. For CWC, the agency ID should include 'CWC'. For states, the state abbreviation and exact Department name should be selected e.g. AP Irrigation Department. For CWC, the specific division or region should be selected, e.g. CWC Cauvery Basin Region.

Note that agencies may only be selected from a pre-defined list. It is not possible to enter data in this field. Information on agencies may be changed (adding agencies or changing agency information) through the "Agency/Owner Agency and Offices definition".

***Address, City, PIN Code, Telephone, Email, State, Fax, Telex (mandatory)***

A laboratory should enter all relevant contact information about the laboratory: address, telephone, fax, email, etc.

***Level of the laboratory and remarks (mandatory)***

The laboratory level must be selected: I, II or II+.

The level of the laboratory is an indication of the analytical capacity of the laboratory based on the equipment available. The level is not necessarily linked to the actual number of parameters analysed, it rather represents the (potential) capability of the laboratory. The parameters associated with each laboratory level will all be placed on the standard data entry form.

The following practical guideline may be followed:

| | |
|---|---|
| Level I: | Laboratory located at or near the monitoring site (field), generally analysing Temperature, pH, Conductivity, (Total) Suspended Solids, Dissolved Oxygen, Colour and odour (note: these parameters may also be measured in the field at the time of sampling). |
| Level II : | Laboratory has facilities to analyse general water quality parameters, major ions, nutrients, indicators of organic and faecal pollution, etc. |
| Level II+ : | Laboratory in possession of advanced equipment such as Atomic Adsorption Spectrophotometer (AAS), Gas Chromatograph (GC), or UV-Visible Spectrophotometer etc. |

***Remarks***

Any remarks about the laboratory may be entered, especially those remarks valuable during the interpretation of the data may be entered such as:

- record of malfunctioning and break-down of equipment (with dates);
- date when the last maintenance of equipment was performed;
- power failure events and their duration;
- record of within-laboratory AQC results and control chart results for different parameters;
- record and result of participation in inter-laboratory AQC.

***Parameters***

The analytical capacity of the laboratory regarding the number of parameters it can, and normally does, analyse should be entered. After the HP-Level has been entered, a list of parameter packages (‘PACK/DESCRIPTION’), parameters (‘PARA_ID’) and accompanying ‘Analysis Methods Used’ is displayed. These default set of parameters are set automatically once the Level of the Laboratory is defined. This set of parameters is automatically used in the data entry form. (Note: ‘Parameter packs’ are also called ‘parameter groups’).

The parameters are grouped in parameter packages. Select among the different packages by selecting the desired package under ‘PACK | DESCRIPTION’. For the selected parameter pack, the relevant parameters and their analysis method(s) will be shown. Where more than one method is possible for the analysis, a default method is shown. The default method is the preferred (recommended) method, which are incorporated in Volume 7, Water Quality Analysis, Operation Manual, Chapter 4. If the method used by a laboratory is different from the preferred method, the *actual* method which a laboratory uses for analysis each parameter *must* be selected. It is very important for every laboratory to register the actual method used for analysis of a specific parameter. There are several reasons for this:

- The accuracy of results can be related to the method used for analysis. Changes in water quality results may be related to a change in analysis method at a laboratory rather than to an actual change in the quality of the water.
- For comparison of results between different laboratories it is important to know if they are following the same method of analysis. Especially when it comes to comparison of data from the same region in case of groundwater or the same river in case of surface water.
- The analysis method used determines the Limit of Detection (LOD) for a particular parameter. This may be important for reporting of non-detectable concentrations.

The list of standard water quality parameters (for HP laboratories) and the methods that are available for analysis of each of the parameters are included in the SWDES database. Section 12.3 describes how to add a parameter to the list or how to add an analytical method for an existing parameter.

To the right side of the parameters, two columns are displayed, the first labelled as 'C' (short for customs) and 'All'. Parameters that are ticked in these columns will be included in the customised or standardised data entry sheet, respectively. Parameters may be ticked in one or both columns. The purpose is two fold:

- Tick the 'C' column to place parameters on the 'customised' data entry sheet Parameters that are already present on the standard data entry form (ticked under 'All') may be repeated on the custom form for convenience. *Note: parameters ticked in the 'C' column are automatically added to the 'All' column and may be removed as well from both columns.*
- The 'All' column displays all parameters the laboratory should be capable of analysing according to its level (I, II or II+). Commonly analysed parameters are ticked by default and are automatically put on the 'standardised data entry form'. Additional parameters may be selected for special cases. *Note: any parameters that is added to 'C' column is automatically added to 'All' column. Removal of a parameter from the 'All' column is not possible in unless it concerns a customised parameter (ticked in the 'C' column).*

### 14.2.3 COMMON DATA ENTRY TASKS IN THE LABORATORY INFORMATION FORM

***Editing, adding, or deleting a laboratory information record***

It is possible to edit the information about a specific laboratory or to add a new laboratory to the SWDES laboratory database. Fill in all records for Lab ID, Name, HP Domain and Agency ID. Also, fill in all records relevant to Lab Contact Information. Information about a specific laboratory may also be deleted.

***Specifying the parameters analysed in a laboratory***

Once Laboratory ID, Name, HP Level and the Agency are added, the Parameter list will automatically be added to the form. This starts as a full list of all parameters that potentially can be analysed by the selected laboratory (the "All" list). The list may be customised to the actual capacity of the laboratory by selecting the desired parameters (the "C" list). The full list and the customised parameter list will be on the standard and customised data entry form, respectively.

***Changing the method of analysis used for a parameter***

For each parameter, the Analytical Method Used by the selected laboratory is shown next to the parameter. If more than one method is possible, the preferred (recommended) method of analysis is indicated by default in the field 'Method Used'. If a laboratory uses another method, it must select the alternative method from the drop-down list in the form. In case the laboratory uses a method that is not present in the drop-down list, it should first enter the method details in the 'Parameter Information' form (see Section 14.3) and after that select this method.

***Changing the order of the parameters in the data-entry sheet***

The order in which parameters are given on the customised data entry form can be changed. The parameter order can only be changed for the custom-data entry form, not the standardised form.

## 14.3 ENTRY OF PARAMETER INFORMATION

### 14.3.1 GENERAL

In the Parameter Information form, all the important information about the water quality parameters and the analytical methods available for each parameter are shown. All standard water quality parameters for HP laboratories, their analysis method(s) and their preferred (recommended) methods of analysis are provided upon installation of the software, as well as e.g. units, categories, required lab level, no. of decimals, for reporting, etc.

Most of the information provided for the standard parameters *cannot* be changed. The laboratory can change only Max, Lower Warning Limit (LWL) and Upper Warning Limit (UWL). All other parameter information for the standard HP parameters are fixed and cannot be edited (e.g. units, no. of decimals). This is to ensure standardisation of data entered by different laboratories.

New parameters, if required, can be entered in this form. The form also allows specification of additional methods of analysis for the standard HP water quality parameters in the database. The Parameter Information Form Layout is presented in Figure 14.4.

#### 14.3.2 SCREEN LAYOUT

Three data entry on this form is divided into the following items:

***Parameter ID and name***

The parameter ID is a unique code which identifies each parameter while the name is generally the full name of the parameter. Both the parameter ID and parameter name are mandatory information.

***Parameter group***

The parameter group categorises a parameter. In the data entry form parameters are ordered according to their group (also called parameter pack). Each parameter can be a member of one group only. The following groups are distinguished:

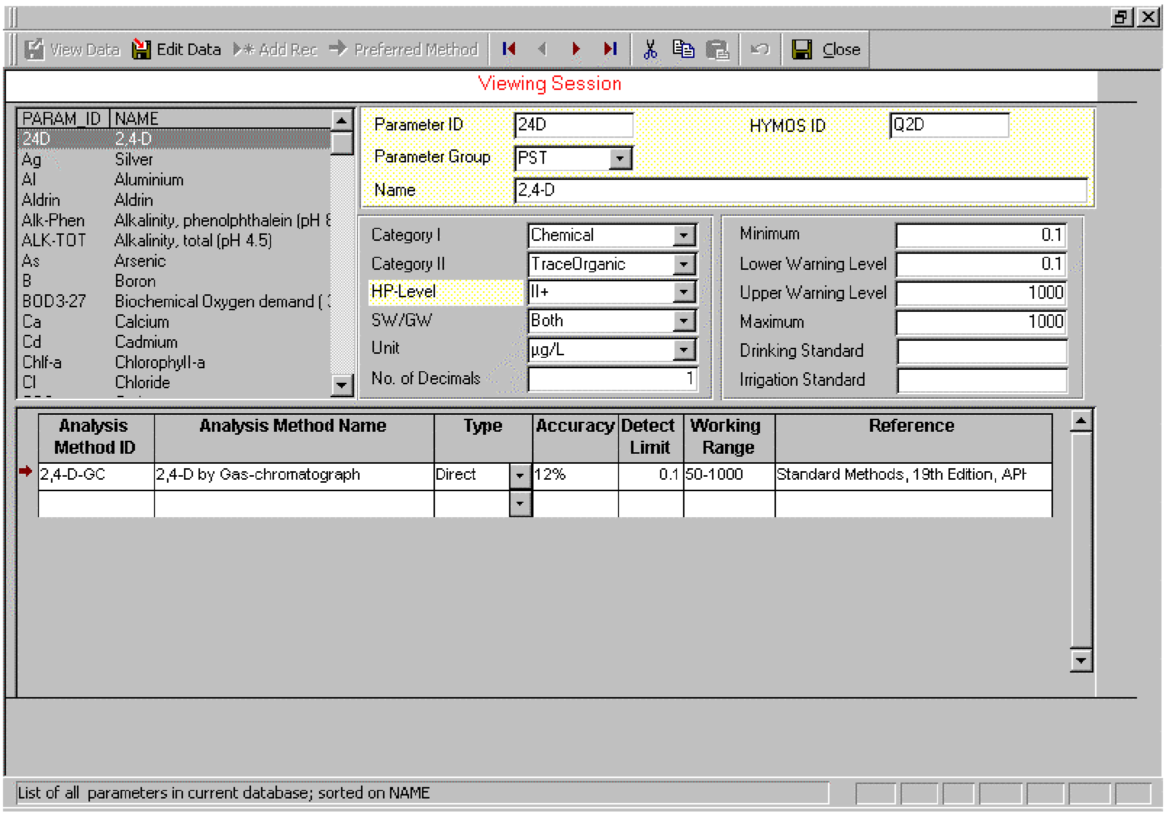



*Figure 14.4: Layout of Parameter Information Form*

| Group ID | Parameter group name | Examples |
|---|---|---|
| ALK | Alkalinity | Phenolphthalein Alkalinity |
| BIO | Biological | Chlorophyll-a |
| COL | Coliforms | Total Coliforms , Faecal Coliforms |
| FLD | Field Determinations | pH, EC |
| GEN | General parameters | Temperature |
| HAR | Hardness | Hardness |
| HM | Trace Heavy Metals | Cadmium, Copper, Zinc |
| MAJ | Major Ions | Sodium, Calcium, Potassium |
| NUT | Nutrients | Ammonia, Nitrate, Phosphate |
| OM | Organic Matter | Biochemical Oxygen Demand |
| OMP | Organic Micro Pollutants | PAHs, PCBs etc |
| OTH | Other inorganics | Fluoride, Cyanide |
| PST | Pesticides | Lindane, BHC, DDT, Endosulphan |

*Table 14.1: Parameter Groups in the data entry software*

***HYMOS ID***

Each standard HP water quality parameter has a unique HYMOS ID code which is used for data storage and analysis in HYMOS (at the State Data Centers). The 3-letter HYMOS code always starts with 'Q' (for Water Quality). The second and third letter of the code are derived from the parameter name. A list of all the HYMOS ID codes are given in Appendix A.

### *Category I, Category II*

Category I and II give additional information on the nature of a parameter. It helps in sorting the parameters for reporting purpose.

The following options exist for Category I:

- Physical
- Chemical
- Biological

The following options exist for Category II:

- Salts
- Solids
- Gas
- Organics
- Bacteria
- Trace Metals
- Trace Organics
- Others

### *Unit*

For the standard HP water quality parameters which are included with the SWDES upon installation, the units of measurement are fixed for each of the parameters. This is to ensure that all the laboratories report their data in the same unit. The standard reporting units are very important for standardising the data received from different laboratories and allowing comparison of data. The following units are recognised as standard units of data reporting and presentation:

| Unit | Use |
|---|---|
| **mg/L** | For most of the chemical parameters |
| **mgN/L** | For nitrogen related parameters |
| **mgP/L** | For phosphorus related parameters |
| **$mgSiO_2$** | For Silica |
| **mgCaCO3/L** | For hardness and alkalinity parameters |
| **µg/L** | For most of the trace constituents and chlorophyll a |
| **µmhos/cm** | For conductivity |
| **MPN/100mL** | For bacteria measured by multiple tube fermentation |
| **°C** | For temperature |
| **pH unit** | For pH |
| **NTU** | For turbidity |
| **%** | For dissolved oxygen saturation percentage or percent sodium |
| **m** | For Sechhi depth |
| **-** | For dimensionless parameters [e.g. SAR, RSC (numerical) and odour, colour (code or text)] |

*Table 14.2: Accepted units within SWDES*

For reasons of standardisation, other units are not accepted by SWDES. If the laboratory uses different parameter units internally, conversion to one of the standard units listed above is required before entering the data. The procedures for analytical methods and the standard reporting units are presented in Volume 7, Water Quality Analysis, Operation Manual, Chapter 4.

| Parameter | Unit reported by State/Central Agencies | Multiply by | To get HP recommended unit |
|---|---|---|---|
| Electrical conductivity | mmhos/m or mS/m | 10 | μmhos/cm |
| -do- | μS/m | 0.01 | μmhos/cm |
| -do- | μS/cm | 1 | μmhos/cm |
| -do- | mmhos/cm or mS/cm | 1000 | μmhos/cm |
| Ammonia, $NH_4^+$ | mg/L | 14/18=0.778 | mgN/L |
| Ammonia, $NH_3$ | mg/L | 14/17=0.824 | mgN/L |
| Ammonia, $NH_4^+$ | meq/L | 14 | mgN/L |
| Nitrite, $NO_2^-$ | mg/L | 14/46=0.304 | mgN/L |
| Nitrite, $NO_2^-$ | meq/L | 14 | mgN/L |
| Nitrate, $NO_3^-$ | mg/L | 14/62=0.226 | mgN/L |
| Nitrate, $NO_3^-$ | meq/L | 14 | mgN/L |
| Orthophosphate, $PO_4^{---}$ | mg/L | 31/95=0.326 | mgP/L |
| Orthophosphate, $PO_4^{---}$ | meq/L | 31/3=10.333 | mgP/L |
| Total phosphate | mg/L | 31/95=0.326 | mgP/L |
| Alkalinity-pH | meq/L | 50 | mg$CaCO_3$/L |
| Alkalinity-total | meq/L | 50 | mg$CaCO_3$/L |
| Hardness-total | meq/L | 50 | mg$CaCO_3$/L |
| Hardness-Ca | meq/l | 50 | mg$CaCO_3$/L |
| Carbonate, $CO_3^{--}$ | meq/L | 30 | mg/L |
| Bicarbonate, $HCO_3^-$ | meq/L | 61 | mg/L |
| Calcium | meq/L | 20 | mg/L |
| Magnesium | meq/L | 12.15 | mg/L |
| Sodium | meq/L | 23.0 | mg/L |
| Potassium | meq/L | 39.1 | mg/L |
| Iron, $Fe^{+++}$ | meq/L | 56/3=18.67 | mg/L |
| Iron, $Fe^{++}$ | meq/L | 56/2=28 | mg/L |
| Aluminum, $Al^{+++}$ | meq/L | 9 | mg/L |
| Chloride | meq/L | 35.45 | mg/L |
| F | meq/L | 19 | mg/L |
| Sulphate, $SO_4^{--}$ | meq/L | 96/2=48 | mg/L |
| Silicate, $H_4SiO_4$ | mg/L | 60/96=0.625 | mg$SiO_2$/L |
| Silicate, $SiO_3^{--}$ | meq/L | 60/2=30 | mg$SiO_2$/L |
| Arsenic | mg/L | 1000 | μg/L |
| Cadmium | mg/L | 1000 | μg/L |
| Chromium | mg/L | 1000 | μg/L |
| Copper | mg/L | 1000 | μg/L |
| Mercury | mg/L | 1000 | μg/L |
| Manganese | mg/L | 1000 | μg/L |
| Nickel | mg/L | 1000 | μg/L |
| Lead | mg/L | 1000 | μg/L |
| Selenium | mg/L | 1000 | μg/L |
| Zinc | mg/L | 1000 | μg/L |
| Any parameter | ppm | 1 | mg/L |
| ppm = 1 part per million, for aqueous solution with a density of around 1000 g/L 1 ppm equals 1 mg/L | | | |

*Table 14.3: Some Conversion units for water quality parameters*

### *Minimum and Maximum*

Minimum and maximum values serve as a first validation for the parameter when it is entered in the data entry form.

The maximum value represents the highest values that may be expected for the parameter under *natural conditions in surface waters in India*. For example, a usual maximum value for water temperature is something like 40°C. The main purpose of the maximum value is to prevent obvious mistakes during data entry or even in analysis or calculation. In case an obvious typing mistake is made and a value of 221 is entered for temperature (instead of the intended value of 22.1) the SWDES will not accept such value for entry. *The maximum value can be edited by the laboratory.*

The minimum value (or the detection limit, LOD) of the parameter (for the analysis method used), is taken as minimum value to prevent any data entry below such value. For almost all parameters, the minimum value is the same as the LOD. For some of the trace contaminants (e.g., heavy metals, pesticides, etc.), it is possible to record a value lower than the detection limit (e.g. < LOD).

In case the software is preventing entry of any data, the user has to check the data entry, the data value, the data calculation or even analysis.

***Upper Warning Limit (UWL) and Lower Warning Limit (LWT)***

These limits are provided in the software to warn the user in case the values are exceeding the usual lower or upper limits. UWL and LWL can be edited by the laboratory, but must meet the criteria:

UWL $\leq$ Maximum and
LWL $\geq$ Minimum (LOD)

These limits will not prevent data entry but will display a warning symbol that the value is above/below the warning limits.

The usual lower and upper limits for a parameter vary with time and space. For a particular region such limits are usually known to the analysts, who have been working for long time in the region. Presently these limits are provided in the software based on the experience from national water quality data of Central Pollution Control Board (CPCB). These limits can be changed by the user based on his/her experience with the values (ranges) encountered for different parameters for a particular region/laboratory.

This provision is useful as a check on entry of unusual data for a region. If an unusual value is entered, which is higher than the UWL, a warning will appear on screen indicating range of values for that parameter usually encountered. The user then will have to check if there is any mistake in entry of the data, calculation or even in analysis. If he finds no mistake, then he can enter the data and the computer will accept the value with an indication of arrow either upward (for the values higher than the UWL) or downward (for the values lower than the LWL).

***No. of Decimals***

The number of decimals refers to the number of digits after the decimal point. This determines the representation of the parameter in the data entry form and in the reports. The number of decimals is fixed for the standard HP water quality parameters and cannot be changed.

The number of decimals is set in accordance with the accuracy of the method by which the parameter is measured. As an example, there is no point in reporting the temperature value of surface water in two decimals (e.g. temperature = 13.32°C) since the accuracy of the thermometer used for the measurement is limited to 0.1°C. In other words, only significant numbers should be reported. The theory of expression of results is explained in 'Standard Methods for the Examination of Water and Wastewater' (19th edition APHA, 1995) or in the training module X.- 'Basic Chemistry Concepts' (Hydrology Project, 1999). Reference is also made to Volume 2, Sampling Principles, Design Manual.

#### *HP-Level*

The (minimum) laboratory level necessary for analysing a parameter is selected from the list: I, II or II+ .The level of the laboratory is an indication of its analytical capacity. If a parameter can be analysed in the lowest level laboratory (e.g. pH can be measured in a level I laboratory) it implies that higher level laboratories are capable of analysing this parameter also.

#### *Analysis Method ID and Name*

The Analysis Method ID is a unique code which identifies each method. The Analysis Method Name is the full name/description of the method. Both the Method ID and name are mandatory information, and are specified for all the standard HP water quality parameters.

#### *Preferred Method*

For each water quality parameter, the preferred (recommended) method is indicated by a red arrow (➔). If there is more than one possible method, the recommended method is based on the 'Guidelines on Standard Analytical Procedures for Water Analysis', (HP, May, 1999). The preferred method *cannot* be changed for the standard HP water quality parameters.

The preferred method may differ from the actual method used by a laboratory. Each laboratory should indicate the actual method used if it is different from the preferred method

#### *Type*

Two types of methods are distinguished: direct and indirect. Most parameters are determined directly by chemical analysis. Whenever a parameter is calculated from one or more other parameter(s) without chemical analysis, it is an indirect-type. For example SAR (Sodium Adsorption Ratio) is not directly measured in the laboratory, but calculated. Such parameters are typified as indirect.

#### *Accuracy*

It is an indication of combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value. It is usually expressed as %. Indications of the accuracy of an analytical method are usually given along with the method, e.g. in a section on precision and bias in 'Standard Methods for the Examination of Water and Wastewater' ($19^{th}$ edition APHA, 1995), see also Volume 2, Sampling Principles, Design Manual.

#### *Limit of Detection (LOD)*

The lowest concentration that can be detected by a specific analytical method is indicated here. Different methods for analysing a single parameter can have different LODs. If a new parameter is added to the list, the LOD must be specified (in the same units as the reporting units).

#### *Working range*

The working range is related to an analytical method for a given parameter. It refers to the concentration range for which the analytical method can be used, without a dilution factor being applied. For BOD, the working range may e.g. be defined as 1-6 mg/L. If sample concentrations are above the working range, samples should be diluted prior to analysis.

***Reference***

The literature reference of each analysis is given. The latest version of 'Standard Methods for the Examination of Water and Wastewater' ($19^{th}$ edition APHA, 1995) and the 'Guidelines on Standard Analytical Procedures for Water Analysis' prepared under HP (May, 1999) are the main references.

### 14.3.3 COMMON DATA ENTRY TASKS

***Changing the Maximum, LWL and/or UWL***

After selecting a specific parameter and choosing the edit mode of the software, the Maximum, LWL and UWL fields can be edited.

***Adding a parameter***

A new parameter can be added to the database choosing the edit mode of the software. All data fields are then blank, and the necessary information on the parameter can be entered.

***Adding a method to a parameter***

A new analytical method can be added for one of the existing water quality parameters by choosing the edit mode of the software, selecting a parameter, and providing all methods details in the data entry form.

***Changing or deleting parameters or methods***

This action is not allowed.

## 14.4 ENTRY OF SAMPLE COLLECTION INFORMATION

### 14.4.1 GENERAL

In this data entry section, all the important information about when, where, and how a sample was collected is entered. This form allows entering of new samples for a particular sampling date. The layout for the Sample Collection Information Form is presented in Figure 14.4.

Note: Many items in this Sample Collection form may not change frequently, especially not for routine monitoring. It is however important to keep track of all collection details. For that reason many of the fields have a default value that is entered automatically when a new sample is created. This default value may be changed manually thereafter, however. There is also provision to save information about a specific sampling location in a template with the 'Save Template' option. This saves the template for a particular sampling location. Whenever a new sample is collected at the same sampling location, the template can be loaded with the 'Load Template' option. This saves lot of time in entering the same types of information again and again.

### 14.4.2 FILTER SAMPLE STATIONS

With the Filter option, it is possible to make a selection of specific stations, laboratories or dates to be shown on the data entry form. Limiting these variables to those that are relevant to a specific laboratory can simplify the data entry process.

### 14.4.3 ENTRY OF DATA ON SAMPLE COLLECTION

Four main types of information must be entered on this form, shown in Figure 14.4:

- Information on where and when a sample is collected;
- The laboratory where the sample is sent for analysis and the lab sample ID;
- Sample collection details, including among others details of the water sample, the collection agency, the sample collector and the project under which the sample is collected;
- Details about the number of containers filled, and the treatment of the sample on its way from the field to the laboratory.

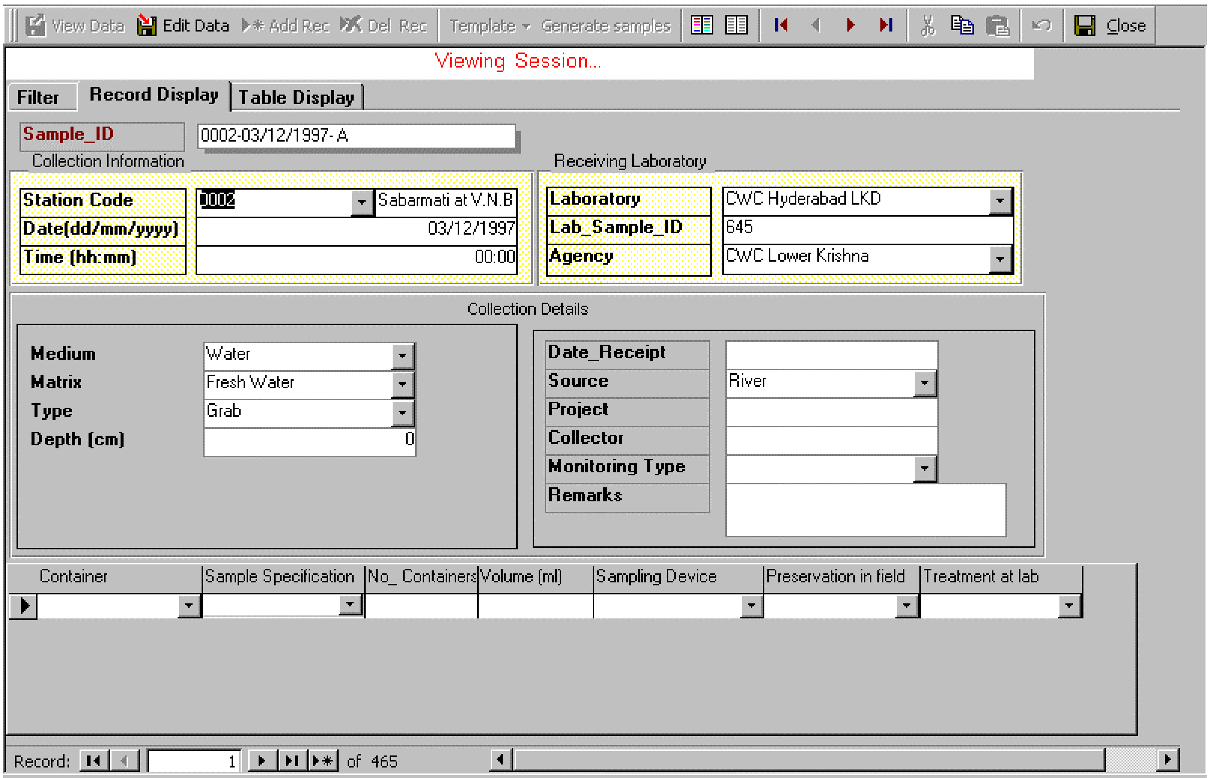



*Figure 14.4: Layout of the Sample Collection Information Form*

#### *Sample ID*

The sample ID is a code that uniquely identifies the sample. This field is filled automatically and is composed of **Station code + date of collection + letter code (A through ZZ)**. The letter code is used to distinguish between different samples collected on the same day (e.g. to be sent to different laboratories or for recording the change of water quality during pumping tests). The user cannot edit the Sample ID. On receipt, a laboratory may assign their own code, the Lab Sample ID, used in their internal administration.

#### *Station Code*

The Station Code is the unique name of the sampling location and is selected from the drop down box. The station codes in the drop down box are the available stations in the database that are earmarked as water quality monitoring stations. These are entered by the Hydrological Observation Group as observation stations. From the observation stations, only the stations which are earmarked as water quality stations appear.

In case the station from which a sample has been received is not in the station list a new station can be added through the 'station particulars' form ('Entry of Static and Semi-Static Data', in SWDES).

***Date of Collection***

The date of sample collection must be given in the DD/MM/YYYY format.

***Time of Collection***

Time of sample collection should be given in hours and minutes: HH:MM. Hours should be recorded in 24 hour system (e.g. 3:15 PM should be entered as 15:15).

***Laboratory***

The laboratory where the sample has gone for analysis must be selected from the drop down box. The list of laboratories may be changed using the 'select' option under the 'Filter' tab. Alternatively, a single laboratory can be selected as the 'Default Lab' in the Laboratory Information Form.

***Lab Sample ID***

The lab sample ID is a code or number given to the sample by the laboratory, which *may* be same or different than the Sample ID explained above. For example, a laboratory may have its own ID system, giving a sequential number to all the samples that it collects and analyses. In the SWDES software, there are 3 options for entering Lab Sample ID:

1. retain sample ID as Lab-Sample ID,
2. manually enter sample ID, or
3. automatically generate the Lab-Sample ID (sequential numbering).

The desired option can be selected in the 'Water Quality Option' form, explained in Section 14.6.

***Collecting Agency***

The agency ID is the name of the agency that is collecting the sample from the field and is responsible for delivery to the laboratory. The laboratory may belong to the same agency, but not always. The agencies listed in the drop down box are currently available in the database. Agencies can be added or their attributes may be changed through the "Agency / Owner Agency & Offices definition" in SWDES.

***Source***

Here the type of water body that was sampled is specified:

- River$^{def}$
- Lake
- Tank
- Reservoir
- Drain
- Canal
- Rain water
- Groundwater

In most cases, the sample is collected from a 'river' source, therefore this is set as the default in the data entry field. CWC sometimes collects groundwater samples. In special studies, rain-water may be sampled.

### *Medium*

Here the medium of the sample is specified:

- Water[def]
- Suspended Matter
- Sediment (bottom sediment)
- Biota

In most cases, the sample medium will be 'water', therefore this is set as the default in the data entry field. In some special studies, biota or sediment may be sampled.

### *Matrix*

Here the matrix of the sample is specified:

- Fresh water[def]
- Brackish water
- Salt water
- Effluent

In most cases, the sample matrix will be 'Fresh water', therefore this is set as the default in the data entry field. In some special studies, other types of matrix may be sampled.

### *Type*

Here the sample type is specified:

- Grab sample[def]
- Time-composite
- Flow-composite
- Depth-integrated

In most cases, the sample type will be a 'Grab' sample', therefore this is set as the default in the data entry field. In some special studies, other types of samples may be collected.

### *Depth*

Enter the depth at which the sample was collected, in centimeters. Typical values should be around 30 cm, measured from the water surface.

### *Project*

Here the name of the project, if any, may be given. In most cases, the project will be the 'Regular Monitoring Programme'. If the sample is collected as part of a special survey or surveillance programme, the name of this programme or project should be given.

### *Collector*

The name of the person who collected the sample is entered here.

### *Monitoring Type*

Identify the type of monitoring sample, namely:

- Baseline
- Trend
- Flux
- Surveillance
- Survey

Reference is made to Volume 6, Water Quality Sampling, Design Manual.

### *Remarks*

Any relevant remarks to the sample collection can be added here: weather (raining, cloudy, windy), hydrological condition in the river (flooding, meagre flow, eroding, depositing, island formation in the bed, meandering, dividing into several channels), problems with equipment, unusual circumstances, etc.

### *Container, Sample Specification, Volume, Sampling Device, Preservation, and Treatment*

In the Sample Collection form, specific information on the sample containers that were filled is entered, including sample specification, volume collected, sampling device used, preservation in the field, and treatment in the laboratory are entered. This information must be entered in the table for EACH type of sample container that is filled.

Example of data entry for 'Container, Sample Specification, Volume, Sampling Device, Preservation, and Treatment:

| *Container* | *Sample Specification* | *No. Containers* | *Volume per container(ml)* | *Sampling Device* | *Preservation in field* | *Treatment at lab* |
|---|---|---|---|---|---|---|
| Plastic[def] | General | 1 | 1000 mL[def] | Bottle[def] | None[def] | None[def] |
| DO bottle | Dissolved Oxygen | 3 | 300 | DO sampler | DO fixing chemicals | None[def] |

*Table 14.4: Sample Collection data entry information*

### *Container*

Select from the pull-down menu the sample container that is filled:

- DO bottle
- Glass
- Amber Glass Bottle
- Polyethylene (PET)
- PVC
- Other plastic
- Stainless steel
- Other Metal
- Unknown

Discriminating between the different type of plastic (PET, PVC and others) may seem nit picking but the opposite is true. In general, the conditions of the sample before analysis are very important, the material of the container is one of them. Most plastics are not airtight, even when properly sealed. E.g., PVC containers are not suitable for collecting trace metals because the material contains metals itself. For each group of parameters to be analysed, a specific container may be needed. See 'Guidelines on Standard Analytical Procedures for Water Analysis' (Volume 7, Water Quality Analysis, Operation Manual, Chapter 4) for details. If more details about the material of the container are known, please supply this information.

### *Sample Specification*

It is important to specify the type of analysis to be performed on the sample collected in each container in the 'Sample Specification' column. This is important for the laboratory staff and field staff to ensure the right container for different parameters, right preservation and precautions during transportation and holding time for analysis. In this column the pull-down menu contains following options:

| ***Option*** | ***Type of analysis to be performed*** |
|---|---|
| General | For measurement of general parameters like, pH, conductivity, solids, ions, nutrients, BOD etc. sample is generally collected in polythene bottle and cold preserved. |
| DO sample | For measurement of Dissolved Oxygen, needs special DO bottles and fixed with DO reagents (Manganous sulphate and sodium iodide-azide solutions). |
| Coliform | For coliform measurement, sterilised glass bottles are required. Sample is to be preserved in cold. |
| Heavy metals | For heavy metal analysis, samples are collected in polythene bottles and acidified with nitric acid. |
| Ammonia, oxidised nitrogen and COD | For ammonia, total oxidised nitrogen and COD the samples are to be acidified with sulphuric acid. |
| Pesticide | Pesticide samples are collected in amber colour glass bottles and preserved in cold (ice-box). |
| Chlorophyll | Chlorophyll sample is to be collected in glass or polyethelene bottle and preserved in cold (ice-box) |

*Table 14.5: Sample Specification options*

### *No. Containers*

The number of containers that are collected for each container type is entered.

***Volume***

The volume of sample collected in each container, *in ml* is entered. Typical volume for a sample bottle is 1000 ml.

***Sampling device***

The sampling device used is select from the pull-down menu:

- Bottle
- Weighted Bottle
- Depth sampler
- Multi purpose sampler
- Bucket
- DO sampler
- Bailer or

A DO sampler should always be used to collect the dissolved oxygen measurement sample. Other samples are typically collected with different depth samplers available. A bailer or groundwater pump are only used to collect groundwater samples (CWC sometimes collects groundwater samples also).

***Preservation in field***

The type of preservation that is used on the sample after it is collected in the field is selected:

- Cooling (4°C)
- Acidification
- Freezing
- Other
- None$^{def}$

In principle, *all samples* should be cooled during transport to the laboratory. For this purpose, a cool-box with ice cubes or cooling elements should be carried on a sampling tour.

***Treatment at laboratory***

The type of treatment that is applied to the sample in the laboratory is selected:

- None$^{def}$
- Centrifuged
- Filtered (0.45 μm)
- Solvent Extraction
- Resin Extraction

***Save Template (on toolbar)***

The 'Save Template' option saves the current settings of the form to a location specific template. The following items will be saved in the template: Laboratory, Collecting Agency, Source, Medium, Matrix, Type, Depth, Collector, Project, Monitoring Type and all Container details. The Remarks, the date and time of sampling and Sample ID are not stored. This option is useful when samples are collected regularly (e.g. monthly) at a given location since many of the sample collection details remain the same.

***Load Template (on toolbar)***

The 'Load Template' option loads the saved template settings for a specific location- this is useful when entering new sample collection information for the location.. After the desired location is selected from the sample location list, the following fields are then filled with information stored in the template: Laboratory, Collecting Agency, Source, Medium, Matrix, Type, Depth, Collector, Project, Monitoring Type and all Container details.

***Filtering Sample Collection Information***

Sometimes information on how many sample data records are available in the SWDES for a particular sampling location or locations attached to a particular period is required. In the SWDES there is an option available to find this through the filtering option. By selecting the 'Filter' 'tab' on the 'Sample Collection Information Form' the user can prompt the filtering option form. In this form, the user can define the station(s) and desired period from the calendar. User can also define the sort order either by date-ascending or descending and by stations.

The selected filter becomes effective after leaving the filter form. To get the full list of samples available in the database the user has to de-select all filters applied. This is again done in the filter form by double-clicking on selected stations and dates.

### 14.4.4 COMMON DATA ENTRY TASKS

***Create a new sample record***

Switch to editing mode and select the 'Add Record' option. Fill in the location, data and time of collection. The Sample ID is automatically created based on the sampling date and location. Some fields on the form are filled with default values and need to be checked and possibly changed. Subsequently, the required information for all blank fields must be entered.

***Add a new sampling location***

Adding or modifying location/site characteristics cannot be done from the Water Quality Data Entry Form. See 'Entry of Static and Semi static Data' in SWDES manual.

## 14.5 ENTRY OF FIELD AND LABORATORY ANALYTICAL RESULTS

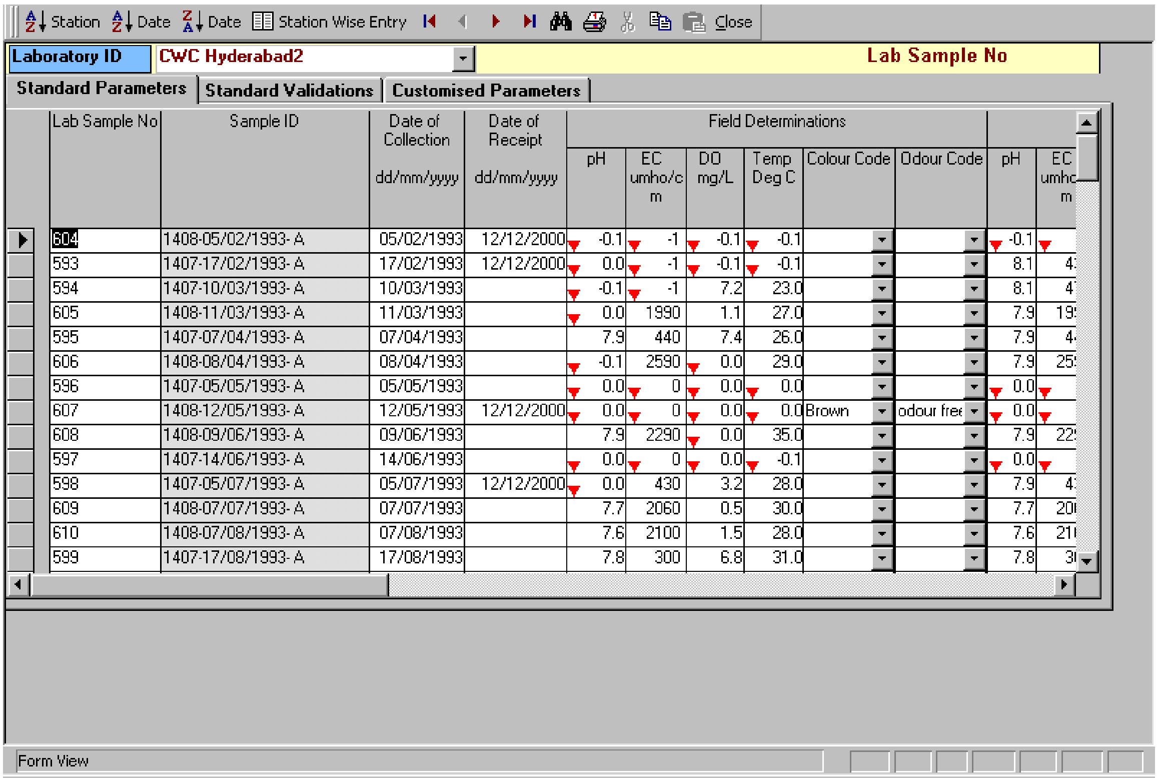
### 14.5.1 GENERAL

In the data entry section, water quality analytical results as measured in the field and in the laboratory are entered into the database. This section has two main functions:

- Data entry
- Data validation

Data values are entered in the form displayed in Figure 14.5, which shows the tab-sheet 'Standard Parameters' where data are entered. A similar form for customised parameters is available under the tab-sheet 'Customised Parameters' which includes only the customised parameters selected in the 'Laboratory Information Form'. Note that there is only one mode available for the data entry form (i.e. editing mode).

All samples which have been entered in the 'Sample Collection Information' Form are listed automatically in the Data Entry form (with Lab Sample No. and Sample ID).




| Lab Sample No | Sample ID | Date of Collection dd/mm/yyyy | Date of Receipt dd/mm/yyyy | Field Determinations pH | EC umho/cm | DO mg/L | Temp Deg C | Colour Code | Odour Code | pH | EC umho/cm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 604 | 1408-05/02/1993- A | 05/02/1993 | 12/12/2000 | -0.1 | -1 | -0.1 | -0.1 | | | -0.1 | |
| 593 | 1407-17/02/1993- A | 17/02/1993 | 12/12/2000 | 0.0 | -1 | -0.1 | -0.1 | | | 8.1 | 4 |
| 594 | 1407-10/03/1993- A | 10/03/1993 | | -0.1 | -1 | 7.2 | 23.0 | | | 8.1 | 4 |
| 605 | 1408-11/03/1993- A | 11/03/1993 | | 0.0 | 1990 | 1.1 | 27.0 | | | 7.9 | 19 |
| 595 | 1407-07/04/1993- A | 07/04/1993 | | 7.9 | 440 | 7.4 | 26.0 | | | 7.9 | 4 |
| 606 | 1408-08/04/1993- A | 08/04/1993 | | -0.1 | 2590 | 0.0 | 29.0 | | | 7.9 | 25 |
| 596 | 1407-05/05/1993- A | 05/05/1993 | | 0.0 | 0 | 0.0 | 0.0 | | | 0.0 | |
| 607 | 1408-12/05/1993- A | 12/05/1993 | 12/12/2000 | 0.0 | 0 | 0.0 | 0.0 | Brown | odour free | 0.0 | |
| 608 | 1408-09/06/1993- A | 09/06/1993 | | 7.9 | 2290 | 0.0 | 35.0 | | | 7.9 | 22 |
| 597 | 1407-14/06/1993- A | 14/06/1993 | | 0.0 | 0 | 0.0 | -0.1 | | | 0.0 | |
| 598 | 1407-05/07/1993- A | 05/07/1993 | 12/12/2000 | 0.0 | 430 | 3.2 | 28.0 | | | 7.9 | 4 |
| 609 | 1408-07/07/1993- A | 07/07/1993 | | 7.7 | 2060 | 0.5 | 30.0 | | | 7.7 | 20 |
| 610 | 1408-07/08/1993- A | 07/08/1993 | | 7.6 | 2100 | 1.5 | 28.0 | | | 7.6 | 21 |
| 599 | 1407-17/08/1993- A | 17/08/1993 | | 7.8 | 300 | 6.8 | 31.0 | | | 7.8 | 3 |

*Figure 14.5: Layout of Data Entry Form*

### *Laboratory ID*

First, the laboratory for which data are to be entered or validated is selected from the list of selected laboratories. Alternatively, if a laboratory is set as a 'Default Lab' (on the Laboratory Information Form) this lab will automatically be shown on the data entry form.

### *Lab Sample ID*

Here a sample is selected through its Lab-Sample ID. The Lab-Sample ID is assigned to a sample in the sample collection form as described in Section 14.4.3.

### *Sample ID*

Here a sample is selected through its sample ID. The sample ID cannot be changed since it is automatically assigned by SWDES in the sample collection form. From the Sample ID, it is easy to read the station code and the date of collection.

### *Date of Receipt*

The date on which the sample was received by the laboratory should be entered in this form as follows: dd/mm/yyyy, e.g. 21/01/2000.

### *Date of Analysis*

For a some of the parameters, it is important to know how soon they were analysed after the collection date (i.e. the holding time of the sample before analysis). This is especially important for BOD and Coliforms, where the sample should be analysed within 24 hours of collection. The analysis date for these parameters should be entered as: dd/mm/yyyy, e.g. 21/01/2000.

### *Laboratory results*

In the remaining fields, the data of laboratory results must be entered.

A warning is issued when a result beyond the warning limits (both UWL and LWL) is entered and the data is tagged with a symbol indicating that the value is above/below the warning limit.

If the values are below detection limit of the method being used, the *value will not be accepted by the computer*. Similarly, if the value is higher than the maximum limit set for a particular parameter, the *value will not be accepted* for entry. This is to prevent entry of the exceptionally high or low values.

### *Calculated Parameters*

Some of the parameters need not be entered in the form because they are automatically calculated. These parameters are called indirect parameters.

In SWDES, six (indirect) parameters are calculated based on the measured results of other (direct) parameters. The formulas are given below. Once the value for the required (direct) parameters is entered, the indirect parameters are automatically calculated and their values are incorporated in the data entry form.

***Note: all ionic species in the equations 1, 2 and 3 below are in meq/L.*** Data for these ionic species are entered in mg/L and SWDES automatically makes the conversion.

**1) Sodium Adsorption Ratio (SAR)**

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

**2) Percent Sodium**

$$\%\ Na = \frac{Na \times 100}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}}$$

**3) Residual Sodium Carbonate (RSC)**

$$RSC = (CO_3^{\ 2-} + HCO_3^{\ -}) - (Ca^{2+} + Mg^{2+})$$

**4) Calcium Ion ($Ca^{2+}$)**

$Ca^{2+}$ (mg/L) = 0.4 × (Calcium Hardness (mg $CaCO_3$/L))

**5) Magnesium ion ($Mg^{2+}$)**

$Mg^{2+}$ (mg/L) = 0.24 × [Total Hardness (mg $CaCO_3$/L) - Calcium Hardness (mg $CaCO_3$/L)]

**6) Carbonate ion ($CO_3^{2-}$) and Bicarbonate ion ($HCO_3^-$)**

Normally in natural waters, Phenolphthalein Alkalinity (P) is never equal to Total Alkalinity (T) and therefore, the Hydroxide (OH) alkalinity does not occur in significant concentration. Thus, the alkalinity is mainly due to Carbonates and Bicarbonates and by using measured values of Phenolphthalein Alkalinity (P) and Total Alkalinity (T) one can calculate the Carbonate and Bicarbonate ion concentrations in water using following formulas:

| Condition | OH alkalinity as in mg $CaCO_3$/L | $CO_3^-$ alkalinity as mg $CaCO_3$/L | $HCO_3^-$ alkalinity as mg $CaCO_3$/L |
|---|---|---|---|
| P = 0 | 0 | 0 | T |
| P < ½ T | 0 | 2P | T-2P |
| P = ½ T | 0 | 2P | 0 |
| P > ½ T | 2P-T | 2(T-P) | 0 |
| P = T | T | 0 | 0 |

### 14.5.2 COMMON DATA ENTRY TASKS

***Adding laboratory results for a sample***

The data entry form is always in edit mode so the user can directly select a sample for which laboratory results will be entered. If sample information has been entered in the Sample Collection Information Form, then the sample (Lab Sample No. and Sample ID) will automatically shown in the Data Entry Form.

***Deleting or changing a sample***

Deleting a sample is only possible when it does not contain any data. In case a sample record containing data is to be deleted, first all data from the record must be deleted from the record.

***Sorting Data***

Data records can be sorted by station or date by selecting one of the toolbar buttons

***Station wise entry***

By selecting 'Station Wise Entry' on the Toolbar, you get a data entry form only for one specific station.

## 14.6 OPTIONS FOR DATA ENTRY

### 14.6.1 GENERAL

In a few of the data entry forms, there are options for changing some of the data entry system. The options are set in the 'WQ Options' Form. Presently options exist for:

- Method of entry for Lab-Sample ID in 'Sample Collection Information' Form ,
- Validation of ion balance in the Data Validation option of 'Sample Data Entry and Validation Register'
- Selection of Drinking Water Standards to be used for comparison with data, and
- Definition of the seasons used in creating Seasonal Box-Whiskers plots.

### 14.6.2 OPTION FOR CHANGING METHOD OF ENTERING THE LAB SAMPLE ID

On the 'Sample Collection Information' form, there is provision to enter a Lab Sample ID, which may the same as, or different from the (automatically generated) Sample ID. The Lab-Sample ID option has provision to change the method of defining/entering the Lab Sample ID. These options are:

- Auto-Generate: in which the Lab Sample ID is automatically generated. The first sample collected by a laboratory and entered into the database is number '1'. For every new sample collected and entered, the next consecutive number will appear in the box automatically. The number assigned is based on the number of records already in the database;
- Duplicate Sample ID: in which the Lab-Sample ID is created same as Sample ID.
- Manual: in which the Lab-Sample ID can be manually entered.

The default in SWDES in the 'Auto-Generate' method.

### 14.6.3 OPTION FOR CHANGING PERCENT DIFFERENCE IN ION BALANCE

One of the data validation steps on the Data Validation Form checks the validity of sample analysis result based on the percentage difference between the sum of anions and the sum of cations. The sum of the major anions and cations, when expressed as milli-equivalents per liter, should be nearly equal, as the natural water is electrically neutral. Since water may contain large number of ions and not all the ions are analysed, the sum of measured major cations and anions may not be exactly equal. However, the percent difference should be small. The percent difference may vary with concentration of the total ions and the accuracy with which they are measured. It is common procedure to accept a percent difference $\leq$ 10%. In the software, there is a provision to choose either 5% or 10%.

The default value for the acceptable percent difference is 10%.

### 14.6.4 OPTION FOR CHANGING THE TYPE OF DRINKING WATER STANDARDS

There are four different sets of Drinking Water Standards commonly used in India. In the SWDES software, the default set of drinking water standards used for comparison with data is BIS. The options are:

- BIS (Bureau of Indian Standards) *(default).* Two options: desirable or permissible
- ICMR (Indian Council on Medical Research)
- CPHEEO (Central Public Health Environmental Engineering Org.
- WHO (World Health Organisation)

These values from the selected set of standards are shown in the 'Parameter Information Form' in the field 'Drinking Standard'. One option of the Water Quality Report is to show water quality results compared with the selected standards.

**All standards are currently expressed in the units prescribed by the data entry software (see e.g. Section 14.2.3 and Table 14.2.**

## 14.7 DATA ENTRY FOR AQC DATA

**General**

Under the Hydrology Project, a system of quality control in laboratories based on Inter-laboratory Analytical Quality Control (AQC) exercises has been introduced. The results of the first two exercises were analysed manually. Upon reviewing the results, questions of uncertainties about the processing of exercise results were encountered. The results of AQC exercise are important since the proficiency and credibility of laboratories is involved. To avoid ambiguity in future, special software for "Automatic Processing of Inter-Laboratory AQC Exercise Data" was developed (The software is available on request).

Participating laboratories use their Data Entry Software (SWDES) to enter their analytical results of the AQC samples. This facility is provided in the SWDES and is referred as **AQC Data.** This part of the software can store the analysis results generated from the exercise for all the required parameters in samples A and B.

When the option **"AQC Data"** is chosen in the **"Water Quality" s**witchboard (Figure 14.6), AQC Data switchboard will be displayed. The switchboard has the following options:

- AQC Parameters
- AQC Data Entry
- AQC Export

The layout of the switchboard is shown in Figure 14.6.

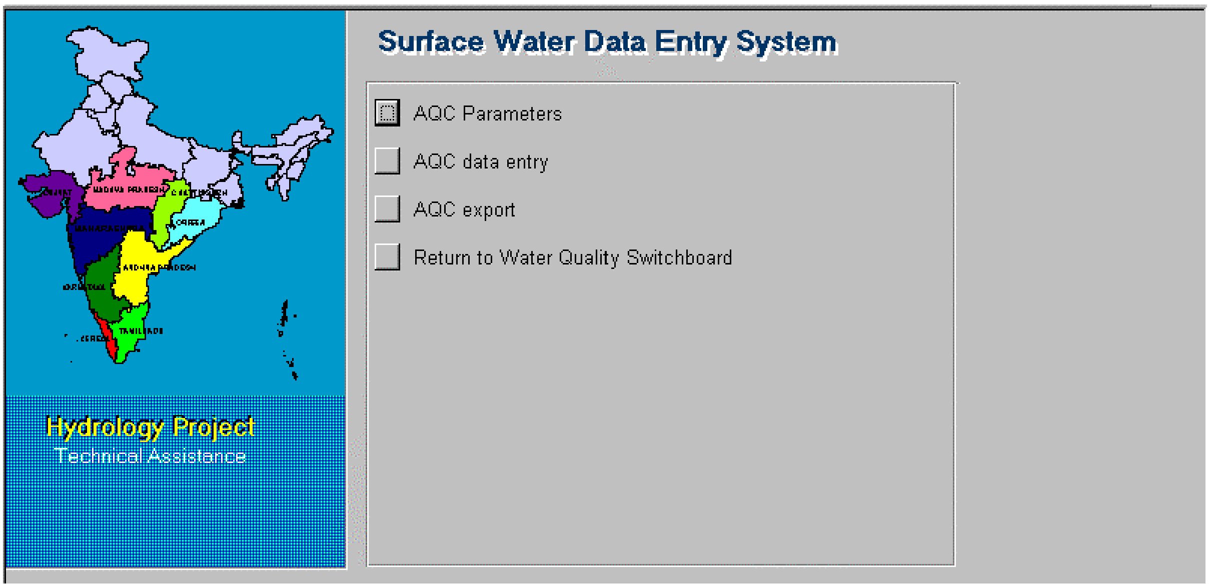



*Figure 14.6: Layout of the AQC Data Switchboard*

### 14.7.1 AQC PARAMETERS

When AQC Parameters button is clicked, the parameter form is displayed as shown in Figure 14.7. In this form, one can choose the parameters for which AQC is conducted after entering appropriate AQC. Round ID. For selection of the parameters for which AQC was conducted, click on the desired parameter in the left column and click the rightward arrow. In case you want to unselect a parameter from the selected list, you can do so by again clicking the parameter to be unselected in the AQC Parameters Column (in the right) and then clicking the leftward arrow. The number of decimal places and units can be changed in the lower portion of the form, if required.

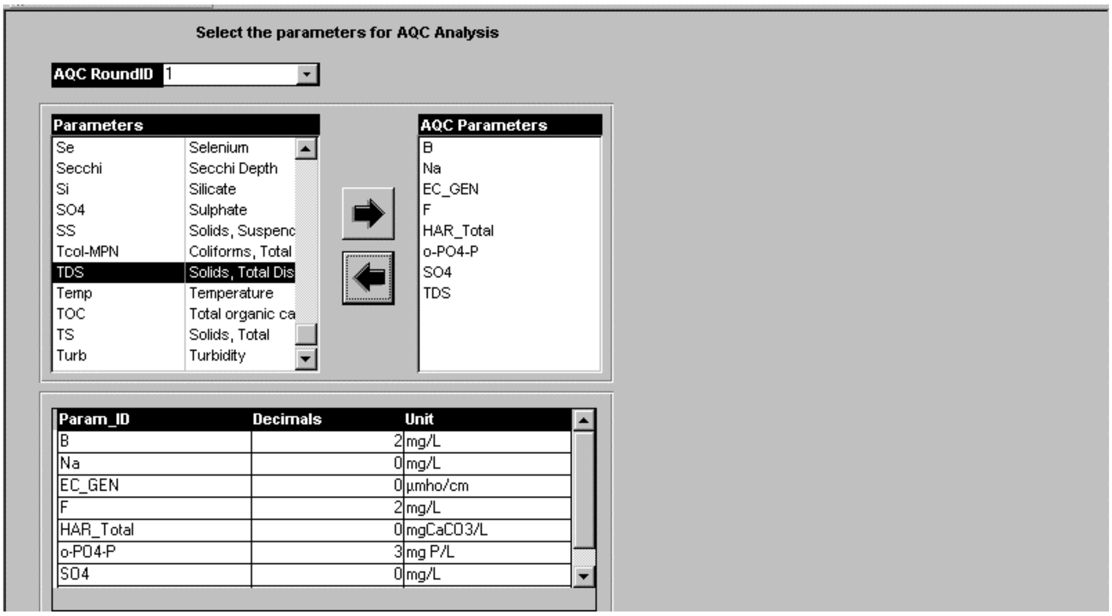



*Figure 14.7: Layout of AQC Parameters Form*

### 14.7.2 AQC DATA ENTRY FORM

When the button for AQC Data Entry is pressed, the AQC data entry form will be displayed. Select appropriate AQC Round ID, the parameter list of selected AQC Round will appear. The analysis results for different parameters as obtained for both the samples A and B can be entered in this form. Once all the results are entered, the data can be exported to organising laboratory. The data entry form is displayed in Figure 14.8.

***Round ID***

The software will store all the data from many rounds of AQC exercises, each round is to be given a unique round ID number. The organising laboratory needs to provide a unique round identification code to the participating laboratories along with the dispatch of the samples for each new round. A meaningful identification code will include a serial number followed by the year in which exercise was conducted e.g. 12-2005 (round 12 conducted in the year 2005).

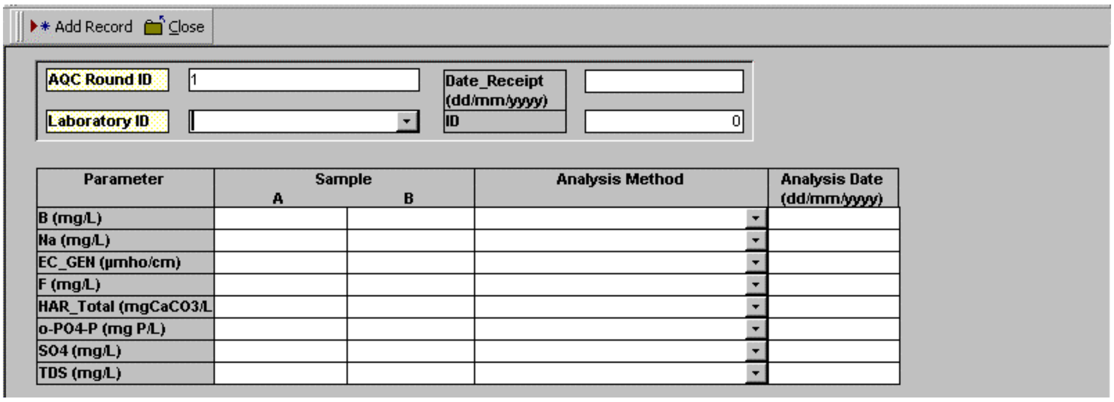



*Figure 14.8: Layout of the AQC Data Entry Form*

The overall procedure for AQC data entry is as follows:

1. organising laboratory provides the participating laboratory with a unique ID for the current round of AQC.
2. The receiving laboratory enters the results of their AQC analysis (Sample A and B) in the data entry software together with the method of analysis used (select from a list), date of sample receipt and date of analysis for each parameter (see Figure 12.9).
3. Note that the reporting format (i.e. number of digits after the decimal point) for each parameter is fixed as follows:

| | | | |
|---|---|---|---|
| Conductivity (EC) | 0 | Sulphate ($SO_4$) | 0 |
| Total Dissolved Solids (TDS) | 0 | Nitrate ($NO_3$-N) | 1 |
| Total Hardness (TH) | 0 | Phosphate ($PO_4$-P | 3 |
| Sodium (Na) | 0 | Boron (B) | 2 |
| Fluoride (F) | 2 | | |

The number of digits entered in the AQC data entry form for each parameter should not be more than those specified above. If more digits are entered, **the data will be rounded to the listed number of digits before comparison with acceptable limits.**

### 14.7.3 EXPORT OF AQC DATA

After completion of the entry form, the participating laboratories export the data to a file (on DES toolbar). It is possible for a laboratory to enter AQC results from another laboratory also. During export, all data available in the AQC-database for the selected round-ID will be exported. The name of the file in which the data are stored includes Laboratory ID followed by AQC round ID with MDB extension e.g. CTN-COIM_122005.MDB. This indicates that the file is sent from the CWC laboratory at Coimbatore and contains data of the twelfth AQC round conducted in the year 2005, the file extension MDB indicates it is an microsoft Access Database. The data can be easily sent either through e-mail or floppy to the organising laboratory for further processing.

## 14.8 DATA ENTRY (IMPORT) OF HISTORICAL WATER QUALITY DATA

Most of the agencies involved in the Hydrology Project have a rich archive of observed water quality data. The period of available data varies from agency to agency and from well to well within an agency. While some agencies have put a part of the WQ data on to magnetic media, others are yet to start. For achieving better efficiency in using this vast amount of data, which is an asset created by various agencies at a huge cost, it is essential to properly organise it on computer. The benefits derived from such an effort need no emphasis.

It is important to make inventory on all historical data available with the agency. All the water quality stations along with their ID must be available river basin-wise, district-wise or division-wise along with the associated characteristics. This is already available with Discharge Recording Groups. The inventory must indicate the period of availability of data (in years) for each station. The inventory should also include those stations which were WQ stations for quite a long period but now non-functional. Many agencies have already entered the data in different softwares (e.g. lotus, excel, dbase etc). It is normally possible to read such data automatically and write back in the formats desired by SWDES and, therefore, it is not necessary to enter them again. Provisions have been made in SWDES for importing such historical data.

**It is important for import, that information on Station ID to which WQ data belong, date of sampling (or at least year and month), parameters along with their values and Laboratory (along with its ID), where the sample was analysed is available.**

***Access to Import Function***

When 'Utilities' button is pressed in the main switchboard (Figure 14.1), you are prompted to another switchboard containing several utilities including 'Import of Data'. When 'Import of Data' button is clicked another switchboard containing several options for import of various data is displayed including 'Import water quality data'. On clicking 'Import of water quality data' button the form shown in Figure 12.9 will appear.

***Select the file***

The import can be done from excel or dbase files. By clicking the file name button on the lower right part of the format one can prompt to desired file either from hard disk or floppy.

***Link the parameters (columns)***

Once the desired file is opened, the second column of the right half of the format will get list of the parameters existing in the external file. One has to link the parameters of the external file with the parameters of the SWDES, including site code, date of sampling, WQ parameters etc. The linking can be done by clicking the corresponding parameters in the two columns, then clicking the arrow-button in between the columns.

***Define the conversion factor***

In case, there is a difference in unit of a particular parameter, a factor of multiplication is required to be put in the middle part of the two right columns. The clicked parameters will appear in the right top columns along with the factor of multiplication. In case, one wants to edit the factor of multiplication, he can do so by clicking the desired factor in the column and retyping it.

***Date of Sampling***

In case the date of sampling is not known, only month and year is known, one can put an arbitrary date in the 'Date of Collection' in the lower right part of the format.

***Define missing value(s)***

For missing values (parameter not analysed), in the external database some sign might have been used e.g. ND for not done, NA for data not available, -1 or any other sign. The user can put that sign in the lower right part of the format against 'Missing Value'. Ensure that the same sign is used in the entire database. In case different signs were used, first make them same in the external database itself. Once all the linkages are made, click 'Import data' button to import the data.

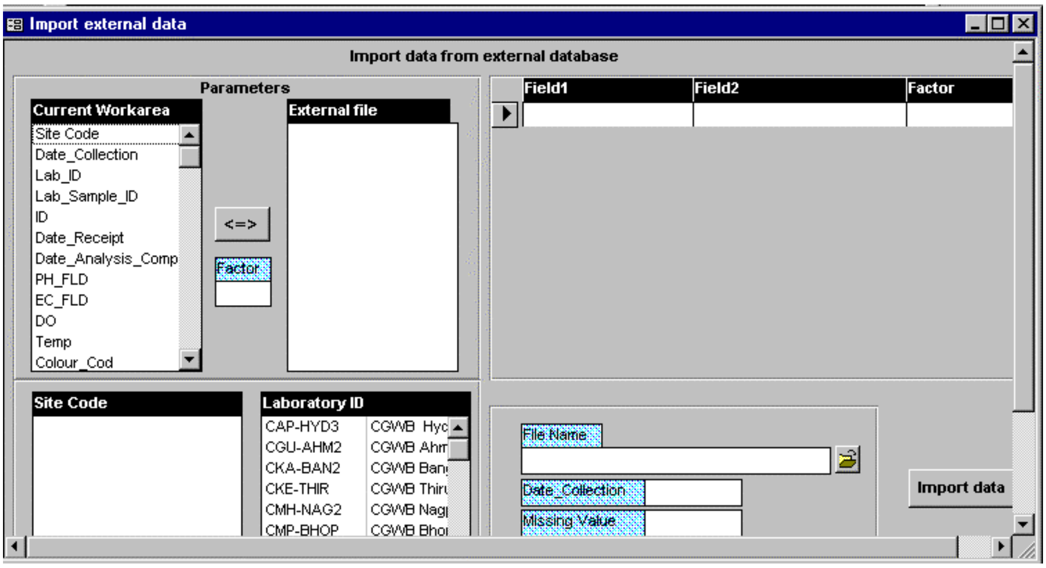



*Figure 14.9: Layout form for import of external data*

***Rules for Importing Historical Data***

- Calculated parameters in the historical database (such as SAR, %DO, %Na etc) cannot be imported into SWDES. The calculation will be re-done in SWDES.
- Units of parameters in historical database must be converted to the prescribed units of the SWDES (use factor or correct in original file).
- The method by which a parameter is analysed in the past must be entered in the SWDES. The laboratory must also record if, and when, the method of analysis was changed. This date of change in method can be incorporated in the database as explained in Section 14.3.
- Ensure that repeated sampling was done at the same stations for at least 3 to 5 years. In one of the HP States, the Ground Water Survey Agency collects samples from new wells every year for water quality, data generated from such sampling can not be put to any statistical analysis and thus of very little significance putting in the software.

# 15 PRIMARY VALIDATION OF WATER QUALITY DATA

## 15.1 GENERAL

The validation results can be viewed in the tab-sheet 'Standard Validations' of the Data Entry Form, as shown in Figure 15.1. SWDES performs several data validation checks for each sample. If the water quality data for a sample do not meet a specific validation check, a red arrow will indicate that the result is above ( ↑ ) or below ( ↓ ) the allowed limit for that check. Furthermore, a small box will indicate a check ( √ )or cross (×), indicating passing or failing of the validation check.

## 15.2 DATA VALIDATION TESTS

***Ion balance for cations and anions***

The relative imbalance between the sum of the major actions ($Na^+$, $K^+$, $Mg^{++}$ and $Ca^{++}$, in meq/L) and the sum of the major anions ($Cl^-$, $SO_4^{--}$, $CO_3^{--}$, $HCO_3^-$, $NO_3^-$+$NO_2^-$, in meq/L) is expressed in % and should not exceed 5-10%. The percent difference may be somewhat lower for samples with low TDS values. In the software, the default value for this check has been put at 10% but this value can be changed depending upon the requirements of the monitoring programme (see Section 7.8, WQ Options).

*Note: The ion balance is not calculated (NA) if one of the major actions or anions (except for $NO_3^-$ +$NO_2^-$) is missing. The SWDES software converts the concentrations entered in mg/L to meq/L.*

***Na and Cl ratio***

Normally, in sodium dominated waters, most of the Na is associated with Cl, and thus, the ratio between Na and Cl (in meq/L) remain within 0.8 to 1.2. The software indicates if the ratio is outside this range. *Note: The SWDES software converts the measured concentrations entered in mg/L to meq/L.*

***EC and TDS ratio***

For fresh water conductivity (EC, in μmhos/cm) and Total Dissolved Solids (TDS in mg/L) usually obey the following relationship:

$$EC = TDS \times a,$$

Where ‘a’ ranges from 0.55 to 0.9. The constant ‘a’ is usually high for chloride rich waters and low for sulphate rich waters. The software indicates if the value of ‘a’ is outside this range.

***COD and BOD ratio***

Values measured for COD should always be higher than BOD values. SWDES checks if the ratio COD/BOD >1 and indicates if the values do not meet this criteria.

***Carbonate and pH relation***

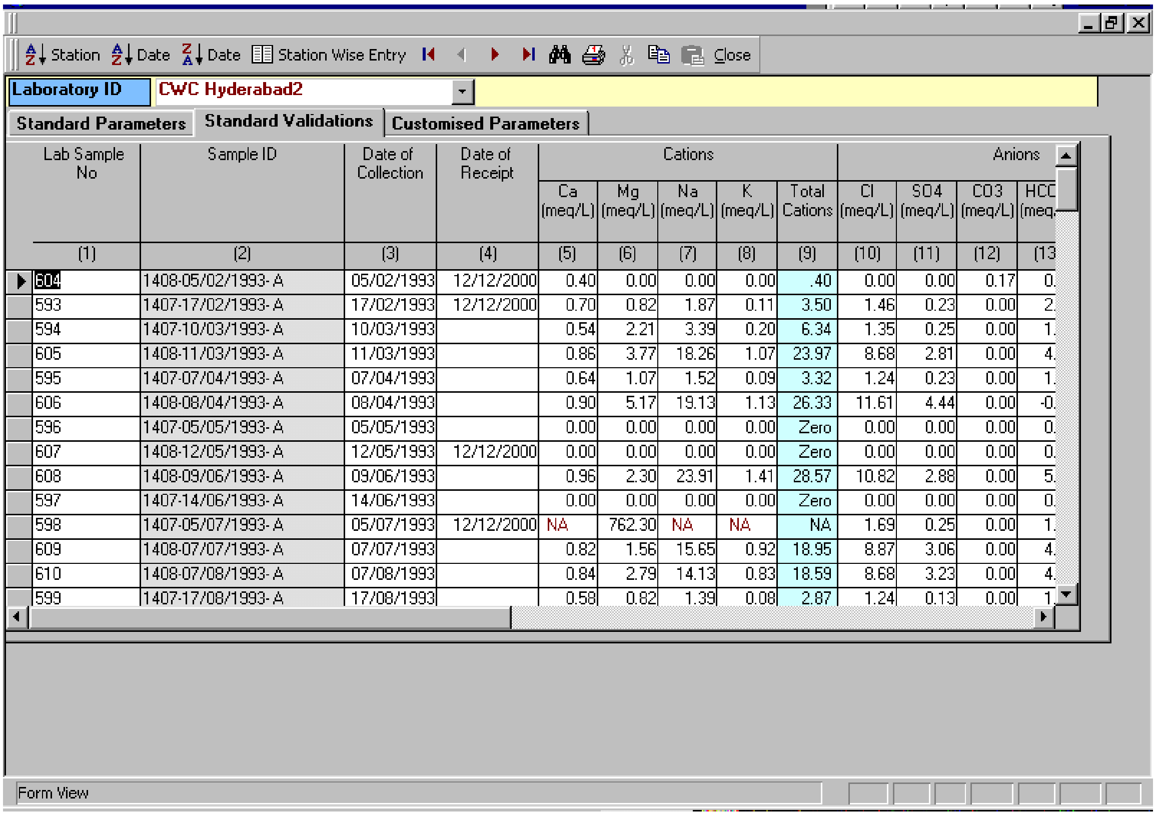
At pH values below 8.3 the $CO_3^{2-}$ (phenolphthalein alkalinity) alkalinity should be zero. SWDES checks if this condition is met and indicates if the values do not meet this criteria.

***Checked by***

Here the responsible person, e.g. the head of the laboratory, should put his name or initials after checking the outcome of the validation.

***Remarks***

In this field the person who has checked the data may put some remarks, e.g. to explain why a sample did not pass a certain validation check.




| Lab Sample No | Sample ID | Date of Collection | Date of Receipt | Cations | | | | | Anions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ca (meq/L) | Mg (meq/L) | Na (meq/L) | K (meq/L) | Total Cations | Cl (meq/L) | SO4 (meq/L) | CO3 (meq/L) | HCO (meq/ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13 |
| 604 | 1408-05/02/1993- A | 05/02/1993 | 12/12/2000 | 0.40 | 0.00 | 0.00 | 0.00 | .40 | 0.00 | 0.00 | 0.17 | 0. |
| 593 | 1407-17/02/1993- A | 17/02/1993 | 12/12/2000 | 0.70 | 0.82 | 1.87 | 0.11 | 3.50 | 1.46 | 0.23 | 0.00 | 2. |
| 594 | 1407-10/03/1993- A | 10/03/1993 | | 0.54 | 2.21 | 3.39 | 0.20 | 6.34 | 1.35 | 0.25 | 0.00 | 1. |
| 605 | 1408-11/03/1993- A | 11/03/1993 | | 0.86 | 3.77 | 18.26 | 1.07 | 23.97 | 8.68 | 2.81 | 0.00 | 4. |
| 595 | 1407-07/04/1993- A | 07/04/1993 | | 0.64 | 1.07 | 1.52 | 0.09 | 3.32 | 1.24 | 0.23 | 0.00 | 1. |
| 606 | 1408-08/04/1993- A | 08/04/1993 | | 0.90 | 5.17 | 19.13 | 1.13 | 26.33 | 11.61 | 4.44 | 0.00 | -0. |
| 596 | 1407-05/05/1993- A | 05/05/1993 | | 0.00 | 0.00 | 0.00 | 0.00 | Zero | 0.00 | 0.00 | 0.00 | 0. |
| 607 | 1408-12/05/1993- A | 12/05/1993 | 12/12/2000 | 0.00 | 0.00 | 0.00 | 0.00 | Zero | 0.00 | 0.00 | 0.00 | 0. |
| 608 | 1408-09/06/1993- A | 09/06/1993 | | 0.96 | 2.30 | 23.91 | 1.41 | 28.57 | 10.82 | 2.88 | 0.00 | 5. |
| 597 | 1407-14/06/1993- A | 14/06/1993 | | 0.00 | 0.00 | 0.00 | 0.00 | Zero | 0.00 | 0.00 | 0.00 | 0. |
| 598 | 1407-05/07/1993- A | 05/07/1993 | 12/12/2000 | NA | 762.30 | NA | NA | NA | 1.69 | 0.25 | 0.00 | 1. |
| 609 | 1408-07/07/1993- A | 07/07/1993 | | 0.82 | 1.56 | 15.65 | 0.92 | 18.95 | 8.87 | 3.06 | 0.00 | 4. |
| 610 | 1408-07/08/1993- A | 07/08/1993 | | 0.84 | 2.79 | 14.13 | 0.83 | 18.59 | 8.68 | 3.23 | 0.00 | 4. |
| 599 | 1407-17/08/1993- A | 17/08/1993 | | 0.58 | 0.82 | 1.39 | 0.08 | 2.87 | 1.24 | 0.13 | 0.00 | 1. |

*Figure 15.1: Layout of Data Validation Form*

# APPENDIX A: NOTE ON DATA TYPES AND THEIR IDENTIFICATION CODES

There are numerous parameters which are observed from both hydrometric and meteorological network. Using full names for parameters is not always possible while displaying them on the screen. For an easy recognition of various parameters an identification code of upto 3 characters is used in the software. The parameters can be classified in 4 major categories: ***(a) hydrometric data, (b) meteorological data, (c) sediment transport data, and (d) water quality data***. For easier association of these parameter identification codes with the respective categories, the first character of the code is occupied by the first alphabet of the category name with the exception for water quality parameters. A large number of water quality parameters (about 70-80) are required to be coded and if the first character is reserved for the alphabet "Q" then only two more character spaces would be effectively left for giving the codes. This will give little opportunity to codify the water quality parameters with codes that are easily recognisable. For this reason all water quality parameters are coded such that the first character is not the same as for other three categories ***(i.e. H, M, S or Q).*** This will also distinguish water quality parameters from parameters of other categories.

A standardised full list of all parameter identification codes for hydrological, meteorological and sediment data is given in Table 1 below. The list of water quality parameters will be incorporated later. It is not possible for a user to alter this standardised list of parameter codes. However, additional parameters as per the requirement of the user can similarly be coded and used in the software.

**Table 1: List of standardised data types:**

| S.No. | Name of Parameter | Code for Parameter | Units | Type of measurement |
|---|---|---|---|---|
| **Hydrometric:** | | | | |
| 1 | Water level by Staff Gauge w.r.t Gauge Zero | HZS | m | I |
| 2 | Water level by AWRL w.r.t Gauge Zero | HZA | m | I |
| 3 | Water level by DWRL w.r.t Gauge Zero | HZD | m | I |
| 4 | Maximum Water level by gauge 1 w.r.t Gauge Zero | HZX | m | I |
| 5 | Maximum Water level by gauge 2 w.r.t Gauge Zero | HZY | m | I |
| 4 | Water level by Staff Gauge w.r.t M.S.L | HHS | m | I |
| 5 | Water level by AWRL w.r.t M.S.L | HHA | m | I |
| 6 | Water level by DWRL w.r.t M.S.L | HHD | m | I |
| 7 | Maximum Water level by gauge 1 w.r.t M.S.L. | HHX | m | I |
| 8 | Maximum Water level by gauge 2 w.r.t M.S.L. | HHY | m | I |
| 9 | Observed Discharge | HQ0 | m3/sec. | I |
| 10 | Computed Discharge | HQC | m3/sec. | I |
| 11 | Simulated Discharge | HQS | m3/sec. | I |
| 12 | Computed Runoff Volume | HRC | Ha-m | A |
| 13 | Simulated Runoff Volume | HRS | Ha-m | A |
| **Meteorological:** | | | | |
| 1 | Rainfall Observed by Standard Raingauge | MPS | mm | A |
| 2 | Rainfall Observed by Autographic Raingauge | MPA | mm | A |
| 3 | Rainfall Observed by Digital TBR | MPD | mm | A |
| 4 | Tips of TBR | MPT | mm | A |
| 5 | No. of rainy days | MPN | days | A |
| 6 | Maximum daily temperature | MTX | Deg. C | I |

| S.No. | Name of Parameter | Code for Parameter | Units | Type of measurement |
|---|---|---|---|---|
| 7 | Minimum daily temperature | MTN | Deg. C | I |
| 8 | Dry bulb temperature | MTD | Deg. C | I |
| 9 | Wet bulb temperature | MTW | Deg. C | I |
| 10 | Temperature by Thermograph | MTA | Deg. C | I |
| 11 | Dew point temperature | MTU | Deg. C | I |
| 12 | Absolute Pressure by Barometer | MBS | mb | I |
| 13 | Absolute Pressure by Barograph | MBA | mb | I |
| 14 | Vapour Pressure | MVP | mb | I |
| 15 | Saturation Vapour Pressure | MVS | mb | I |
| 16 | Relative Humidity by thermometers | MHS | % | I |
| 17 | Relative Humidity by Hygrograph | MHA | % | I |
| 18 | Wind Direction (16 pts. Alphanumeric) | MW1 | - | I |
| 19 | Wind Direction (16 pts. numeric) | MW2 | - | I |
| 20 | Wind Run | MWR | kms/day | I |
| 21 | Wind Speed | MWS | kms/hr. | I |
| 22 | Pan Evaporation | MEP | mm | A |
| 23 | Potential Evaporation | MEW | mm | A |
| 24 | Potential Evapotranspiration | MET | mm | A |
| 25 | Actual Potential Evapotranspiration | MEL | mm | A |
| 26 | Sunshine Duration | MSD | hrs. | A |
| 27 | Radiation | MSN | watt/m2 | A |
| **Sediment Transport:** | | | | |
| 1 | Fine Suspended Sediment Concentration | SCF | g/l | I |
| 2 | Medium Suspended Sediment Concentration | SCM | g/l | I |
| 3 | Coarse Suspended Sediment Concentration | SCC | g/l | I |
| 4 | Sand-silt Suspended Sediment Concentration | SCS | g/l | I |
| 5 | Total Suspended Sediment Concentration | SCT | g/l | I |
| 6 | Fine Suspended Sediment Transport Rate | SQF | kg/sec./m | I |
| 7 | Medium Suspended Sediment Transport Rate | SQM | kg/sec./m | I |
| 8 | Coarse Suspended Sediment Transport Rate | SQC | kg/sec./m | I |
| 9 | Sand-silt Suspended Sediment Transport Rate | SQS | kg/sec./m | I |
| 10 | Total Suspended Sediment Transport Rate | SQT | kg/sec./m | I |
| 11 | Fine Suspended Sediment Load | SLF | Tonne | A |
| 12 | Medium Suspended Sediment Load | SLM | Tonne | A |
| 13 | Coarse Suspended Sediment Load | SLC | Tonne | A |
| 14 | Sand-silt Suspended Sediment Load | SLS | Tonne | A |
| 15 | Total Suspended Sediment Load | SLT | Tonne | A |
| 16 | Bed Load Transport Rate | SBLQ | kg/sec./m | I |
| 17 | Mean Size of Bed Load Sediment | SBM | mm | I |
| 18 | Max. Size of Bed Load Sediment | SBX | mm | I |
| 19 | Min. Size of Bed Load Sediment | SBN | mm | I |
| 20 | D10 of Bed Load Sediment | SB1 | mm | I |
| 21 | D16 of Bed Load Sediment | SB2 | mm | I |
| 22 | D35 of Bed Load Sediment | SB3 | mm | I |
| 23 | D50 of Bed Load Sediment | SB5 | mm | I |
| 24 | D65 of Bed Load Sediment | SB6 | mm | I |

| S.No. | Name of Parameter | Code for Parameter | Units | Type of measurement |
|---|---|---|---|---|
| 25 | D84 of Bed Load Sediment | SB8 | mm | I |
| 26 | D90 of Bed Load Sediment | SB9 | mm | I |
| 27 | Bed Material Nature | SMU | - | I |
| 28 | Mean Size of Bed Material | SMM | mm | I |
| 29 | Max. Size of Bed Material | SMX | mm | I |
| 30 | Min. Size of Bed Material | SMN | mm | I |
| 31 | D10 of Bed Material | SM1 | mm | I |
| 32 | D16 of Bed Material | SM2 | mm | I |
| 33 | D35 of Bed Material | SM3 | mm | I |
| 34 | D50 of Bed Material | SM5 | mm | I |
| 35 | D65 of Bed Material | SM6 | mm | I |
| 36 | D84 of Bed Material | SM8 | mm | I |
| 37 | D90 of Bed Material | SM9 | mm | I |
| **Water Quality:** | | | | |
| 1 | Dissolved Oxygen Saturation Percentage | Q%D | % | I |
| 2 | Silver | QAg | ug/l | I |
| 3 | Aluminium | QAl | mg/l | I |
| 4 | Nitrogen, ammonia | QAm | mg/l | I |
| 5 | Alkalinity, phenolphthalein (pH 8.3) | QAP | mg/l | I |
| 6 | Sodium Adsorption Ratio | QAR | % | I |
| 7 | Arsenic | QAs | mg/l | I |
| 8 | Alkalinity, total (pH 4.5) | QAT | mg/l | I |
| 9 | Boron | QB | mg/l | I |
| 10 | Biochemical oxygen demand (3 days, 27°C) | QB3 | mg/l | I |
| 11 | Biochemical oxygen demand (5 days, 20°C) | QB5 | mg/l | I |
| 12 | Barium | QBa | mg/l | I |
| 13 | Chemical oxygen demand | QC | mg/l | I |
| 14 | Carbonate | QC3 | mg/l | I |
| 15 | Calcium | QCa | mg/l | I |
| 16 | Cadmium | QCd | ug/l | I |
| 17 | Coliforms, Ecoli | QCE | MPN/100ml | I |
| 18 | Coliforms, Faecal | QCF | MPN/100ml | I |
| 19 | Chlorophyll-a | QCh | ug/l | I |
| 20 | Chloride | QCl | mg/l | I |
| 21 | Cyanide | QCN | mg/l | I |
| 22 | Cobalt | QCo | mg/l | I |
| 23 | Chromium | QCr | mg/l | I |
| 24 | Coliforms, Total | QCT | MPN/100ml | I |
| 25 | Copper | QCu | ug/l | I |
| 26 | Dissolved oxygen | QDO | mg/l | I |
| 27 | Solids, total dissolved | QDS | mg/l | I |
| 28 | Detergents | QDt | mg/l | I |
| 29 | Electrical conductivity | QEC | mS/m | I |
| 30 | Fluoride | QF | mg/l | I |
| 31 | Iron | QFe | mg/l | I |
| 32 | Bicarbonate | QHC | mg/l | I |

| S.No. | Name of Parameter | Code for Parameter | Units | Type of measurement |
|---|---|---|---|---|
| 33 | Mercury | QHg | ug/l | I |
| 34 | Hardness, number | QHn | - | I |
| 35 | Potassium | QK | mg/l | I |
| 36 | Colour | QIr | - | I |
| 37 | Magnesium | QMg | mg/l | I |
| 38 | Manganese | QMn | mg/l | I |
| 39 | Sodium | QNa | mg/l | I |
| 40 | Nickel | QNi | ug/l | I |
| 41 | Nitrogen, nitrate | QO2 | mg/l | I |
| 42 | Nitrogen, nitrite | QO3 | mg/l | I |
| 43 | Carbon, dissolved organic | QOC | mg/l | I |
| 44 | Odour | QOd | - | I |
| 45 | Nitrogen, organic | QoN | mg/l | I |
| 46 | Phosphorus, ortho phosphate | QoP | mg/l | I |
| 47 | Nitrogen, total oxidised (NO2+NO3) | QOt | mg/l | I |
| 48 | Phosphorus, organic | QP | mg/l | I |
| 49 | Lead | QPb | ug/l | I |
| 50 | Carbon, particulate organic | QPC | mg/l | I |
| 51 | pH | QpH | - | I |
| 52 | Sulphate | QS4 | mg/l | I |
| 53 | Salinity | QSa | ‰ | I |
| 54 | Secchi depth | Qsd | m | I |
| 55 | Selenium | QSe | ug/l | I |
| 56 | Silicate | QSi | mg/l | I |
| 57 | Solids, suspended | QSS | mg/l | I |
| 58 | Turbidity | QTb | - | I |
| 59 | Carbon, total organic | QTC | mg/l | I |
| 60 | Hardness, total | QTH | mg/l | I |
| 61 | Nitrogen, total | QtN | mg/l | I |
| 62 | Phosphorus, total | QtP | mg/l | I |
| 63 | Solids, total | QTS | mg/l | I |
| 64 | Vanadium | QV | ug/l | I |
| 65 | Temperature | QWT | °C | I |
| 66 | Zinc | QZn | mg/l | I |

# APPENDIX B: LIST OF MAJOR RIVER BASINS/ZONES AND INDEPENDENT RIVERS

**Table 1: List of Major River Basins/Zones:**

| S. No. | Name of Major River Basin/Zone | No. of independent rivers in the zone |
|---|---|---|
| 1 | East coast rivers of Orissa and West Bengal | 13 |
| 2 | East coast rivers of Andhra Pradesh | 20 |
| 3 | East coast rivers of Tamil Nadu | 17 |
| 4 | West coast rivers of Gujarat | 26 |
| 5 | West coast rivers of Maharastra, Goa and Karnataka | 26 |
| 6 | West coast rivers of Kerala | 20 |
| 7 | Indus basin | 6 |
| 8 | Ganga Basin | 1 |
| 9 | Bhrahamputra Basin | 6 |
| 10 | Rivers of Meghalaya | 13 |
| 11 | Barak and other rivers of Tripura | 12 |
| 12 | Rivers of Mizoram and Manipur | 8 |

**Table 2a: List of Independent rivers of East coast rivers of Orissa and West Bengal**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Bahuda | 50 |
| 2 | Rushikulya | 100 |
| 3 | Daya | 50 |
| 4 | Mahanadi | 100 |
| 5 | Brahmni | 100 |
| 6 | Baitarani | 100 |
| 7 | Salandi | 100 |
| 9 | Burhabatang | 100 |
| 10 | Jamira | 50 |
| 11 | Subarnarekha | 100 |
| 12 | Rasulpur | 50 |
| 13 | Kasai | 100 |

**Table 2b: List of Independent rivers of East coast rivers of Andhra Pradesh**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | --- | 50 |
| 2 | --- | 100 |
| 3 | --- | 100 |
| 4 | Penner | 100 |
| 5 | Manneru | 100 |
| 6 | Paleru | 100 |
| 7 | Musi | 100 |

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 8 | Gundlakamma | 100 |
| 9 | --- | 50 |
| 10 | Krishna | 100 |
| 11 | Tammileru | 100 |
| 12 | Errakaleva | 100 |
| 13 | Godavari | 100 |
| 14 | Eluru | 100 |
| 15 | Tandava | 50 |
| 16 | Sarada | 100 |
| 17 | --- | 50 |
| 18 | --- | 50 |
| 19 | Nagavali | 100 |
| 20 | Vamsadhara | 100 |
| 21 | Swarnamuki (??) | |

**Table 2c: List of Independent rivers of East coast rivers of Tamil Nadu**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Chittar | 100 |
| 2 | Vaippar | 100 |
| 3 | Gundar | 100 |
| 4 | Vaigai | 100 |
| 5 | --- | 50 |
| 6 | Manimuttar | 100 |
| 7 | Vellar | 100 |
| 8 | Cauvery | 100 |
| 9 | Manimukta | 100 |
| 10 | Gadilam | 50 |
| 11 | Ponnaiyar | 100 |
| 12 | Vidur | 50 |
| 13 | Palar | 100 |
| 14 | Adyar | 50 |
| 15 | Coouna | 50 |
| 16 | Nagari | 50 |
| 17 | Thambraparni | 100 |

**Table 2d: List of Independent rivers of West coast rivers of Gujarat**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Luni | 100 |
| 2 | Banas | 100 |
| 3 | Machhu | 100 |
| 4 | --- | 100 |
| 5 | Und | 100 |
| 6 | --- | 100 |
| 7 | Bahadur | 100 |
| 8 | --- | 100 |

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 9 | Shetrunji | 100 |
| 10 | --- | 100 |
| 11 | Keri | 50 |
| 12 | Sabarmati | 100 |
| 13 | Mahi | 100 |
| 14 | --- | 100 |
| 15 | Narmada | 100 |
| 16 | Kim | 100 |
| 17 | Tapi | 100 |
| 18 | Mindhola | 100 |
| 19 | Purna | 100 |
| 20 | Ambika | 100 |
| 21 | Auranga | 100 |
| 22 | Par | 100 |
| 23 | Kalak | 50 |
| 24 | Daman Ganga | 100 |
| 25 | Vaitarana | 100 |
| 26 | Bhutsa | 100 |

**Table 2e: List of Independent rivers of West coast rivers of Maharastra, Goa and Karnataka**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Amba | 50 |
| 2 | Kal (Kundalika) | 50 |
| 3 | Savitri | 50 |
| 4 | Vashisti | 50 |
| 5 | Shastri | 100 |
| 6 | Kajvi | 50 |
| 7 | --- | 50 |
| 8 | Kodasal | 50 |
| 9 | Vaghutan | 50 |
| 10 | --- | 50 |
| 11 | --- | 50 |
| 12 | --- | 50 |
| 13 | Ajgaon | 50 |
| 14 | Chapora | 50 |
| 15 | Mandovi | 100 |
| 16 | Rachol | 50 |
| 17 | Kalinadi | 100 |
| 18 | Gangavali | 100 |
| 19 | --- | 50 |
| 20 | Sharavati | 100 |
| 21 | Kolluru | 50 |
| 22 | Haladi | 50 |
| 23 | Sita | 50 |
| 24 | Swarna | 50 |

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 25 | Gurpur | 50 |
| 26 | Netravali | 100 |

**Table 2f: List of Independent rivers of West coast rivers of Kerala**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Payaswani | 100 |
| 2 | --- | 50 |
| 3 | Kuppam | 50 |
| 4 | Aralam Puzha | 50 |
| 5 | Maruvabal | 50 |
| 6 | Murat | 100 |
| 7 | Baypore | 100 |
| 8 | Kadalundi | 50 |
| 9 | Ponnani | 100 |
| 10 | Keecheri | 50 |
| 11 | Kurumali | 50 |
| 12 | Periyar | 100 |
| 13 | Muvatpuza | 100 |
| 14 | Meenachi | 50 |
| 15 | Pambiyar | 100 |
| 16 | Achankovil | 100 |
| 17 | Kallada | 100 |
| 18 | Itthikara | 50 |
| 19 | Attinga | 50 |
| 20 | Podayar | 50 |

**Table 2g: List of Independent rivers of Indus basin**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Indus | 100 |
| 2 | Jhelum | 100 |
| 3 | Chenab | 100 |
| 4 | Ravi | 100 |
| 5 | Sutlej | 100 |
| 6 | Ghaggar | 100 |

**Table 2h: List of Independent rivers of Ganga Basin**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Hoogly/Ganga | 100 |

**Table 2i: List of Independent rivers of Bhrahamputra Basin**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Purnabhaba | 50 |
| 2 | Atrai | 50 |
| 3 | Tista | 100 |
| 4 | Jaldhaka | 100 |
| 5 | Raidak | 100 |
| 6 | Brahmaputra | 100 |

**Table 2j: List of Independent rivers of Meghalaya**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Bugi | 50 |
| 2 | Dareng | 50 |
| 3 | Kangra | 50 |
| 4 | Semesuri | 50 |
| 5 | Jadulai | 50 |
| 6 | Umngi | 50 |
| 7 | Umiew | 50 |
| 8 | Umrew | 50 |
| 9 | --- | 50 |
| 10 | Umngot | 50 |
| 11 | Myntdu | 50 |
| 12 | Lumnbha | 50 |
| 13 | Gumra | 50 |

**Table 2k: List of Independent rivers of Barak and other rivers of Tripura**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Barak | 100 |
| 2 | Singla | 50 |
| 3 | Longai | 50 |
| 4 | Juri | 50 |
| 5 | Manu | 50 |
| 6 | Dalai | 50 |
| 7 | Khowai | 50 |
| 8 | Haora | 50 |
| 9 | Burigang | 50 |
| 10 | Gumti | 100 |
| 11 | Muhari | 50 |
| 12 | Feny | 50 |

**Table 2l: List of Independent rivers of Mizoram and Manipur**

| S. No. | Name of independent river | Length more than (kms) |
|---|---|---|
| 1 | Tuishong | 100 |
| 2 | Karnaphuli | 100 |
| 3 | Kaladan | 100 |
| 4 | Boina | 100 |
| 5 | --- | 50 |
| 6 | Manipur | 50 |
| 7 | Tixu Nanitaluk | 50 |
| 8 | --- | 50 |

# APPENDIX C: USERS FEEDBACK FORM (SWDES)

## Surface Water Data Entry System

## (SWDES)

### Users Feedback Form

Date:………..……………...

Agency: ……………………………… Division/Sub-division: ………………..

SWDES Version No. : ……………………. Date of Release: ……..…………

**List of Users' Observations (Please list errors with adequate details about how exactly it occurred):**

| S.No. | Category | Errors/Remarks/Suggestions |
|---|---|---|
| | | |
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| | | |

***Use photocopies of this form to fill in your feedback***
***Send your feedback to the State Management Consultant of HP in your State***

# Surface Water Data Entry System

# (SWDES)

## Users Feedback Form

Date:………..……………...

Agency: ……………………………… Division/Sub-division: ………………..

SWDES Version No. : ……………………. Date of Release: ……..…………

**List of Users' Observations (Please list errors with adequate details about how exactly it occurred):**

| S.No. | Category | *Errors/Remarks/Suggestions* |
|---|---|---|
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***Use photocopies of this form to fill in your feedback***
***Send your feedback to the State Management Consultant of HP in your State***