HYDROLOGY PROJECT

Technical Assistance

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Training module # SWDP - 40

How to compile discharge data

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CSMRS Building, 4th Floor, Olof Palme Marg, Hauz Khas,
New Delhi – 11 00 16 India
Tel: 68 61 681 / 84 Fax: (+ 91 11) 68 61 685
E-Mail: dhvdelft@del2.vsnl.net.in

DHV Consultants BV & DELFT HYDRAULICS

with
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1. Module context

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

2. Module profile

Title	:	How to compile discharge data
Target group	:	Assistant Hydrologists, Hydrologists, Data Processing Centre Managers
Duration	:	One session of 30 minutes
Objectives	:	After the training the participants will be able to: • Compile discharge data
Key concepts	:	• Aggregation of discharge data • Runoff volumes
Training methods	:	Lecture, software
Training tools required	:	Board, OHS, Computer
Handouts	:	As provided in this module
Further reading and references	:	

3. Session plan

No	Activities	Time	Tools
1	***General*** • Important points	5 min	 OHS 1
2	***Aggregation of data to longer durations*** • Computations for aggregation	5 min	 OHS 2
3.	***Computation of volumes and runoff depth*** • Computations for volumes • Computations for runoff depths	5 min	 OHS 3 OHS 4
4	***Compilation of maximum and minimum series*** • General	2 min	 OHS 5

4. Overhead/flipchart master

5. Handout

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

6. Additional handout

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

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

7. Main text

Contents

How to compile discharge data

1. General

- **Discharge compilation is the process by which discharge at its observational or recorded time interval and units is transformed:**

  - **to another time interval**
  - **from one unit of measurement and especially from discharge (a rate of flow) to volume or runoff (a depth over the catchment)**

- **Computations for aggregation of data from one time interval to another depends on the data type. If the data is of instantaneous nature then the aggregation is effected by computing the arithmetic average of the individual constituent data values. Whereas when the data type is of accumulative nature then the constituents values are arithmetically summed up for obtaining the aggregated value.**

- **Compilation is required for validation, analysis and reporting**

- **Compilation is carried out at Divisional offices; it is done prior to validation if required, but final compilation is carried out after correction and 'completion'.**

2. Aggregation of data to longer duration

Discharge and its precursor water level is observed at different time intervals, but these are generally one day or less. Manual observation may be daily, hourly for part of the day during selected seasons, or some other multiple of an hour. For automatic water level recorders a continuous trace is produced from which hourly level and hence discharge is extracted. For digital water level recorders level is usually recorded at hourly intervals though for some small basins the selected interval may be 15 or 30 minutes. **Sub-hourly, hourly and sub-daily discharges, computed from levels, are typically aggregated to daily mean. For example, the daily mean discharge (Q_d) is computed from hourly values (Q_i) by:**

$$Q_d = \frac{1}{24}\sum_{i=1}^{24} Q_i \qquad (1)$$

For a given day the mean is normally calculated for hours commencing 0100 and finishing 2400. For some purposes daily discharge averages are calculated over the day from 0800 to 0800 (i.e. for hourly measurements the average of observations from 0900 to 0800) to enable direct comparison to be made with daily rainfall.

Daily data are typically averaged over weekly, ten daily, 15 daily, monthly, seasonally or yearly time intervals. In general,

$$Q_{Nd} = \frac{1}{Nd}\sum_{i=1}^{Nd} Q_i \qquad (2)$$

where,

Q_{Nd} is the discharge for Nd days duration,

Q_i is the discharge of i^{th} day in duration of Nd days.

Time intervals used while aggregating the data generally corresponds to the month or year ending. For example a ten daily data series corresponds to three parts of every month in which the first two parts are the 1-10 and 11-20 days of the month and the third part is the remaining part of the month. Thus every third value in the series corresponds to 8,9,10 or 11 days (the last part of the month) depending on the total days in the month. Similarly, weekly data depending on its objective is the taken in two ways: (a) as four parts of the months where first three parts are of seven days each and the fourth part is of 7, 8, 9 or 10 days period (as per the total days in the month) or (b) as 52 parts of a year where first 51 weeks are of 7 days each and the last week is of 8 or 9 days depending upon whether the year is a leap or a non-leap year. Such culmination are often desirable for the operational purpose as the time interval is reset to the 1st of a month or year every time.

Averaging over longer time intervals is required for validation and analysis. For validation small persistent errors may not be detected at the small time interval of observation but may more readily be detected at longer time intervals.

3. Computation of volumes and runoff depth

To facilitate comparisons between rainfall and runoff it is usual to express values of rainfall and flow in similar terms. Both may be expressed as a total volume over a specified period (in m^3, thousand m^3, (Tcm) or million m^3 (Mcm)). Alternatively, discharge may be expressed as a depth in millimetres over the catchment.

Volume is simply the rate in m^3/sec (cumecs) multiplied by the duration of the specified period in secs., i.e. for daily volumes in cubic metres with respect to daily mean flow Q_d in cumecs following equation may be used:

$$V_d\ (cum) = (24 \times 60 \times 60\ seconds)\ Q_d\ (cumecs) = 86400\ Q_d \quad (cum) \tag{3}$$

Runoff depth is the volume expressed as depth over the specified catchment area with a constant to adjust units to millimetres; i.e. for daily runoff:

$$R_d\ (mm) = \frac{V_d\ (cum)\ x\ 10^3}{Area\ (km^2)\ x\ 10^6} = \frac{V_d\ (mm)}{Area\ (km^2)\ x\ 10^3} = \frac{86.4\ Q_d}{Area\ (km^2)} \tag{4}$$

Runoff depths provide not only a ready comparison with rainfalls; they also provide a comparison with other catchments standardised by area. Such comparions may be made for monthly, seasonal and annual totals but are not generally helpful for daily or shorter duration depths, where basins respond at different time scales to incident rainfall.

For the purposes of annual reporting it is usual to compare the monthly and annual runoff from a station with the long term average, maximum and minimum monthly runoff derived from the previous record. This requires the annual updating of runoff statistics with the concatenation of the previous year with earlier statistics

Volumes and runoff depths may also be required for irregular periods to compare with rainfall depths over a storm period. Providing sufficient measurements are available over the period, the runoff over the storm period can be expressed simply as:

$$R(mm) = \frac{0.001}{Area} \sum_{i-1}^{N} (Q_i \Delta t) \qquad (5)$$

Where:

N	=	Number of observations in the period
Dt	=	Time step in seconds
A	=	Catchment area in km^2
Q_i	=	Discharge at time *i* in m^3 / sec

It is not generally necessary to use more complex procedures such as Simpson's rule, to account for the non-linear variation of flow between observations.

For the purposes of storm analysis, it is also generally necessary to separate the storm flow, resulting from the incident rainfall, and the base flow originating from continuing groundwater sources. Various methods have been suggested for such separation; they are described in standard texts and not discussed further here.

Another unit which is sometimes used to standardise with respect to area is specific discharge which may be computed with respect to instantaneous discharges or the mean discharge over any specified duration as discharge over area (m^3/sec per km^2).

Imperial and other units are regarded as **obsolete** and should not be used; these include Mgd (million gallons per day), acre-feet and ft^3 /sec (cusecs).

4. Compilation of maximum and minimum series

The annual, seasonal or monthly maximum series of discharge is frequently required for flood analysis, whilst minimum series may be required for drought analysis. Options are available for the extraction of maximum and minimum values for the following time periods:

- day
- month
- year
- period within a year

For example if the selected time period is 'month' and the time interval of the series to be analysed is 'day', then the minimum and maximum daily value is extracted for each month between a start and end date.