HYDROLOGY PROJECT

World Bank & Government of The Netherlands funded

Training module # SWDP - 24

How to correct and complete water level data

New Delhi, November 1999

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
HALCROW, TAHAL, CES, ORG & JPS

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1. Module context

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

2. Module profile

Title	:	How to correct and complete water level data
Target group	:	Assistant Hydrologists, Hydrologists, Data Processing Centre Managers
Duration	:	One session of 60 minutes
Objectives	:	After the training the participants will be able to*:* • Correct the erroneous water level data • Fill-in missing water level data
Key concepts	:	• Use of staff gauge and analogue data of same station • Temporal interpolation • Relationship between water levels at adjoining stations • Error in level of gauge zero.
Training methods	:	Lecture, software
Training tools required	:	OHS, computers
Handouts	:	As provided in this module
Further reading and references	:	

3. Session plan

No	Activities	Time	Tools
1	***General*** • Text • Text	10 min	 OHS 1 OHS 2
2	***Correction using river level or discharge?*** • Text	5 min	 OHS 3
3	***Comparison of staff gauge and autographic or digital records*** • Text • Text • Text • Text • Text • Text • Figure 3.1 • Figure 3.2	10 min	 OHS 4 OHS 5 OHS 6 OHS 7 OHS 8 OHS 9 OHS 10 OHS 11
4	***Linear interpolation of short gaps*** • Text	5 min	 OHS 12
5	***Use of relation curve with adjacent staions*** • Figure 5.1 • Text • Text • Figure 5.2	10 min	 OHS 13 OHS 14 OHS 15 OHS 16
6	***Exercise*** • Infilling missing data in KHED_ZA record, by interpolation and use of relation curve		

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 correct and complete water level data

1. General

- **Correction and completion of water level will be carried out at Divisional offices.**

- **Although separated from validation in these Modules, correction and completion will generally be done as a continuous process with validation**

- **After validation a number of values will be flagged as incorrect or doubtful**. Some records may be missing due to non-observation or loss on recording or transmission**. Incorrect and missing values will be replaced where possible by estimated values based on interpolation or other observations at the same station or neighbouring stations. The process of filling in missing values is generally referred to as 'completion'.**

- **Values identified as suspect by numerical validation tests will be inspected and corrected if necessary or the flag removed if they are found to be acceptable.** Numerical test of records with respect to maximum, minimum and warning limits and rates of rise will have identified suspect values (and flagged them) during primary validation. Unless these were due to entry error, they will not have been corrected and will thus require further inspection and correction and completion if necessary.

Where multiple level records at the same station are thus flagged, but the observations agree, then the records may be assumed to be correct. Other suspect values outside warning limits are inspected for violations of typical hydrological behaviour but are also checked against neighbouring stations before correction or acceptance.

- **It must be recognised that values estimated from other gauges are inherently less reliable than values properly measured. Doubtful original values will therefore be generally given the benefit of the doubt and will be retained in the record with a flag.** Where no suitable neighbouring observations or stations are available, missing values will be left as 'missing' and incorrect values will be set to 'missing'

2. Correction using river level or discharge?

Correction and completion may be carried out with respect to the water level series or it may await transformation to discharge using a stage discharge relationship. The choice of water level or discharge for correction depends on the type of error, the duration of missing or faulty records and the availability of suitable records with which to estimate. Correction as level has the advantage that it is the primary measurement whereas error in the discharge may result either from error in the level record or in the stage discharge relationship; it has the disadvantage that it provides no volumetric water balance checks.

Conditions where correction and completion will usually be carried out as level include the following:

- where the level record is complete but the recorder has gone out of adjustment and periodic check observations are available
- where the level record is correct but shifted in time
- where the primary record (e.g., from a digital water level recorder) is missing but an alternative level record of acceptable quality is available at the same station
- where the record is missing but the duration is short during a period of low flow or recession.

Correction and completion may be carried out as level include:

- where a record is available from a neighbouring station with little lateral inflow or abstraction between the stations

Correction and completion will normally be carried out as discharge:

- where a record is available only from a neighbouring station with much lateral inflow or abstraction
- where one or both stations are affected by variable backwater
- where the only available means of infilling is from catchment rainfall and the use of a rainfall runoff model.

Records completed as stage will receive further validation as discharge and may require further correction.

3. Comparison of staff gauge and autographic or digital records

Where two or more measurements of the same variable are made at a station, one record may be used to correct or replace the other where one is missing. Where more than one record exists but they differ, the problem in the first instance is to determine which record is at fault. Typical measurement errors from each source are described under 'primary validation' (Module 22) and guidelines are provided for identifying which record is at fault. Suspect values are flagged during validation. **Errors and their correction may be classified as follows:**

- observer errors
- recorder timing errors
- pen level errors
- errors arising from stilling well and intake problems
- miscellaneous instrument failures

3.1 Observer errors

Staff gauge and autographic or digital records can be displayed together graphically as multiple time series plots. Differences can also be displayed. Simple and isolated errors in reading and transcription by the observer (e.g., 6.57 for 5.67) can be identified and replaced by the concurrent measurement at the recording gauge. Persistent and erratic differences from the recording gauge (negative and positive) indicate a problem with the observer's ability or record fabrication. They should be notified to the Sub-division for corrective action; the full staff gauge record for the period should be flagged as doubtful, left uncorrected and the recording gauge record adopted as the true stage record for the station.

3.2 Recorder timing errors

When the clock of the recording gauge runs fast or slow, the rate at which the recorder chart moves in the time direction under the pen will also be fast or slow. This can be detected by comparing with staff gauge readings, e.g. if observations are taken daily at 0800 and the clock of the recording instrument is running slower, then the observer's stage record at 0800 will correspond to the same observation in the recording gauge before 0800, say 0700 Clock times and recorder times annotated on the chart or

recorded in the Field Record book at the time of putting on or taking off the chart can be used to determine the time slippage during the record period.

3.2.1 Correction Procedure

For time corrections, it is assumed that a clock runs fast or slow at a constant rate. Where a digital record is produced from an analogue record using a pen-follower digitiser, the annotated clock and recorder time and level can be fed into the digitising program and the level record expanded or contracted as required to match the clock duration.

Where a digital record is extracted manually at a fixed interval from a chart, it will result in extra records for a fast clock and deficient records for a slow clock. This can be expediently corrected by removing or inserting (interpolating) records at appropriate intervals, e.g. if the clock runs 4 hours fast in eight days, and hourly data have been extracted, then one data point should be removed at 2 day intervals.

3.3 Pen level errors

The pen of the autographic recorder may gradually drift from its true position. In this case, analogue observations may show deviation from the staff gauge observations. This deviation can be static or may increase gradually with time.

3.3.1 Correction Procedure

Where a digital record is produced from an analogue record using a pen-follower digitiser, the annotated clock and recorder time and level can be fed into the digitising program and an accumulative adjustment spread over the level record from the time the error is thought to have commenced till the error was detected or the chart removed. However, such procedure is not recommended to be followed as the actual reasons for the shift may still be unknown at the time of digitising the charts. It is always appropriate to tabulate/digitise the chart record as it is in the first instance and then apply corrections thereafter.

HYMOS provides such facility for correcting the gradual spread of error in digital records extracted from a chart recorder, with a growing adjustment from the commencement of the error until error detection. Let the error be DX observed at time $t = i+k$ and assumed to have commenced at k intervals before, then the applied correction reads:

$$X_{corr,j} = X_{meas,j} - ((j - i)/k)DX \qquad \text{for } j = i, i+1, ..., i+k$$

Prepare the time-series plot of deviation of staff gauge observations from the recording gauge observations. If the deviation is static with time, then the difference must be settled (increased or decreased) directly from the analogue gauge observations. However, if the deviation increases gradually with time, then corrections for the difference between the pen observation and the staff gauge reading are made in the same way as time corrections. For example, assume that the pen trace record gradually drifted 0.08 m away (recording lower levels) from the corresponding staff gauge record in a period of 10 days. This shows that the pen readings has an error which is increasing gradually from 0 to 8 cms in 10 days period. Now error in such a data can be compensated by adding a proportionate amount of 8 mm per day from the starting point of the error.

3.4 Errors arising from stilling well and intake problems

Problems with stilling well or intake pipe may be intermittent or persistent and can be serious. In extreme floods, the hydrograph may be truncated due to inadequate height of the well, restricting the travel of the float, or counterweight reaching the well bottom. Blockage of the intake pipe with silt will result in a lag between river level (as recorded by the staff gauge) and well level, or a flat trace.

3.4.1 Correction procedure

The recorder trace is replaced by the observer's staff gauge record if the time interval is sufficiently small in relation to the changes in the water levels. If the staff gauge record is intermittent or frequent changes in the levels are expected to be present then use of relation curves, as described in subsequent sections, is to be preferred for correcting the water level record.

3.5 Miscellaneous instrument failures

Unacceptable recorder traces may result from a wide variety of instrument problems. These are often displayed as stepped or flat traces and may be corrected by interpolating a smooth curve on the hydrograph plot.

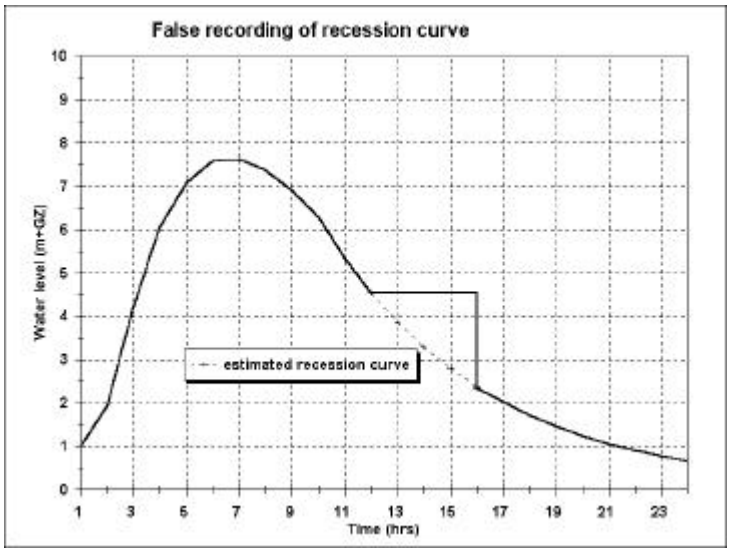


Figure 3.1

False recording of recession curve

Fig. 3.1 represents false recording of the recession curve because of: a) silting of stilling well; or b) blocking of intakes; or c) some obstruction causing the float to remain hung. The figure also shows the time when the obstruction is cleared. The correct curve can be estimated by reading the smooth curve that joins the first and last reading during the period of obstruction.

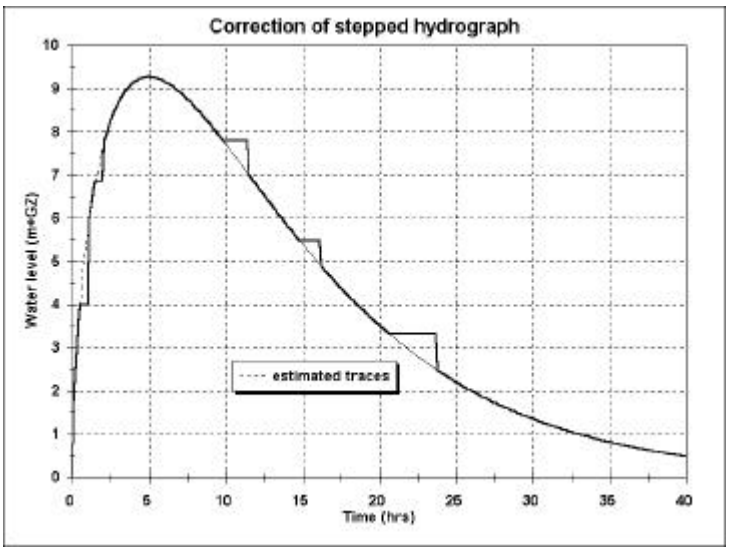


Figure 3.2

Correction of stepped hydrograph

Figure 3. 2 shows small steps in the stage records because of the temporary hanging of the float tape or counterweight, or kinks in the float tape. Such deviations can be easily identified and true values can be interpreted by reading the smooth curve in the same way as for recession curve.

4. Linear interpolation of short gaps

Where only a single record is available at a station, gaps may occur due to instrument failure, observer sickness, station maintenance, etc**. Gaps may be infilled by simple linear interpolation where they occur during periods of low flow or during recession and the difference between the level at the beginning and end of the gap is small.** During periods of low flow, gaps of one to several days may be infilled in this way but it is recommended that infilling by linear interpolation during the monsoon or on a heavily regulated river should not exceed 6 hours.

For longer periods of missing data during a recession when the runoff is result only of outflow from a groundwater reservoir, the flow shows an exponential decay, which, when plotted as discharge on a sem-logarithmic scale, plots a a straight line. Using the stage discharge relationship it is possible to infill the series as water level rather than flow, but infilling as flow is conceptually simpler (Module 39). Gaps of a month or more may be filled in this way.

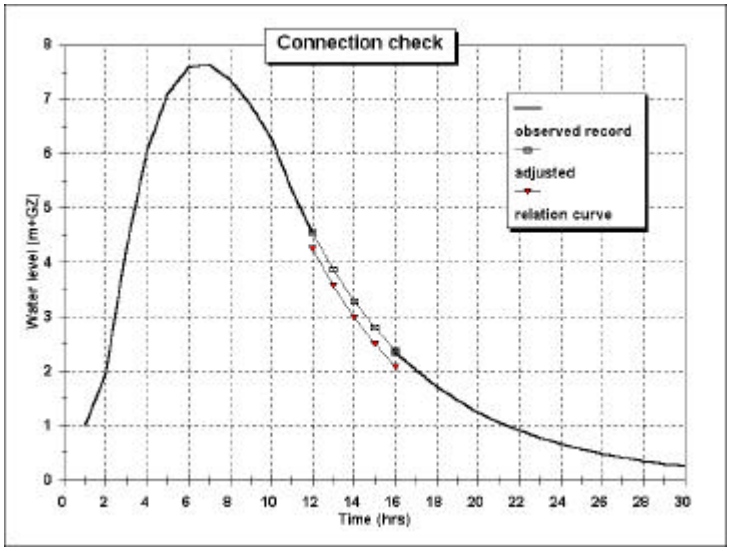
5. Use of relation curves with adjacent stations

5.1 General

The use of relation curves for water level data validation has been described in Module 23. It is also an effective way of infilling missing records and of correcting suspect ones especially for sequential stations on a river with little lateral inflow between. **The following are typical uses.**

- infilling of missing records
- identifying and correcting misreadings in one series
- identifying and correcting shift in gauge zero or change in cross section

5.2 Infilling of Missing Records



A relation curve based on the data of two series can be used to infill the missing data in the dependent variable of the relationship. The relation curve is used to calculate the missing value(s) at the station corresponding to the observed values at the adjacent station An example is given in Figure 5.1.

Figure 5.1

Infilling of missing data with relation curve

Figure 5.1 shows that the relation curve did not provide a good connection between the existing record and the infilled part. These situations do sometimes happen, particularly, when the standard error is more than a few centimetres. Therefore, one should always verify the correctness of the infilled part.

5.3 Identifying and correcting misreadings

If, after taking the lag between stations into account, there is a strong relationship between the two series, incidental misreading or incorrect booking will show up as outliers in the relation curve plot. Having identified its occurrence it is then required to determine in which series the problem has arisen and the actual value at fault, taking into account the lag time between stations. A corrected value is estimated using the relation curve or relation equation and substituted in the time series.

5.4 Identifying and correcting shift in gauge zero or change in cross section

Shifts in water level observations due to change in gauge zero or changes in cross section conditions can be detected by comparing two relation curves or the plot of one period with that of another. For routine validation and completion, the comparison will be between data for the current period and an established curve for the station. If the new relation differs and there is a new stable relationship between the records and the deviation from the previous relation is constant, then a shift in the reference gauge is suspected. The time of its occurrence can be identified from the comparative plots. If there is a change in slope of the relation curve compared with the standard curve, then a change in cross section at one of the stations may be suspected.

On the identification of such changes, consultation should be made with sub-divisional staff and the Field Record Book inspected. If the conditions of change had been previously recognised in the field and adjustments made to the rating curve to account for the shift in gauge zero (or change in station location) or altered cross section, then no further action need be taken. If the change had not been recognised in the field then, since the analysis does not indicate which station is in error, then further action is necessary on following lines:

- Where additional stations are available for comparison, further relation curves may be developed and the station in error identified.
- Field staff are requested to re-survey gauges and the cross section at both stations
- If, after survey the gauge zero at one station is found to have inadvertently altered, then it should be reset to its former level. The stage level during the period between gauge shift and resetting should be corrected by the deviation shown by survey (and confirmed by the constant difference in relation curves).
- If no change in gauge zero is found but the cross section at one station has altered, then field staff are requested to intensify current meter gauging to establish a new stage discharge relationship. Usually the stage record will not be changed but the revised rating curve applied over the period from the occurrence of the change in cross section (usually during a flood).