

BS 17898:2014



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Code of practice for the management of observed hydrometric data

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Contents

Foreword *ii*

Introduction *1*

1	Scope	<i>1</i>
2	Normative references	<i>2</i>
3	Terms and definitions	<i>2</i>
4	Principles of hydrometric data management	<i>2</i>
5	Metadata	<i>12</i>
6	Precipitation data	<i>20</i>
7	Water level data	<i>27</i>
8	Velocity and discharge data	<i>32</i>
9	Volume data	<i>41</i>

Bibliography *42*

List of figures

Figure 1 – Data management sequence *3*

Figure 2 – Example of monitoring stations, sites and points at a river discharge gauging station *13*

List of tables

Table 1 – Recording intervals *28*

Table 2 – Parameters to be archived when calculating discharge, as appropriate *33*

Table 3 – Techniques for infilling discharge data *40*

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 42, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2014. It was prepared by Technical Committee CPI/113, *Hydrometry*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7898:1997, which is withdrawn.

Use of this document

This British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

The word “should” is used to express recommendations of this standard. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Water management decisions and policies ought to be based upon quantitative knowledge of the hydrological system. Commonly, such knowledge results from observational hydrometric data, the collection of which is the subject of other standards, e.g. BS 7843 and BS EN ISO 18365. The subsequent management of such hydrometric data provides the linkage between field measurement and the eventual use of processed data to address a wide range of strategic and operational river and water management applications. As both the demand for and complexity of hydrometric data increase, it is important that the procedures and processes used to manage these data are standardized to allow greater intergration of data and ensure their protection for future use.

The availability of high-quality observational data is vital to developing an understanding of the hydrological cycle. Optimizing data management systems helps ensure that the maximum benefits are achieved from those resources invested in hydrometric monitoring. Effective standardized procedures for data transmission, manipulation, quality control, expression of uncertainty and storage are vitally important and their use is to be promoted throughout hydrometric observation networks.

Those responsible for hydrometric data management are encouraged by this code of practice to adopt the ethos of a professional stewardship and to remember their role as guardians of an important national, and sometimes international, resource.

This code of practice is concerned with general aspects of good practice in data management. Techniques for managing data are recommended, covering metadata collection, data storage and quality control. This standard assumes that the raw data have been collected and transmitted from the field in line with other British Standards for hydrometry, so this standard concentrates on the subsequent processing and management of these hydrometric data.

1 Scope

This British Standard gives recommendations for the management of observed hydrometric data, including raw data and other data and statistics derived from these observations. While the principles of data management can be applied to all hydrometric observations, particular focus is placed on measurements of precipitation, water level (including stage) and discharge in open channels.

NOTE The range of sites where water levels, and sometimes flow, are measured includes lakes, reservoirs, rivers, canals, tidal waters, sewers, wells, and boreholes.

There are other data (for example, evaporation, soil moisture and snow depths) that are embraced by the term “hydrometry”, as defined in this British Standard, and there are yet others (for example, water temperature, pH, atmospheric pressure) that are peripheral. These are not discussed explicitly but it is intended that the same general principles be applied to the management of all such data.

The standard covers metadata associated with hydrometric data, including recommendations for the production and management of descriptive, analytical and statistical material relating to sites where hydrometric data are collected. The recommendations of this standard can be applied to some forms of data directly derived from observational records (for example, summary time series of monthly mean river flows), but are not designed for the management of data resulting from more complex numerical models or spatially aggregated datasets (for example, remotely-sensed data).

This standard does not cover the field collection of data or its transmission, but focuses on the management of data once they have been received in a hydrometric information management system.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7843 (all parts), *Acquisition and management of meteorological precipitation data from a gauge network*

BS EN ISO 772, *Hydrometry – Vocabulary and symbols*

BS EN ISO 18365, *Hydrometry – Selection, establishment and operation of a gauging station*

BS ISO 1100-2, *Measurement of liquid flow in open channels – Part 2: Determination of the stage-discharge relation*

BS ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS EN ISO 772 and the following apply.

3.1 data flag

indicator relating to the quality and characteristics of an observation

3.2 derived data

information calculated, or deduced, from raw data (3.5)

3.3 precipitation

water or ice derived from the atmosphere and deposited at ground level

NOTE Measured in terms of the depth in millimetres (mm) of its liquid equivalent.

3.4 quality control

process of confirming that the data held are a reliable representation of the variable being measured or derived

3.5 raw data

data resulting directly from the measurement of variables

3.6 UTC

Coordinated Universal Time

4 Principles of hydrometric data management

4.1 The requirement for data management

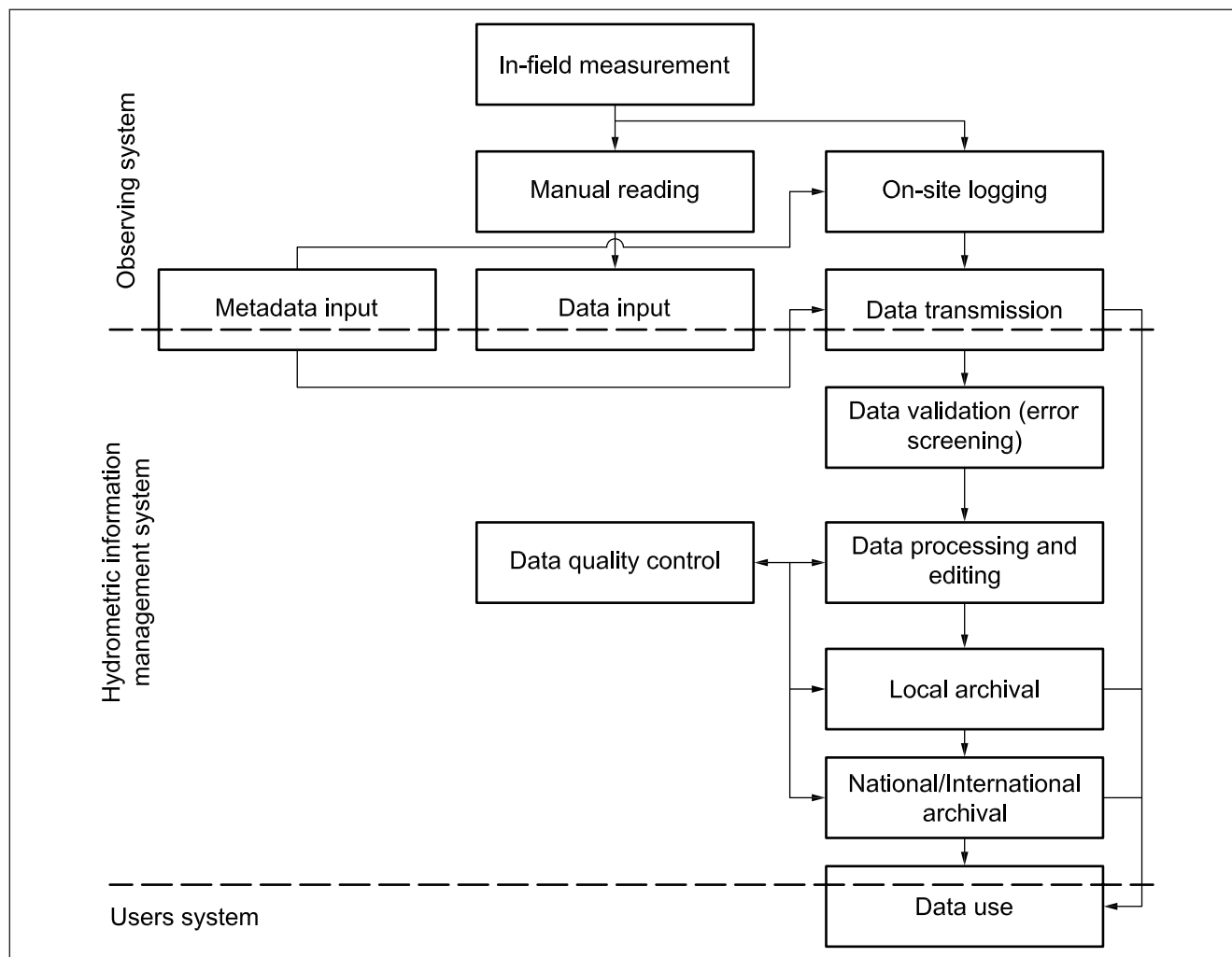
Hydrometric data management systems should be designed such that the utility of data to end-users at all levels is a central consideration. The value of data can be significantly affected by the treatment of data after collection, so data management systems should be designed to maximize the quality and continuity of records.

As water management decisions and policies are based upon quantitative knowledge of the hydrological system both now and in the past, the protection of data for future use should be a central requirement of any data management systems. As such, the design of such systems should consider, as far as possible, both current and future user requirements.

4.2 The sequence of data management

The management of hydrometric data is a continuous sequence (See Figure 1), which starts in the field at the point of collection and ends if and when data are destroyed. The design of any hydrometric data management system should consider all stages in this sequence.

Figure 1 Data management sequence



The management of data at the point of collection and their subsequent transmission vary depending on the hydrological variable being recorded, hydrometric methods employed and instrumentation used. Any data management systems used should ensure that adequate data and metadata are recorded at the point of collection to allow future management and use.

Some data management processes, such as quality control, may occur at more than one stage in the sequence and be completed by more than one organization. In designing, operating and reviewing data management systems, all stages in the acquisition, processing and dissemination of data should be considered.

4.3 Duty of care

4.3.1 General

Data often have significant value outside the organization that collected them, and data management systems should be designed, where possible, to capture all information required for future, sometimes unforeseen, uses.

Responsibility for the operation of hydrometric monitoring systems may be transferred (for example, to another organization or other personnel), so data management systems should be capable of preserving all data and associated metadata required to inform new operators.

4.3.2 Legacy data

The duty of care to manage hydrometric data should be taken to cover any such data currently held by an organization. In addition to data collected under the direct control of the organization, the duty of care extends to data collected by predecessors and inherited.

An assessment should be made of all legacy data upon inheritance (or discovery) to determine their contents and current state. An assessment should be made of their current, and likely future, utility to the organization and other external parties. While the management (and improvement) of legacy data can be demanding, the value of the resulting information can be high.

NOTE 1 Long historical records, even those of lower hydrometric quality, can be particularly valuable in providing an indication of previous hydrological conditions and often improve the value of current data through extending record lengths.

All legacy data should be actively managed. Where possible, such data should be brought into current data management systems and managed in accordance with 4.5 to 4.10 and Clause 5 to Clause 9.

Where legacy data are not integrated into management systems for current data, they should be secured in archives maintained either by the organization which collected/inherited them or by independent bodies (for example, national archives, libraries).

Where the quality of legacy data (including inherited data) is poor, efforts should be made to improve it. Special attention should be paid to the collation and storage of metadata (both hard copy and digital) associated with data. In the case of discharge data, current meter gauging records and details of derived rating relationships are of particular value and should be maintained. Care should be taken to preserve operational catchment management information, for example, sluice gate operation, reservoir releases and resiting of raingauges, which is often vital for understanding apparent anomalies in hydrometric data.

Where data are considered "at risk" (for example, due to physical deterioration or storage in obsolete systems/formats) then consideration should be given to a programme of "data rescue" (see 4.8.7).

Due to the difficulty in assessing future, currently unknown, requirements for hydrometric data, legacy data and associated information holdings should normally be preserved even if there is no immediate requirement to use the data.

NOTE 2 Where data are deemed surplus to requirements, their archival (alongside metadata describing their lineage) is highly preferable to disposal. Recommendations for data disposal are given in 4.8.3.

4.4 Data types and terminology

For the purposes of 4.5 onward, hydrometric data should be considered to include:

- a) time series of continuous or regular observations of a hydrological variable at a point-in-space;
- b) sporadic or single point-in-time observations of a hydrological variable at a point-in-space;

- c) metadata (including, discovery metadata and temporal metadata) and other descriptive material which provide information about the measurement, hydrological conditions and/or subsequent processing of hydrometric data.

Hydrometric data should also be taken to include time series and statistics derived from these data types. Typical examples of such hydrometric data include: total monthly rainfall, mean annual flood and Q_{95} (the flow equalled or exceeded 95% of the time).

NOTE 1 For the purposes of this standard data types a) and b), as well as time series subsequently derived from such data, are considered to be time series data.

NOTE 2 Spatially aggregated data (e.g. data produced by remote sensing or areal rainfall estimates) are not covered by this standard as their nature and management often differ from those used for other hydrometric data.

4.5 Time series data

4.5.1 Time of observation

All data points in a time series should be associated with a single point-in-time or period of time (e.g. for integrations), either by:

- a) recording the start point-in-time and interval of a regular time series; or
- b) recording the point-in-time against every value in a time series.

The representation of dates and times should conform to BS ISO 8601. When storing raw data, the standard Gregorian calendar conventions should apply, both to the year (1 January to 31 December) and day (midnight to midnight). To avoid gaps or overlaps in the records caused by biannual daylight-saving time adjustments, all times should be recorded in UTC. When recording an observation made at the instant dividing one calendar day from the next, then the time should be given as 00:00:00 (i.e. the start of the new calendar day).

Raw data should be recorded against the point-in-time to which the observation was made. Therefore, instantaneous observations should be recorded against the point-in-time the measurement was taken, and accumulations (e.g. rainfall totals) should be recorded against the end point of the accumulation.

Processed data (including derived data representing integration over a set period of time, e.g. daily mean flow or monthly rainfall total) may be recorded against either the start or end of the period in question. The convention used should always be clearly specified in the metadata associated with the record or a related data dictionary.

UK convention should normally be to calculate derived data using the hydrological day/month/year. Whether using these periods or others, the convention applied should be clearly specified in the metadata associated with the record or a related data dictionary. If using hydrological days/months/years (otherwise known as water or rainfall days/months/years) the following conventions should be used when deriving data:

- 1) hydrological day = observations made in the 24-hour period starting at 09:00 UTC, recorded against the start point of the period;
- 2) hydrological month = observations made during the hydrological days of that month; and
- 3) hydrological year = observations made during the hydrological days of 01 October to 30 September, inclusive, recorded against the end year of the period.

While the UK convention [as recommended in this subclause] is to present processed daily data (for example, total daily rainfall or daily mean flow) for the hydrological day, the raw data from which these time series are produced should always be stored using the normal calendar day. For example, raw hourly rainfall total data recorded at 06:00 on 13 April would be recorded against that time in the raw data series but subsequently included in the processed daily rainfall total for 09:00 on 12 April to 09:00 on 13 April, presented against the 12 April hydrological day. As a result, to avoid confusion, when presenting hydrological data for daily (or longer) time periods the associated metadata should always clearly specify whether they relate to calendar days/months/years or hydrological days/months/years.

4.5.2 Derived data terminology

Common examples of derived data produced from raw discharge time series are daily mean flows and annual maximum flows.

For any derived data or statistics held, the data management systems should clearly describe the method of derivation in metadata associated with the dataset. There should be clear, non-ambiguous associations between all derived datasets and the raw time series data from which they are derived.

While many derived data and statistics may be generated on demand, to assist in the future understanding of data processing, the data derived at each of the important stages in the data processing (or an unambiguous method for regenerating them) should be stored, even if these are only interim data. For example, when deriving daily mean discharge from a 15-minute stage series for an open-channel gauging station, it would be useful to store both the edited stage series, the derived 15-minute discharge and the subsequent daily time series.

In cases where statistical extremes are extracted at regular intervals prior to averaging (or vice versa), care should be taken to describe the resulting item of derived data correctly. For example:

- a) maximum daily mean discharge (the maximum value of the sequence of daily mean discharges in a stated period);
- b) mean daily maximum discharge (the average value, in a stated period, of a sequence of maximum instantaneous discharges recorded daily);
- c) mean discharge (the average discharge over a stated period); and
- d) mean annual runoff (the average value of annual flow volume expressed in millimetres over the catchment area).

4.5.3 Resolution of data storage

The number of significant figures to which data are stored should reflect the resolution of the original measurement (not necessarily the instrument), for example, staff gauge readings are usually read to 1 mm or 0.001 m. In the case of raw data, the storage precision should not degrade original measurement. The recommended maximum resolution for each data type are given in 6.3, 7.1.5, 8.3 and 9.4.

4.5.4 Uncertainty

NOTE It is important that those responsible for hydrological data management systems have a good understanding of the component and overall hydrometric uncertainties pertaining to the data for which they are responsible.

ISO/IEC Guide 98-3, Guide to the expression of uncertainty in measurement (GUM), and DD CEN ISO/TS 25377, Hydrometric uncertainty guide (HUG), provide guidance on the estimation of uncertainties in hydrometric measurements and determinations.

A measurement result comprises:

- a) an estimate of the measured value; and*
- b) a statement of the uncertainty of the measurement.*

In accordance with DD CEN ISO/TS 25377 (HUG), the uncertainty of a hydrometric measurement or determination should be estimated as a combined uncertainty, calculated from the various component uncertainties. For example, the overall uncertainty in a flow determined from a stage-discharge rating should consist of the combined uncertainties in the stage measurement and the rating.

ISO/IEC Guide 98-3 (GUM) and DD CEN ISO/TS 25377 (HUG) use standard uncertainties (i.e. at the 68% confidence limit). DD CEN ISO/TS 25377 (HUG) recommends final resultant uncertainty of measurement to be expressed at the 95% confidence limit since this is normal hydrometric practice. Nevertheless, in the first instance, the standard uncertainty is estimated and this result is multiplied by the coverage factor ($k = 2$) to express the uncertainty at the 95% confidence limit. The statement of the uncertainty should specify the confidence level or number of standard uncertainties for which the uncertainty estimation has been made.

4.6 Metadata and descriptive material

The metadata and other descriptive material which provide information about the measurement and/or subsequent processing of hydrometric data are wide ranging and can take many forms. Clause 5 provides further recommendations relating to metadata, but the following principles should be observed.

Metadata should be stored permanently and organized in such a way that they can be linked to any measurement to which they relate. For example, where the information being stored relates to a specific monitoring site this should be associated with the site's unique identification code in a defined referencing system (see 5.2.2).

Where information relates to a specific time (or time period) this should be clearly recorded alongside the information. For example, the period of applicability of a particular stage-discharge relation should be stored along with the definition of the relation.

Each piece of information should have a record of the name/affiliation of the author and date of preparation. The same information should be recorded for any subsequent changes to information.

Processes should be in place to ensure that metadata records are updated.

4.7 Maximizing data utility

NOTE The recommendations of this subclause are intended to ensure that hydrometric data management systems are designed and operated to maximize the utility of data both now and in the future.

4.7.1 Availability of metadata

All hydrometric data should be associated with descriptive metadata detailing their origin and subsequent processing. Such information should be made available to data users.

4.7.2 Data quality control

Hydrometric data should be subject to defined quality control procedures to ensure that they are fit for purpose. Quality control procedures should cover the assessment and subsequent alteration of data. Quality control normally involves editing and applying quality flags and comments to improve the quality and utility of the data, and should be undertaken to:

- a) minimize instrument errors;
- b) minimize processing errors and human errors; and
- c) ensure the data and their derivatives are plausible.

Any changes to data should be made in accordance with **4.8.2**.

NOTE 1 Where more than one organization is involved in processing data, it is essential that responsibilities for the quality control and changing of data are clearly agreed by the organizations concerned.

Quality control procedures for hydrometric data should be defined according to the following four levels, with the choice of quality control level ranging from 1 (no quality control) to 4 (extended quality control) reflecting the importance of the data to anticipated users.

- Level 1: No quality control.
- Level 2: Primary quality control.
- Level 3: Secondary quality control.
- Level 4: Extended quality control.

NOTE 2 Quality control procedures may incorporate more than one level of checks according to a predefined schedule. For example, a site may receive Level 2 checks every week, Level 3 checks every month and Level 4 checks every year.

NOTE 3 The techniques for quality control of hydrometric data vary according to the parameter being observed and further recommendations for what each level of quality control should involve are given in Clause 6 to Clause 9.

4.7.3 Data gap infilling

Gaps in time series data can severely damage the utility of records and should be minimized. Where appropriate, estimates of missing data should be made and these estimates included in the processed dataset. Data infilling should be done at the appropriate time step.

NOTE Guidance on methods for data infilling can be found in 7.2.4 and 8.5.3.

Estimated data should always be clearly flagged as such (see **5.5.3**) and should be associated with metadata describing how the estimate was made, by whom and when.

4.7.4 Regular data reviews

Regular reviews of all data currently collected or stored (including legacy data) should be carried out to assess the degree to which the data management system and procedures are meeting the identified user requirements and to identify any necessary improvements.

Regular reviews of individual time series should be carried out to identify and address issues such as: recurring problems encountered during validation, associating apparent changes in data with physical changes at a site/in the observation methodology, the implications of site maintenance, and ensuring metadata are complete and up-to-date.

4.8 Data storage considerations

4.8.1 Data storage

In order that reviews and investigations into past hydrological events can be properly conducted and allow a full understanding of historical monitoring, all raw observed data should be permanently stored. These may be in hard copy format or digital form, depending on the original observation method (see 4.8.5).

Erroneous data should be stored but flagged as such to prevent its future misuse. However, any data judged to be entirely unrepresentative of the measured variable (for example, as a result of known severe system problems) may be discarded.

Data and statistics derived from raw data may be stored or computed on demand in accordance with 4.5.2.

4.8.2 Changes to data

In accordance with 4.8.1, raw data should never be destroyed or amended. To preserve raw data, any changes or corrections to original data should be made within a parallel data series and should be flagged, recorded and described in metadata associated to the altered data point(s). If changes are applied to a whole record (for example, datum shift) this should be recorded in the metadata for the dataset.

Where changes are made to any data, a record should be kept of the change along with details of who it was made by and when.

4.8.3 Data disposal

Data archival (alongside metadata describing their lineage) is highly preferable to disposal. Where data disposal is proposed or data are at risk, other potentially interested parties should be identified and contacted to determine whether data could be transferred elsewhere.

If any data are disposed of, records of what was destroyed, when and why should be kept.

4.8.4 Electronic data storage system considerations

Electronic data can be stored in a range of different digital storage systems, from flat files to dedicated relational databases. When choosing a data storage system consideration should be given to security, ease of maintenance, costs, accessibility, possible future expansion, and ability to store metadata and other associated data/information.

Where possible, data storage systems should not be reliant on particular software. The data should be held in a format which can be easily accessed and transferred into a new system if software being used to manage it becomes obsolete or unavailable.

All data storage systems used should have the ability to contain both the hydrometric data and the associated metadata (including data flags).

A catalogue of the current contents of any database or file system should be maintained.

Where possible, a record of changes to the data storage system should be maintained detailing what changes were made, by whom and when.

4.8.5 Tapes, charts and other data in paper format

Some raw data, especially historical records, can exist in the form of paper charts or tapes. Such data should be digitized to maximize their utility before they become unreadable due to physical deterioration or inaccessible due to lack of equipment to read the data format. Where the original format contains key information not captured during the digitizing/scanning process, the originals should be stored in a secure and catalogued fashion.

4.8.6 Data security

Data management systems should include backup and data recovery systems appropriate to the importance of the data being stored.

Processes should be put in place to ensure that the risk of the loss or corruption of data held in the data storage system is kept to an absolute minimum. Actions that should be taken include:

- a) ensuring that the data management system and the computer system on which it resides meet up-to-date security standards;
- b) ensuring the computer system is designed in such a way as to minimize the risk of infection by viruses and other malicious software;
- c) ensuring those given write permissions to the data storage system are fully aware of the risks of corruption and the number of people with write access is kept to a minimum consistent with efficient operations;
- d) undertaking regular monitoring of the pattern of changes to the data held in the system;
- e) making regular backups of the system;
- f) maintaining off-site backups, which may include archives for local use;
- g) regularly reviewing the effectiveness of security procedures; and
- h) where data are stored using systems or media which are at risk of becoming obsolete, transferring to a more secure storage system should be prioritized (see 4.8.7).

4.8.7 Data rescue

A process of data rescue to improve data storage conditions (see 4.8.5) should be considered where data are at risk of being lost due to deterioration of records (for example, by damage to the medium), or there is a high risk of catastrophic loss (due, for example, to storage media becoming unreadable, obsolete electronic file formats or loss of knowledge about records leading to unintentional destruction). A full inventory of the data holding (including measured values and metadata) should be made to identify the contents and current state of the data. Where data at risk of loss are not to be rescued the recommendations of 4.8.3 should be followed.

4.9 Archiving hydrometric data: national collations

NOTE 1 For the purposes of this standard, the archival of data refers to their long-term storage for future use.

Permanent national archives of precipitation, river discharge and groundwater level data for the UK should be maintained. Some network operators may maintain a regional or local archive which contributes data to the national archives.

The national archives should:

- a) include current and historical measurements from as many appropriate sites as possible;
- b) provide a complete set of associated metadata;
- c) provide assurance of the quality of the measurements, including data flags; and
- d) provide ease of access to the data.

A procedure should be undertaken at regular intervals to determine which monitoring sites contribute to the national archives. The national archives should contain data relating to all sites that make, or have in the past made, regular measurements of the variable. Sites may be excluded from the archives if:

- 1) the data are considered to be of unacceptable quality (e.g. due to poor observing standards); or
- 2) the owner of the intellectual property does not allow general use of the data.

All operators of precipitation, river discharge and groundwater level monitoring sites should consider contributing the resulting data to the national archives.

The archive of current data should be in electronic format, with additional paper records where full digitization and quality control have not been completed.

To ensure the national archives remain up to date, data should be transferred as soon as they have been validated by the collecting organization and then updated when data are changed. Appropriate metadata should be transferred and stored alongside time series.

Efforts should be made to ensure appropriate data consistency between national archives and regional/local archives where they exist.

NOTE 2 The data in the national rainfall archive are designated as permanent, as defined by the Public Records Act 1958 [1]. The Act specifies approved places of deposit for historical paper records.

NOTE 3 All precipitation data in the national archive since 1961 are in electronic format. Many older records, some dating back to the 19th century, are only available in manuscript format. However, a complete electronic record exists for selected long-period stations.

4.10 Electronic transfer of data

Electronic hydrometric data, including metadata (see 5.2.1), should be transferred in a text-based format. The key metadata outlined in Clause 5 should always be included in the data format.

Where possible, transfer of data in proprietary formats should be avoided. While other data formats may be used when transferring data from one machine/data system to another, preference should be given to exchanging hydrological data in an electronic data format currently specified by an ISO, World Meteorological Organization (WMO) or Open Geospatial Consortium (OGC) standard.

The most appropriate internationally agreed format is for data to be made available for transfer in the latest OGC-approved XML format for in situ hydrological time series. Currently, this is the *WaterML2.0 Part 1: Time Series Encoding Standard* produced jointly by OGC and WMO [2]. Related WaterML standards should be used for other types of hydrological data where these are available (for example, using the ratings and gauging standard currently under development).