

Guide to the acquisition and management of meteorological precipitation data —

Part 1: Network design —

Section 1.2 Network design and monitoring

Confirmed
October 2008

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee CPL/113, Flow measurement of surface and ground water, upon which the following bodies were represented:

- British Waterways Board
- Clyde River Purification Board
- Department of the Environment
- Institute of Measurement and Control
- Institution of Civil Engineers
- Institution of Water and Environmental Management
- National Rivers Authority
- Water Services Association of England and Wales

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Forth River Purification Board
- Imperial College, London
- Institute of Hydrology
- Meteorological Office

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Foreword

This Section of BS 7843 has been prepared by Technical Committee CPL/113. BS 7843 is a new publication and no other standard has been superseded or withdrawn.

This Section is one of a series of related publications on the acquisition and management of meteorological precipitation data, of which the overall structure is as follows:

- *Part 1: Network design;*
- *Section 1.1: The user requirement for precipitation data;*
- *Section 1.2: Network design and monitoring;*
- *Part 2: Field practices and data management;*
- *Section 2.1: Technical aspects in the field;*
- *Section 2.2: Methods of observation and data tabulation;*
- *Section 2.3: Data management;*
- *Section 2.4: Areal rainfall.*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

BS 7843 provides guidance on procedures for the measurement of meteorological precipitation, and for the collection, quality control, archiving and exchange of the data obtained from the measurement.

Part 1 describes the users' criteria, and the design of rain gauge networks to enable the desired data to be obtained.

Part 2 gives guidance on practical aspects of field work for the acquisition of the data, and for the subsequent transmission, quality control and archiving of the data obtained.

This Section of BS 7843 advises on techniques which may be used to design the minimum network to meet the required resolution and accuracy for a range of applications. Advice is also given upon the implementation of networks and the monitoring of their overall performance.

This Section of BS 7843 does not consider radar networks and techniques beyond looking at their interaction with gauge networks and their effect upon the accuracy of interpolated totals from such networks.

2 Normative references

This Section of BS 7843 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Section of BS 7843 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

3 Definitions

For the purposes of this British Standard, the definitions given in BS 7843-1.1 apply.

4 Techniques for designing networks

4.1 General principles of design

A broad general understanding of the meteorological and topographical factors influencing the volume, variability, spatial and temporal distribution of precipitation has been developed over the past century. However, this has not yet developed far enough to allow accurate prediction of precipitation or to make possible a purely theoretical design of a sampling network for any area. Network design is still therefore an essentially empirical process with the design evolving as knowledge of the distribution in the area of interest increases. For most parts of the world sufficient information has now been obtained for some of the initial iterations of this process to be by-passed.

In the United Kingdom the national and regional networks which have been built up over the 19th and 20th centuries have resulted in a large body of information being available to the designer. This varies considerably throughout the country, however, since the national network density tends to reflect the population density. Thus, for example, much less information is available for the high rainfall, high altitude areas of the western Scottish Highlands than for the eastern English lowlands. In the former areas the network designer will have to start at an earlier stage of design evolution than in the latter and has much less chance of adapting the existing network to meet the design objectives.

Against this general background it is recommended that the network designer follows the following procedure which is amplified in the remainder of this Section.

- a) Obtain a clear statement of the objectives of the network and the resources available.
- b) Assemble and assimilate all available information on precipitation, present and former networks, quality or radar coverage, meteorology, climatology, topography, land use, population distribution and communications.

- c) Determine by analysis of these data whether the objectives can be attained by some modification of existing networks, the adaptive approach, or whether a new approach is required.
- d) If areal averages are of prime interest, consult BS 7843-2.4 at this stage to determine the method of computation most appropriate to the area and the objectives. The choice of method will influence the distribution of gauges within the network.
- e) Decide whether to incorporate radar data in the design.
- f) Proceed with the detailed development of the design which needs to include specifications for the locations of gauge, the type, volume and intensity of precipitation to be expected at each location and the frequency of sampling and of data transmission required to meet the design requirements.
- g) Document all stages of the design development for future reference.

The application of these general principles for designing networks to accommodate different time scales, different spatial scales and different types of terrain is described in 4.2 to 4.6. Procedures for implementing the design and for establishing that the network performs according to design are given in clause 5. Assessment during the period of its operation of the extent to which the network achieves the design objectives is considered in 6.3.

4.2 Objectives of the network

A broad range of needs for precipitation data are described in clause 4 of BS 7843-1.1:1996, together with a general analysis of their implications for network density. These useful general guidelines need to be confirmed in detail when a data requirement for a specific area arises. This assessment may lead to a request for the design of a new network for the area. Such a request should state precisely what is required and identify the resources available to implement it.

This statement of objectives should encompass the following aspects.

- a) The data requirement. This includes the area to be covered, the duration of the project, the point and/or areal precision required, the data time interval, the reporting frequency and method(s), the quality control standards to be applied and the database requirements to be met.
- b) Constraints. These include the time scales for design, implementation and approval, any variations in gauge density or precision required within the area and an indication of the budgetary constraints.

c) Access limitations. Any known restrictions on access or siting of gauges should be identified at this stage.

d) Operational framework. An outline of the procedures to be followed in monitoring, reporting and reviewing the network and in decommissioning or adaptation.

When the objectives have been clearly documented and accepted the designer can proceed with the next steps of the sequence outlined in 4.1 b) to 4.1 g).

4.3 Assessment of existing information

The next stage in the process is to assemble and digest all available information on precipitation and gauges in the area and on the factors influencing volume and spatial and temporal distribution of the precipitation.

Rainfall maps and topographical maps give a preliminary indication of these variables. Previous analyses carried out for the area can be identified from a literature survey. Details of all registered gauges in the area and the data from these can be obtained from the national or regional network operators. Other possible sources of information should also be investigated. Local authorities, educational establishments, research organizations and private companies may operate or hold data from gauges or networks that are not included in the regional network. Data from such sources should be treated with caution until it is established whether the gauges and operating procedures conform to the national network standards outlined in Sections 2.1 and 2.2 of BS 7843.

In anticipation of any need to site new gauges, information on climate, land use, population distribution, communications and any major development proposals (urbanization, afforestation, reservoir building, etc.) should also be acquired.

The methods of assessing the assembled information will depend to some extent on the objectives. The general aim however is to use the available data to determine whether the objectives can be met by the use of all or part of the existing network, by some adaptation or enhancement of it or whether it is necessary to develop a new network.

4.4 Choice of approach

It is not possible to give detailed guidance on approaches and design techniques to cover every possible combination of network objective, time scale, area and terrain type. In this Section therefore, the following questions are used to provide guidance on the procedure to be adopted in determining whether to adapt or enhance any existing network or to produce a new design.

- Does the existing network meet the relevant quantitative density or coverage requirements?
- Given the topography of the area, does the network represent or sample adequately the range of domains needed?
- Is the urban area sufficiently well represented in terms of the original objectives?
- Is there adequate representation of each catchment that is of significant importance to the user?
- Are there significant gaps between gauges which would prevent an adequate assessment of point or areal precipitation?
- Are the existing gauges capable of producing data appropriate to the objectives?
- Given the topography, will radar data contribute significantly to the accuracy of estimation of areal precipitation?

4.5 Designing the network

The practice of network design is evolutionary in form. It calls on all the principles, objectives and information discussed in 4.1 to 4.3 and, by a process of iteration, combines these into a two-way design procedure. The main considerations in determining which route is followed have been listed in 4.4.

A summary of the key features from 4.1 to 4.3 is given in Figure 1. These preliminary studies result in the production of a data specification which sets out the criteria which the network is designed to meet.

The entire process from the initial definition of objectives to maintenance of the operational network is presented as an eight-stage procedural guide in Figure 2. This shows the sequence involved in designing the network, including the key stages 3 to 6 where it is decided either to modify any pre-existing raingauge network or to design a new network. The choice between the two approaches to raingauge network design is illustrated in Figure 3 to Figure 8.

4.6 Testing of the existing network

Testing of the existing network shows whether it is adequate to meet the data specification. Testing relates to the locations of existing gauges, to the types of gauges already in use and to the methods used to collect the data. Procedures to complete these tests are illustrated in Figure 3, Figure 4 and Figure 5.

The existing network is tested for gauge location parameters as shown in Figure 3. This determines whether it may be adapted or whether a new network needs to be designed. In the latter case, Figure 3 indicates key design parameters which should be defined as part of the testing process.

Even when gauge locations are suitable for the study objective, the types of gauge in use may need to be changed (or supplemented) to meet the data specification. The types of gauges are tested as shown in Figure 4 against the data specification. A fuller description of this process is shown in Figure 5 which also includes the need to test the adequacy of the data capture and handling procedure.

The outcome of this stage of the process indicates any need to modify gauge type or the existing method of data capture.

4.7 Areal estimation

Stage 4 of the procedural guide (see Figure 2) allows for the effect of any specific method for calculating areal estimates, e.g. over catchments. These methods are summarized in BS 7843-2.4 and may indicate specific point rainfall accuracy targets. If this is so, iterate as shown in Figure 5, entering at points 3, 4 or 5 as appropriate, and complete the process as described in 4.6.

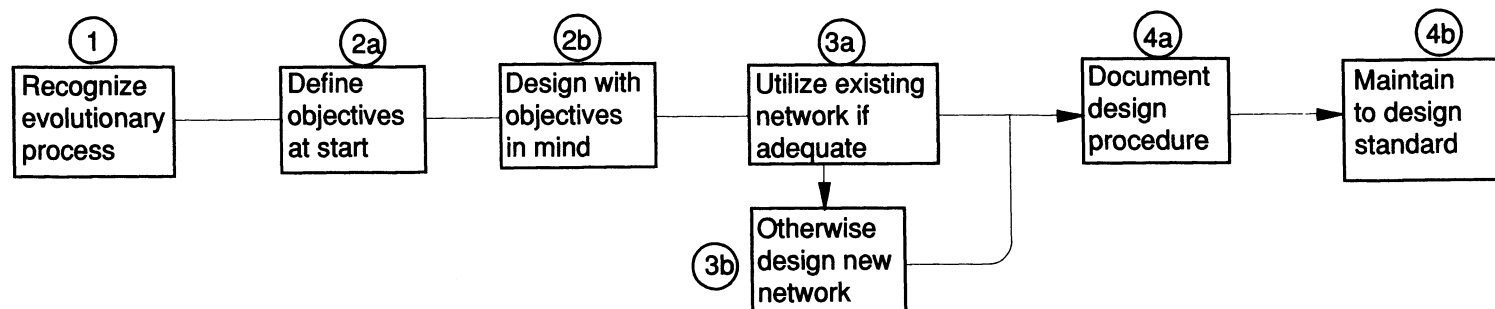
A fuller treatment of the effect of gauge distribution on the adequacy of the point/areal relationship is illustrated in Figure 6. This also allows for the influence of radar data availability on raingauge network decisions relating to areal estimates. The outcome shows whether existing or new networks are to be recommended. If a detailed investigation of areal rainfall is warranted, the procedure illustrated in Figure 7 is advised.

4.8 General points on adapting existing networks

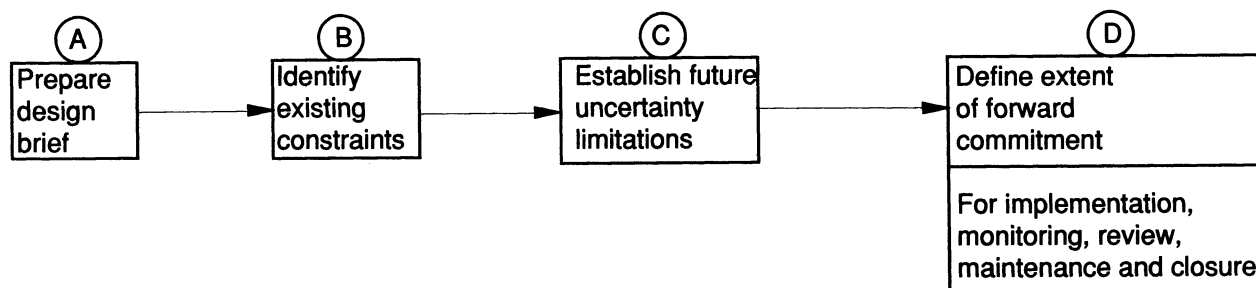
Two outstanding topics remain to be considered. These relate to data availability and to the presence of evidence to show systematic rainfall distribution. Figure 8 shows an option to bypass these items if they are not relevant. Otherwise, either can be sufficiently important to need a complete redesign.

NOTE Data availability relates to the timeliness of data arrival rather than to the temporal characteristics of the data itself. See BS 7843-2.3.

Network design principles



Establishment of network design objectives



Assessment of existing information

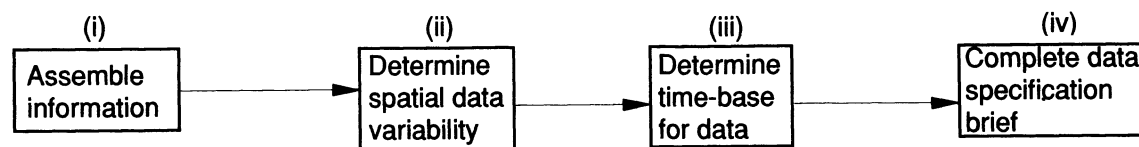


Figure 1 — Network design principles