3.1 Gauging Stations at Surface Water Bodies

Bodies of surface water such as rivers, canals and lakes are a major part of Central European landscapes and cultivated areas. They perform elementary functions in the natural and the human-influenced hydrologic balance and nature system. Watercourses particularly are used in a variety of manners: water supply, waste water disposal, shipping, energy production, fishing, sport and recreation. The flow-rate of watercourses is subject to considerable temporal and spatial fluctuations. So it is always important when planning water management to be able to determine both the volume and the temporal variability of the water. Knowledge of water levels and run-off is also essential when it comes to forecasting floods and providing flood protection. Thus, these factors are of direct significance for the population and enterprises, which are often located very close to water.

The water-levels at surface water bodies are measured using gauges. The most important part of such a gauge is the staff gauge, which consists of a staff and water-post reference points. The gauge can be supplemented by registering, value statement and data transfer devices. The gauge is also used to measure discharge, i.e. the volume of water that flows through a defined cross-section per unit of time. If the value of the discharge is calculated in relation to the catchment area belonging to the cross-section, it is referred to as run-off. Discharge measurements at different water levels are used to calculate water level/discharge ratios. This means that (when the water is running freely) a gauge can be used to calculate the volume of run-off for any water level.

The network of gauging stations at surface water bodies in Germany presently consists of more than 4000 hydrographic gauges (Table 1). On the average, each gauging station thus has a catchment area of 100 km². Figure 2 shows the actual distribution of selected gauging stations that are still in use, in relation to their catchment areas. Figure 3 shows how the number of these gauges has increased over the course of time. For the map and the table referring to it, gauging stations of considerable national hydrographic significance were selected from the hydrographic observation stations.

Water-level measurement – past and present

As early as the end of the Middle Ages extreme floods were already being recorded in the chronicles. Flood marks on important buildings show us the highest water levels reached. The first regular water-level measurements in Germany were carried out at the beginning of the 18th century. In 1727 the first water-level measurements using staff gauges were taken on the Elbe near Magdeburg. These were later followed by regular observations of the water levels at Barby/Elbe (1753), Düsseldorf/Rhine (1766), Cologne/Rhine (1770), Stettin/Odra (1771), Meißen/Elbe (1775), Dresden/Elbe (1776), Küstrin/Odra (1778) and Hamburg/Elbe (1786). Significant progress was also made in the field of run-off measurement in rivers in the 18th century. In the beginning, swimmers, water wheels, hydrometric pendulums or balances were used. The beginning of the 20th century saw extensive use of the Woltmann's hydrometric propeller for discharge measurement. Systematic flow speed measurements to determine run-off were introduced in the Upper Rhine region, for example, in the year 1809.

Fig. 1 Gauging station, 1887

In 1810 the first standardised regulations on the operation of gauging stations were issued, in the form of the "Prussian Gauging Station Instruction". From the middle of the century, the number of observation stations at surface water bodies increased considerably as water management gained in significance. Hydrographic offices were set up in order to establish a secure basis for rational handling of water management issues by means of systematic hydrometric and hydrographic research. Even back then the focus was on the construction and operation of gauges and, equally as important, the recording of statistics of relevance to water management (e.g. Baden 1883, Württemberg 1888, Bavaria 1898, Prussia 1902).

In Germany the national and Federal State offices now have their own networks of observation stations, enabling them to fulfil the various national and international tasks (Table 1). The Länderarbeitsgemeinschaft Wasser (LAWA, Working Group of the Federal States on water issues) is responsible for any coordination necessary. In cooperation with the Wasser- und Schiffahrtsverwaltung (Federal Waterways and Shipping Administration), LAWA draws up and issues rules, such as the gauge regulation, which stipulates how gauges at surface water bodies must be set up, operated and maintained. It also specifies how the gauge measurements are to be evaluated. This ensures that the results can be compared with one another and can be used as a basis for environmental observation and scientific, water management, hydraulic engineering and transport purposes.

In the field of hydrological balance and water management, the federal government is only authorised to issue framework legislation. The administrative enforcement of all regulations concerning water, the exercising of governmental powers in the field of water management, hydrography, flood protection and monitoring of water quality are the responsibility of the Federal States. The expansion and maintenance of the national waterways are regulated and managed by the Federal Waterways and Shipping Administration. These waterways cover around 7300 kilometres of canals and navigable rivers, on which safe and easy shipping must be ensured. The water management offices of the individual Federal States are organised differently.
The Federal States and the national government divide up their networks of observation stations in line with the respective requirements. This means that the gauging station networks are sub-divided into a national network, regional network and special network.

Table 1 Hydrographic gauging stations in Germany (as at 1995)

Federal State	number of gauges Federal State	National
Baden-Württemberg	327	28
Bavaria	686	70
Berlin	58	6
Brandenburg	491	68
Bremen	-	9
Hamburg	89	-
Hesse	155	28
Mecklenburg-Western Pomerania	221	55
Lower Saxony	227	122
North Rhine-Westphalia	401	23
Rhineland-Palatinate	155	53
Saarland	38	10
Saxony	260	9
Saxony-Anhalt	158	31
Schleswig-Holstein	240	49
Thuringia	171	-
Germany as a whole	**4241**	

Map Structures

Map 3.1 shows a selection of the gauging stations at surface water bodies in Germany. Of the > 4000 registered gauges, 857 were chosen for the map on the basis of the criteria listed below. The mode of operation and duration of operation/measurement period of each of the gauges shown are different.

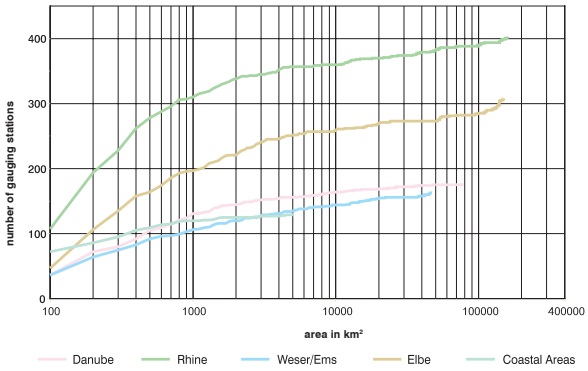

Fig. 2 **Number of gauging stations in relation to the catchment area per gauge** (only includes gauging stations that are of considerable national hydrographic significance and are 1998 still in operation)

The gauging station locations for the map were selected in accordance with the following criteria:

- the thinned-out network of observation stations is intended to provide a representative presentation of the hydrometric factors in the area;
- only gauges of considerable national significance in terms of hydrography or water management should be included;
- the period of observation (standard period 1961-1990) and the quality of the data (series of observation data on run-off) must correspond to the basic specifications for the atlas.

The representation of the observation stations complies with DIN 2425 (Section 5). It shows the technical standard of the gauges in 1996/97. No differentiation of the "water level recorders without discharge calculation", which are primarily situated in the tidal influence areas of coastal regions, has been carried out. The technical standard illustrated on the map may only be considered to reflect the situation at a certain time. Digital data collection and transfer devices are currently being installed in many observation stations in order to upgrade them to the latest technical standard so that the gauge data can be provided immediately after measurement. The names of all of the stations shown are given. Those names printed in italics indicate that the available observation period for that gauge does not cover the entire timeframe from 1961 to 1990. The coloured background of the map shows which stream or coast catchment area the gauge belongs to.

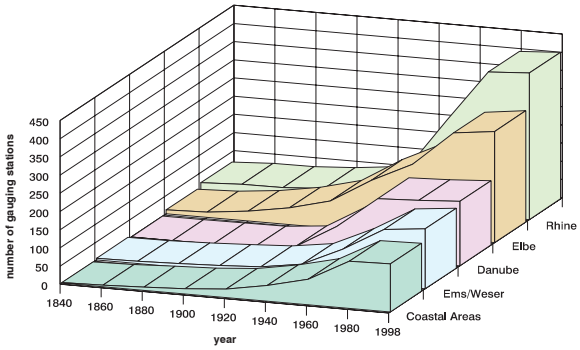

Fig. 3 **Development of the number of gauging stations in the catchment areas** (only includes gauging stations that are of considerable national hydrographic significance and are 1998 still in operation)

The tabular overview on the following pages shows some key data taken from the gauges selected. The gauges listed in the table are assigned to the corresponding stream catchment areas by means of the colours of the text blocks and are ordered alphabetically (by area). Their colours correspond to those on Map 3.1.

Practical Information

The most important source of information with regard to gauge data in Germany is the Deutsches Gewässerkundliches Jahrbuch (DGJ, German Hydrographic Yearbook), which is published by the Federal States' hydrographic offices in collaboration with the Bundesanstalt für Gewässerkunde (BfG, Federal Institute of Hydrology). This shows, in individual volumes, the most important data for selected gauges and, in standardised images, water-level and run-off values. Up until 1989 the DGJ was based on the hydrological year, which runs from 1st November of the previous year to 31st October. However, since then the DGJ has supplied the data for a 14-month period, thus covering both the hydrological and the calendar year. A further source of hydrological statistics is a yearbook that was published for the Federal Republic of Germany from 1965 to 1974 as part of the International Hydrological Decade. Since 1975 it has been published as the IHP Yearbook (Yearbook of UNESCO's International Hydrological Programme). In order to ensure that international comparisons can be made, this publication is based on the calendar year.

In addition, the Federal State ministries responsible usually publish gauge directories with maps with a scale of 1 : 200,000 to 1 : 500,000. Gauge data that is not published in the DGJ is available from the relevant Federal State offices.

As well as atlas Map 3.1 there is a digital version of the map, which is available on the Internet as a graphic-interactive application. The vector-based presentation of the digital map of the Hydrological Atlas (DigHAD) enables more information to be provided than is possible with an analogue map, for reasons of scale. This information also includes all current gauges specified in the DGJ. The "gauging station" map objects are linked to a database that contains selected information from the gauges' data sheets and selected key values concerning water level and run-off, including information on the gauge operators and the bodies responsible for recording the data. In addition, information on the catchment areas and sections of the catchment areas of the bodies of water can be retrieved. Finally, the content of the digital version is updated once a year.