7.4 Flood Protection

According to DIN 4049, flooding refers to a state in surface waters, when the water level or discharge has reached or exceeded a given threshold value. Depending on the level reached and the degree of adaptation to (potential) flooding, floods can have dire consequences for populations living by the water, and for the economy and infrastructure on hand. Floods are mostly triggered by storm precipitation or unremitting rainfall – often in conjunction with snowmelt. Flooding caused by the break-up of ice jams in rivers or by bursting barrages or reservoir dams is very rare.

There have always been disastrous floods. Humans have, however, influenced and, through their actions – such as embanking rivers, river training, sealing over land, deforestation, and others – aggravated the flooding situation to a certain extent. The effects are felt differently on differing scales. For example, land-sealing measures have more of an effect on regional scale, but play only a subordinate role in a large catchment area. A consequence of river training is the shortening of propagation time. When a flood wave of a tributary at a confluent simultaneously meets the flood wave of the main river – then faster propagated due to river training – this can lead to an increase of the peak flood level in the range of decimeters.

Due to the growing densities of settlement and commercial uses in former natural inundation zones, the potential for damage caused by flooding is continuing to escalate. During the 1993 so-called "Christmas Flood" (Fig. 1) in the Rhine catchment area, the damage on German territory alone was estimated at 0.7 billion euros. Across Europe this flood episode in 1993 claimed 10 lives. In July 1997 the Odra flood caused a damage on German territory (Federal State Brandenburg) of approximately 0.65 billion euros. The floods in the Elbe and Danube catchments in August 2002 claimed 18 lives alone in Germany and the estimated amount of damage on German territory is about 9 billion euros. In the ICPR (International Commission for the Protection of the Rhine) Atlas "Atlas on the Risks of Inundation and on Possible Damages Due to Extreme Floods of the Rhine" (IKSR 2001), substantially greater possible damage is presumed in the event of extreme floods along the various segments of the Rhine: the figures range from 38 million euros along the High Rhine, about 12 billion euros along the Upper Rhine, 1.7 billion euros along the Middle Rhine, about 20 billion euros along the Lower Rhine, and 131 billion euros in the Rhine Delta.

The exceptional flood events of the 1990s have brought the worth of flood protection to general attention. In the light of assumed anthropogenic climate changes (the "greenhouse effect") that could lead to global as well as regional changes in the frequency and intensity of flooding the issue becomes even more crucial.

Fig. 1 **"Christmas flood" 1993 at Deutsches Eck in Koblenz**

Technical flood protection measures (e. g. dikes, retention basins, and reservoirs) are expensive to build and require maintenance, so that implementation must be assessed in terms of damage potential. That is why, in addition to technical measures, protective schemes also co-ordinate measures for improving water retention in the catchment area, preventive measures for protecting applications in inundation-prone zones, and procedures to be followed in case of critically flooding. Improving water retention in the catchment area by reclaiming inundation zones, renaturing watercourses, unsealing land, by percolation or land and forestry management frequently also has a positive effect on natural equilibrium. Not declaring building zones in areas that are at risk of flooding, and applying construction methods that are adapted to floods, help avoid increased damage potential prior to flood events. When a flood comes along, flood forecasts take on a central role. The advance-warning period before a flood arrives is constantly being improved. With extremely high water levels, a timely evacuation can mean the difference between life and death for humans and animals. Here the making and drilling of flood management plans for when the event occurs (e. g. disaster plans) are also important. Efforts to inform the public make a point of boosting the general awareness of existing flood risks and of the individual responsibility to protect oneself, and to demonstrate ways of practising self-protection preventively and during flooding.

Map Structures

A general map on the topic of "Flood Protection" in Germany can reproduce only a selection of significant technical prevention and control measures. Areas of emphasis of such measures are reflected in the geographic concentration of protective structures, among other things. The map indicates a selection of such structures that primarily serve flood prevention and control in Germany. Apart from reservoirs and flood retention basins, the map shows the controlled polders along the rivers, which have been in operation since the mid-1990s and say something for an area-oriented flood management. In the zones along the larger rivers and coastal areas that are at risk from extreme flood events, selected dike systems have been mapped. The flood warning gauges and flood warning centres represented are part of the extended flood warning information service in Germany.

In former GDR the general map of the GDR on flood protection at 1 : 500 000 was prepared in the mid-1980s and produced by VEB Kartographischer Dienst (cartographic service) Potsdam under number B15/79. This map, which is based on maps to a scale of 1 : 100 000, shows, among other things, dikes, polder areas, flood drainage and retention areas, and zones protected by dikes. The map contents were largely transposed to Map 7.4 for the territory of the new Federal States.

The following, additional criteria led to the present map: reservoirs generally play a multi-functional role. They provide drinking water, act as energy production sites, furnish increased discharge during low-flow periods, supply water for industrial, etc. uses, offer places for recreation and, last but not least, serve in flood protection. The last-mentioned are among the chief functions of approx. 30 percent of Germany's more significant reservoirs (capacity > 0.3 million m^3). The number of relevant installations was restricted by the condition that only such reservoirs with a minimum capacity of 1 million m^3 should be considered. The same restriction was applied to flood retention basins. The circumstance of regional concentrations of flood protection measures is visually preserved in the map nonetheless. The pertinent total capacity of installations is distinguished by symbol size showing 5 classes of capacity.

In many areas, Topographic Map 1 : 50 000 (TK 50) provided the foundation for the river and coastal dikes recorded in former West Germany. It should be noted here that the map distinguishes only between dikes that are fit for traffic and those that are not. This also includes railway embankments and roads. The cases where constructions serve exclusively to provide flood protection, however, are not apparent from TK 50. For the entire course of the Rhine, existing winter dikes and dams could be drawn from the "Rhine Atlas: Ecology and Flood Protection" (IKSR 1998) of the International Commission for the Protection of the Rhine. The dikes for the territory of the new Federal States were taken from the GDR flood prevention and control map mentioned previously.

"Regions threatened by extreme flood events" indicate zones that may be inundated during very rare episodes of flooding. In many places such zones are protected by flood protection measures. In the coastal areas of the North Sea and Baltic Sea, these regions were derived from the highest observed water levels (HHW in German) indicated in the Hydrological Yearbook of Germany (DGJ, Deutsches Gewässerkundliches Jahrbuch). While taking into consideration the possible duration of corresponding extreme events, the resulting values (gauge datum plus the HHW value) were reduced where appropriate to a maximum level of 2.5 m above sea level. These regionally varying levels were then assigned appropriate contour lines on a map at a scale of 1 : 100 000.

For the majority of streams, inundation boundaries were used that had been calculated with numerical models for a flood event with a 50-year recurrence interval. The data on hand (see Practical Information) were reduced to the areas visible on a scale of 1 : 2 000 000. In addition, other nationally available sources were consulted to identify the areas at risk.

The boundaries of the natural inundation zones along the Rhine were taken from the ICPR Rhine Atlas referred to before (IKSR 1998). In some areas these zones are based on the water level permanencies of the 1993 and 1995 "floods of the century." Similarly to the method applied along the coasts, the heights of those water levels were projected onto the foreshore. Along other sections of the Rhine, extreme events with a recurrence interval of 200 years, plus another 1 m of water, were hypothesised and the corresponding water levels calculated.
The "dike-protected areas" of the GDR flood protection map were established based on the highest observed water level. These zones, too, were incorporated under the legend item "regions threatened by extreme flood events". These areas also include the "polder areas" as well as the "flood drainage and backwater areas" of the flood protection map that cannot be depicted throughout at a scale of 1 : 2 000 000.

According to DIN 4047, polders are lowlands that have been surrounded by embankments to protect them against inundations. Frequently the polders outside the main dikes are termed "summer polders"; these zones are protected solely by advance dikes or summer dikes. The polders shown on the map refer to areas that are used for controlled water retention (flood polders). Regardless of construction and the various flooding and drainage systems, those polders are all flexible as to the moment at which they can be flooded. This is true of both operational retention zones as well as projected ones. For clarity's sake, the designation of land use had to be limited to a few main categories (arable land, woods, grassland, and other). The other types of use consist largely of traffic and water zones. For the polders at the mouth of the Havel River, only the share of agricultural land in the total surface was retained, while woodlands were assigned to the "other" category; this explains the relative high share of this category in the overall picture.

The flood warning gauges and regional and supra-regional (or storm flood warning) services indicated are elements of the flood warning information service. The flood warning information service announces flood alerts when necessary and is treated as a component of flood protection plans by the States. It is structured differently in the individual Federal States. Figure 2 shows a highly simplified representation of the flood reporting and warning service. The inter-regional flood protection plans are co-ordinated by the Working Group of the Federal States on water issues (LAWA).

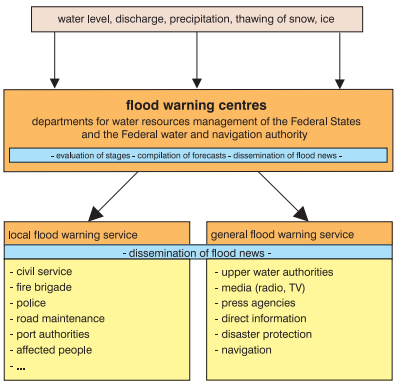

Fig. 2 **Schematic representation of flood warning information services**

Practical Information

There are various published books of maps, dating back to the turn of the century (18th/19th centuries), of the great rivers in what was then the territory of pre-war Germany. These so-called Stromwerke, or books of rivers, describe the Rhine, the Weser and the Ems, the Elbe, and the Odra. Among other things, the maps also point out the natural inundation zones of those waters. The above-mentioned inundation boundaries of the flood event with a 50-year rate of recurrence were made available by the Institut für Angewandte Wasserwirtschaft (IAWW, Institute for applied water management), Prof. Dr.-Ing. H.-B. Kleeberg, München, with the assistance of the Institut für Angewandte Wasserwirtschaft und Geoinformatik (IAWG, Institute for applied water management and geoinformatics), Dr. Willems & Prof. Dr.-Ing. Kleeberg, Ottobrunn. The data were deduced, exclusively model-assisted, for the Federation of the German Insurance Industry umbrella organisation (one-dimensional, stationary water level calculation while using digital ground/elevation models) while disregarding constructions for flood protection.

As a cross-border problem, flood issues are also examined in the International River Basin Commissions. In multi-year, interregional action programmes, solution strategies are developed in the contentious field of flood damage potential and environmental concerns. Within the public-relations work of the Commissions, these topics are appealingly presented on the whole.

Matters of regional flood protection are dealt with by the relevant offices of the water management administrations of the Federal States. Due to the upsurge, mentioned at the start, of major flooding events during the 1990s, the relevant offices usually possess enlightening information material, particularly for local problem spots. In general it may be said that much of the information represented falls within the development processes of water management policy. With that, the selected data, e. g. regarding the location of flood warning centres or the position of flood warning gauges, only reproduce a snapshot of mutating structures.