In addition to protecting developments in the flood plain from loss, any flood plain management plan must also aim to protect the natural and cultural resources of the flood plain. The protection of these resources will also help preserve the natural flood-alleviating functions of the flood plain. For example, wetlands that are left undisturbed will absorb flood waters as they did in the past. This effect can be large; it has been estimated for the upper Mississippi basin that a 1 per cent reduction in wetland area leads to a 3.7 per cent increase in flood peaks. Thus, the preservation of the flood plain resources must be explicitly included in the management plan and table 2 includes this as the fourth strategy to be used in flood plain management, together with the tools required for implementing the strategy.

The difference between structural and non-structural flood control measures has been mentioned above. Early attempts to control floods relied on structural measures. In the United States, for example, the earliest attempts to control floods, dating from the end of the eighteenth century, depended on the construction of dykes or levees along the river to prevent the flood spreading across the flood plain (the levees-only policy). Similar measures were also used in Europe during this period. From about 1930, the United States started building large flood control dams. These were frequently multi-purpose projects that controlled the river for hydropower, irrigation or navigation as well as providing storage for flood control. In subsequent decades these large projects grew in cost and also started to meet objections on environmental grounds, leading in the 1960s to a swing to non-structural measures, such as flood plain zoning and general regulation of development in the flood plain. These two approaches have

Floods Mississipi Illinois, Iowa Missouri 1993. *Black Star. J. Griesedieck*

CHAPTER 3

Flood plain management

Mississipi floods, 1993. *Black Star. G. Stewart*

Floods Mississipi - Floods St Charles & St Louis Counties Missouri 1993.
Black Star. S. Shelton

been characterized as "technological" and "ecological" or "environmental" with the implication that the previously employed structural measures were wrongly conceived and harmful to the environment. Certainly, many of the early flood control structures took little account of environmental principles and were less effective as a result. Though structural measures now enjoy less popularity, they are still valuable in reducing flood losses. For example, the United States Army Corps of Engineers, a major constructor of flood control works, has estimated that flood control structures prevented damages of US$ 11.6 billion in the Great Flood of 1993 on the Mississippi. Any balanced approach to flood plain management needs to consider a range of options, both structural and non-structural and the environmental consequences of any structures that are built.

Flood plain mapping

Before the flood plain can be effectively controlled, it is essential to know the likely extent of flooding so that the area under management can be decided. Flood plain maps are needed for this purpose. These can be prepared at different levels of sophistication from simple maps of areas flooded in the past to comprehensive maps showing the areas that would be flooded with a given probability.

The simple map of areas flooded in the past, or of the area flooded in a particular event are relatively easy to prepare after each flood. If aerial photographs can be taken during the flood, the flooded area can be delineated on a topographic map. Alternatively, surveys can be made after the flood to collect information on the extent of flooding by observing flood debris marks and interviewing local residents. These maps can be used to show the areas at risk in a manner easily understood by the public. However, they have the disadvantage that they give no indication of the likelihood of a particular area being inundated in some future event. Despite this major limitation, maps of the area flooded should be prepared after major floods, partly as a check on the accuracy of more sophisticated flood plain maps to be described below.

The most useful form of flood plain map shows the area that would be inundated with a given probability. The United States Federal Emergency Management Administration (FEMA) uses the 1 per cent or 100-year flood, that is the flood that has a 1 per cent chance of being exceeded in any year. The Canadian Flood Damage Reduction Programme also uses the same probability level. To prepare the map, the 100-year flood for the river is estimated from flow records and the propagation of this flood down the river is then modelled to give the depths that would occur over the flood plain and in the channel. This requires accurate surveys of the river channel and the flood plain. Although the flood plain is generally flat, it will have many small changes in level such as old, abandoned river channels and roads that can divert the flow and these must all be surveyed accurately, which is expensive. The maps of areas flooded during actual floods, described above, can be used to check the results of the surveys and calculations.

The need for accuracy in preparing a flood plain map has been emphasized because of the importance that the map can assume. The flood plain map will be used as the basis of flood plain management, which has as its aim the control of development on the flood plain. Any inaccuracies in the map could lead to developments being permitted that will subsequently be at risk of flooding, or preventing developments that run no risk of being flooded. In addition those stopped from developing may believe that their land on the flood plain has lost