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.

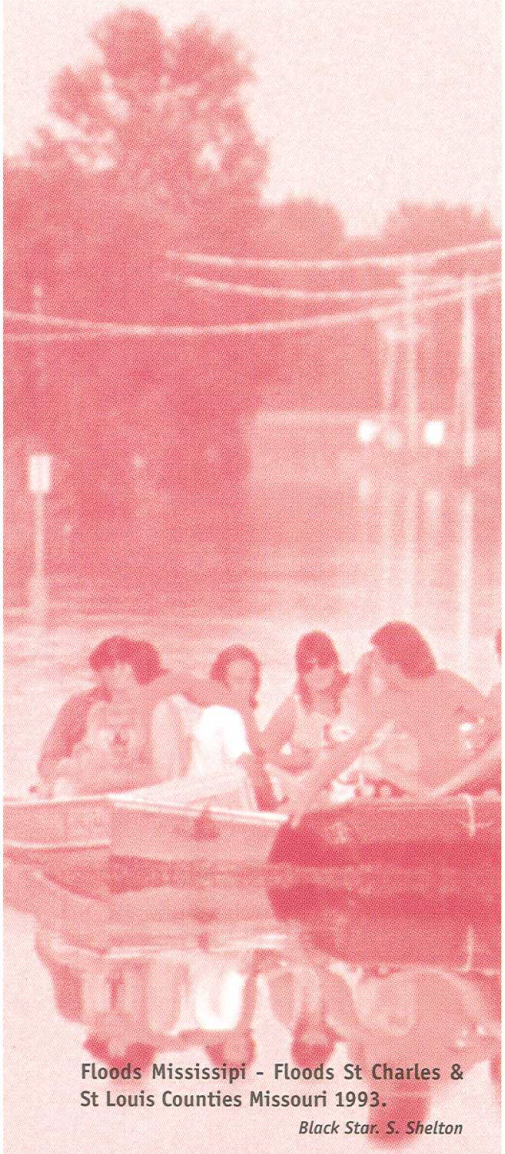
Flood plain mapping

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 clown 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



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

value and they may enter legal objections to the map or make claims for compensation. The map must be prepared carefully to ensure that it can withstand these objections. The map may also be used to decide flood insurance premiums, or to refuse insurance because of the danger of flooding. These examples serve to show that the map has considerable economic and legal importance and must be prepared bearing this importance in mind.

As well as delineating the 100-year flood, the flood plain map may show areas flooded more frequently, perhaps the 50-year or 10-year flood. A floodway is often designated; this would be the permanent river channel and the immediately adjacent flood plain that would carry most of the flood flow. Outside the floodway the water velocities would be low, contributing little to the discharge. The floodway needs to be kept clear of all development to prevent excessive backwater effects, leading to increased levels of inundation upstream, and to ensure rapid evacuation of flood water after the peak has passed.

Flood insurance

The primary purpose of flood insurance is, of course, to pay for the damage caused by flooding, but it is also often recommended as a means of promoting good use of the flood plain. Insurance premiums that correctly reflect the risk of flooding, by being based on long-term annual average damages, should provide an indication of the risk of developing in the flood plain and would deter unsuitable developments there. In practice, this rarely happens. Flood insurance premiums are usually very high as only those likely to make frequent claims consider insuring themselves against floods. This leads to one of two possibilities: the customer decides that the insurance is too expensive and does not insure his or her property or, the insurance companies decide that there will be no profit in underwriting flood damage at a premium that customers are willing to pay and decline to offer the business.

When flood insurance is not available commercially, governments may intervene to ensure that people can insure themselves against flood losses. The United States National Flood Insurance Programme was set up, in part, because of the difficulty of obtaining flood insurance. In other countries, flood insurance is provided as part of compulsory, government-provided natural disaster insurance funded by a levy on fire and buildings insurance premiums. Spain, New Zealand and France operate systems of this type.

The rest of this chapter will describe two flood plain management systems: the United States National Flood Insurance Programme, and the Canadian Flood Damage Reduction Programme.

The United States National Flood Insurance Programme

The National Flood Insurance Programme (NFIP) uses flood insurance to promote well-managed flood plains. The basic principe of the NFIP is that flood insurance should only be available in areas where certain minimum flood plain management polices have been adopted. Thus it is, in effect, a land-use programme with the carrot of insurance to encourage the adoption of the specified policies.