Causes of floods

This chapter gives a brief scientific introduction to flooding. It covers hydrology, including factors influencing runoff, storm surge effects and the frequency of flooding. The concepts introduced here will be used in later chapters to explain the purpose of various flood reduction measures. Several technical terms are introduced and they are printed in italics when first defined.

Flooded streets Haiti.
Still Pictures. M. Edwards

Hydrology

The ultimate source of all river flow is rainfall or snowmelt, collectively termed *precipitation*, over the catchment area of the river. The catchment area or river basin is the area that the river drains. Some rain and snow can be intercepted by vegetation, particularly trees, and re-evaporated. Rain (and water from melting snow) reaching the soil surface can infiltrate into the soil or run off directly into streams and rivers. Soils have an *infiltration capacity* (the maximum rate at which they can absorb rainfall), and once this has been exceeded the excess water runs off as *direct*, or *fast-response, runoff* or *overland flow*. The infiltration capacity depends on the soil type (sandy soils can absorb more than heavy clays) and the amount of water already held by the soil. During the course of a storm the soil may become fully saturated and any further rain would then all form direct runoff. The infiltrated water can be absorbed by plant roots and transpired by the plants or may percolate deeper, below the root zone. Both these processes remove water from the top layers of soil, enabling the soil to absorb more rain or snowmelt from later storms. The water that is not transpired may make its way down slope through the soil to the nearest stream, as *interflow*, or may percolate even deeper to groundwater aquifers. The geology of the underlying rocks has a direct control on this deep percolation and may indirectly control infiltration because the soils are often derived from the rocks below. If the underlying rocks are highly pervious, for example limestones, the deep percolation will be large and the river basin will respond sluggishly to rainfall. Less pervious rocks give a more rapid, flashy reaction to rain. Depending on the soils and geology and the slope of the terrain, the direct runoff may reach the river within hours to days, the interflow within days to weeks while seepage out of the aquifers can take months to years to reach the river and forms the baseflow that sustains the river during long dry periods.

At several points in this cycle, water is evaporated. The interception by vegetation, the transpiration by plants and any direct runoff caught in surface depressions can all be evaporated in a process termed *evapotranspiration*. This process requires energy to be available, which comes largely from solar radiation. During winter there is little, if any, energy available for evapotranspiration and thus the soils become highly charged with water, increasing the proportion of precipitation that runs off directly.

These processes all form part of the hydrological cycle. Water evaporated from the ocean and other water bodies falls as precipitation on the land, is partly evaporated or moves to rivers and streams either overland or through the soil as described above and is eventually returned to the ocean.

Precipitation in the form of snow does not immediately produce runoff or infiltrate into the soil, but waits until the snow melts, which means that several months of precipitation can accumulate above the soil surface. Rain on the snowpack, or water from melting snow can be held within the pack until the high liquid water content finally causes the pack to collapse, releasing water catastrophically and causing a very large runoff very rapidly. Warm rain after a long cold spell may cause the snowpack to melt while the underlying ground is still frozen, which prevents any infiltration. Because of these reasons, snowmelt floods, typical of the spring thaw, can be very large.

It will be appreciated that the direct runoff is the major cause of floods. The interflow may also contribute to flooding, but generally to a lesser degree. Human influences frequently reduce infiltration, causing more direct runoff and thus increase the likelihood of floods. Deforestation is a major influence in many countries. The trees hold the soils of the forest floor together and make a deep litter of fallen leaves etc. Both these factors encourage infiltration. Once the trees are lost, the litter and the soils are soon eroded resulting in increased runoff of sediment-laden water. The resulting erosion of hillsides is very deleterious and also leads to increased sediment loads in rivers and silting up of reservoirs downstream. Overgrazing leads to loss of grass cover on hillsides, which again causes faster runoff and erosion. Soil and water conservation need to be considered together to prevent soil erosion, conserve water resources and reduce floods.

Buildings and roads and other paved areas are effectively waterproof and cause very rapid runoff. To remove this rapid runoff from the city streets drains will be built that lead the storm water directly to streams and rivers, thus increasing again the rapidity of the onset of the flood downstream. The storm water from urban areas is also very polluted, containing sediments, oil and other contaminants from the streets. Other hydrological interventions that increase flooding include land drainage and channel improvements to increase capacity. These both reduce runoff delay times with the effect also of increasing the magnitude of floods downstream. Figure 2.1 summarizes how these human interventions increase flooding.

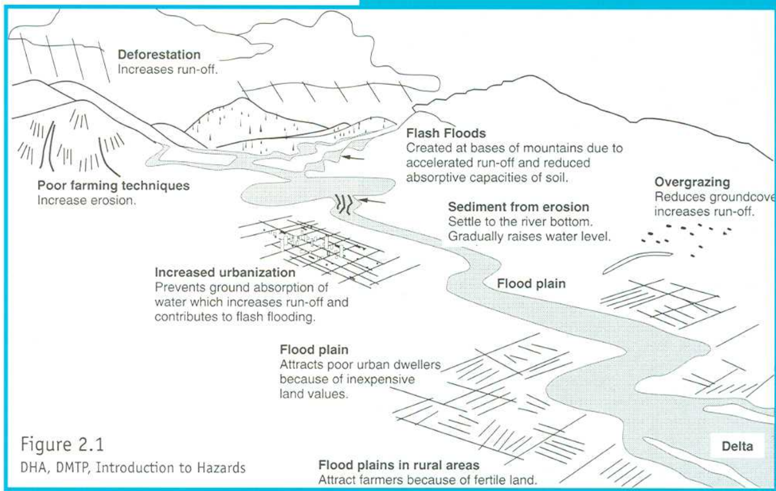

Figure 2.1
DHA, DMTP, Introduction to Hazards

Flash floods are defined in the WMO/UNESCO International Glossary of Hydrology as floods of short duration with a relatively high peak discharge. They arise from local precipitation of extremely high intensity, typical of thunderstorms. The high concentration of rainfall on a small area can have devastating effects as the river flow can rise to several hundred times the normal flow in the space of a few hours. Flash floods are common in arid and semi-arid areas. In these areas what little rainfall there is usually falls in short, intense storms. The intensity of the storms and the poor absorptive capacity of arid zone soils lead to much of the annual runoff occurring as flash floods which carve out the ephemeral wadi channels that are typical of desert regions. Flash floods can also occur following thunderstorms in more humid regions. Mountainous areas are prone to thunderstorms and the steep terrain and thin soils in the mountains assure high runoff with a short delay time. Because of the short delay time it is difficult to forecast flash floods in time for action to be taken. In September 1992, 300 mm of rain fell in three hours on the slopes of Mt. Ventoux (1900 m) in southern France. The River Ouvèze rose rapidly and engulfed the town of Vaison-la-Romaine. A large number of