DRAINAGE BASINS IN DIFFERENT CLIMATES

by Steve Richardson

DRAINAGE BASINS respond in a variety of ways to the inputs of moisture under different conditions of climate, and types of soil, geology and vegetation. The sources of moisture that eventually create the flow of water in a river channel may vary depending on the time of the year. Also, there are factors that can cause water to get into river channels at different speeds, and some of these are dependent upon climate. All river basins must have **inputs**, **transfers** and **outputs** of moisture (see Figure 1), and it is not always obvious where the water that you see in a river channel comes from.

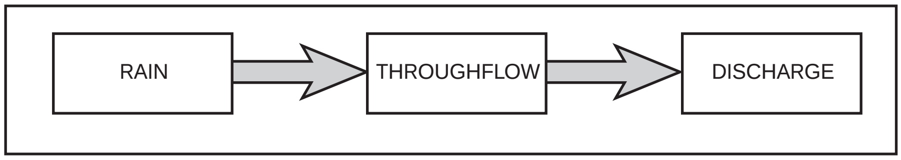

Figure 1: Flow diagram showing input into, transfer through and output from a river basin

Water and channel flow

Strange as it may seem, very little of the moisture – known as **precipitation** – that falls from the sky actually lands directly in a river channel. Moisture falling directly into the channel is known as **meteorologic moisture** (as in 'meteorology' – the study of weather), and in Britain this is most often in the form of rain, but may also be snow, hail, sleet or drizzle. No matter how heavy this precipitation is, it is very unlikely to cause a river to flood – you only have to think of how narrow a river channel is and how much rain does not fall directly into the channel, to work out that much precipitation must get into the channel by other means.

Precipitation falling towards the ground may not get that far! It is very likely that it will be **intercepted** – it will land on plants and may not reach the ground at all, as it may **evaporate** from the surface of the vegetation. If water does land on the ground, it rarely stays where it is. Some of it evaporates, and so is lost back to the atmosphere. It is also unusual for water to flow over the surface of the earth for any great distance. Most precipitation soaks into the ground – a process known as **infiltration**. Once in the ground, water **percolates** (runs down) through the soil and the underlying rock. The speed of infiltration depends upon many factors, including the size of the particles in the soil. Small particles leave small gaps (or **pore spaces**) and so let the water in slowly, while large particles make large gaps and allow fast infiltration. Once the water has percolated down through the soil, it may be taken up by plants and lost through **evapotranspiration**. Water in the soil and underlying rock flows down slopes in a process known as **throughflow**. This is the major source of water for rivers in a climate like that of the British Isles. However, even this water supply is likely to dry up at the end of a long dry summer, and yet the rivers still keep flowing – although their levels are low. This is because some water saturates the underlying rocks to a great depth. This is known as **groundwater**, and it provides **baseflow** – the water that keeps rivers flowing even during a drought.

In summary:

- River basins act as systems, with inputs, transfers and outputs.
- Little of the precipitation falling in a river basin lands directly in a river channel.
- Channel flow is mainly supplied by water that has passed through the soil and rocks around or under the river channel and in the basin.

How rivers respond to precipitation inputs

The rate at which a river flows is known as its **discharge**, and this is usually measured in cubic metres per second (or **cumecs**). A river's discharge does not usually increase as soon as it rains. Following a rainstorm, the discharge increases after a while, and then returns to normal once the extra water has flowed away. Several factors can delay the speed at which a river responds to a period of rainfall or precipitation. However, the actual speed of response to the rainfall can depend on a number of factors, for example:

- how much interception there is
- the state of the ground (wetness)
- the rate of infiltration
- the speed of throughflow.

Several other factors can also influence the speed of a river's response.

The delay in the time between the

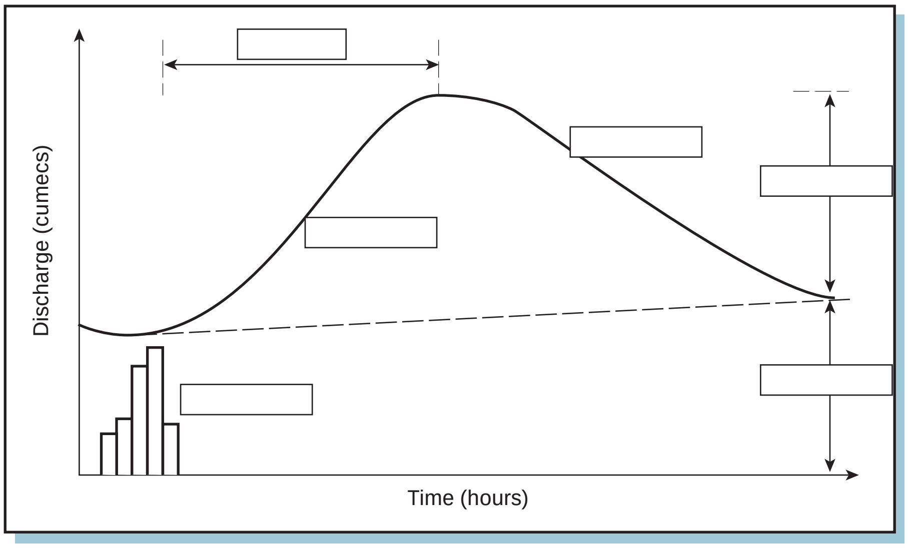

Figure 2: A flood hydrograph

heaviest rainfall and the maximum, or **peak**, river flow (discharge) is known as the **lag time**. This may be quite lengthy in areas where the soil is dry but is able to accept large amounts of water by infiltration. However, if the surface is **impermeable**, there will be no infiltration and the water will quickly make its way to the channel by **overland flow**, and there will be a rapid rise in discharge. The response of discharge to rainfall can be shown on a type of diagram or graph called a **hydrograph** (Figure 2).

If water takes a long time to get into the channel, then there is a long lag time. Similarly, if there is a large amount of water in the basin, then it will take some time for the river to return to its former level. The length of time when a river remains at peak discharge may also be extended by repeated falls of rain.

How rivers respond to different climates

Rivers respond to inputs of precipitation, which is an element of climate. However, rainfall and temperature combine to meet the needs of vegetation, and vegetation – as we have seen – can intercept precipitation. So the wetter a climate, the more likely it is that there will be a lot of interception. This will have an impact on the shape of that river's hydrograph, and on the pattern of flow throughout the year.

Case Studies

In the following case studies we look at the impacts of climate on two contrasting drainage basins – one in the Nevada Desert, the other in the south of England.

Carson Desert basin, Nevada, USA

The Carson Desert basin is high in the mountains of western USA (Figure 3). It has an area of 5,610 square kilometres and a perimeter of 412 kilometres. The gauging station is 1,269 metres above sea level, and the climate is markedly different from that of southern England. As may be seen from the details in Figure 4, the rainfall totals for nearby Las Vegas are low. Typically such a desert area would be able to support little vegetation cover naturally, although irrigation is used to make the desert bloom. So there is a shortage of interception, and also very little rainfall *on average*. Deserts are peculiar places – the small *average* rainfall totals should not hide the fact that many months in a typical year in Las Vegas are totally dry, and some have many dry days, but when it does rain several tens of centimetres may fall in spectacular thunderstorms. It is also possible that at such an altitude, in winter several centimetres of snow may accumulate and this may be released by melting to swell the rivers. Extensive dry periods are likely, and irrigation is necessary for agriculture to occur at all. Figure 4 shows climate data for Las Vegas, close to the Carson Desert basin, and Figure 5 presents data on discharge for the Carson Desert basin.

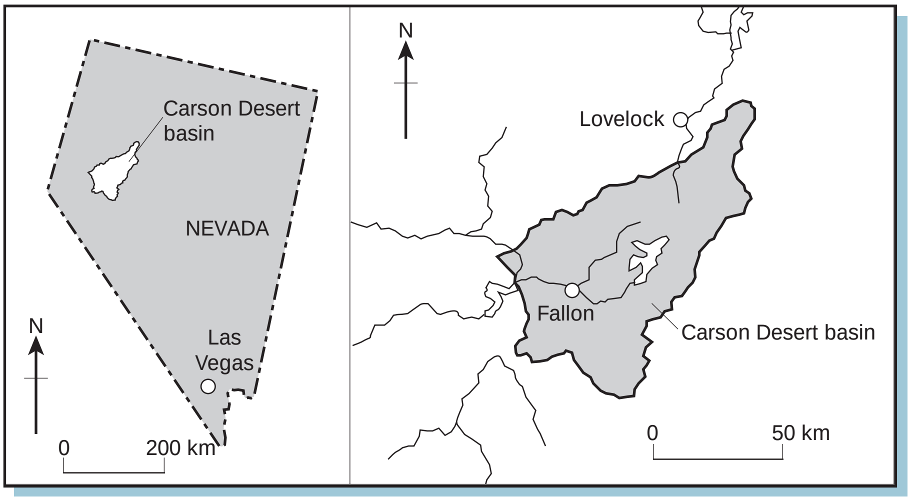

Figure 3: Carson Desert basin in Nevada, USA

Month	J	F	M	A	M	J	J	A	S	O	N	D
Mm	18	13	8	8	5	5	13	13	8	8	5	10
°C	7	10	13	17	21	25	29	29	24	18	12	7

Figure 4: Climate details for Las Vegas, Nevada

Month	J	F	M	A	M	J	J	A	S	O	N	D
Cumecs	0.73	0.45	0.11	0.05	0.06	0.03	0.08	0.07	0.06	0.08	5.44	0.04

Figure 5: Mean monthly discharge, Carson Desert basin, 1997
Source: US Geological Survey

Stour basin, Dorset, UK

This is a very different kind of basin. The Dorset Stour has a basin area of some 1,300 square kilometres (see Figure 8 on page 4). The south of England is typical of a mild maritime climate. There are no dry months in the year, but there is a difference between summer and winter in terms of temperature, precipitation and vegetation cover. It is seldom too cold for snow to last long, and the summers are mild, sometimes warm, but never too hot (Figure 6). However, droughts do occur, and in the recent past some of these have been extensive – there have been periods of as long as three years when rainfall has been below average in the basin of the Stour, for example in the late 1980s, and again in the mid-1990s. The lower part of the Stour basin is on the coast, and the land surrounding the Stour basin does not in any way match the elevation of the Carson Desert – amounts of precipitation are not significantly increased by the effects of altitude.

The Stour is a typical British river. It floods from time to time, but when it does, there is usually plenty of warning that it is going to do so. In any case there would have to be an extended period of very wet weather in order to make the river flood.

The evenly distributed rainfall in the Stour basin ensures that under normal conditions there is no month in the year when the river dries up (Figure 7). Similarly, the presence of vegetation cover for at least half of the year means that much moisture is intercepted and so rapid rises in discharge are unusual. The winter maximum of rainfall ensures that winter discharge is high, and the lack of vegetation cover in the fields and loss of leaves at that time means that there is more likely to be a flood in the winter. Sometimes winter months are dry – Figure 6 was drawn from average figures taken over a number of years – and the flow of the Stour may vary from the pattern shown in Figure 7. Summer months generally have lower rainfall, although sometimes thunderstorms may be accompanied by heavy rain. This seldom makes any impact on the flow of the Stour because much of the basin lies over chalk, which is **porous** (water flows rapidly through it). Also, the fields in this rural area are filled with growing and ripening crops in the summer, which intercept the rainfall.

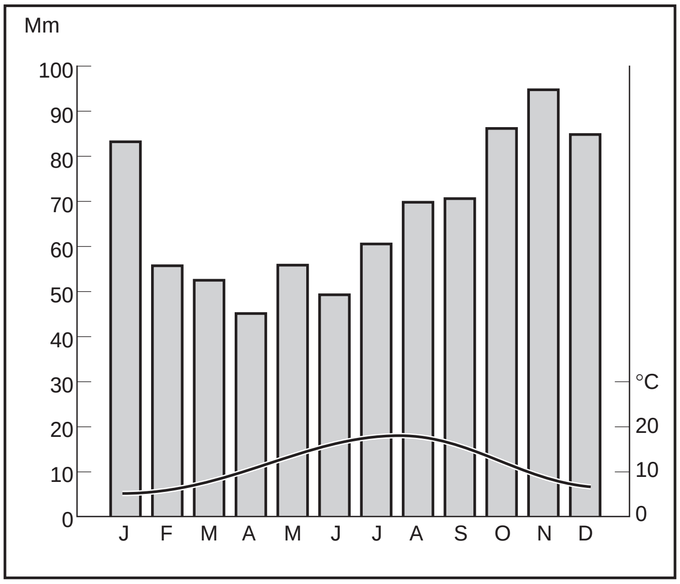

Figure 6: Southampton's climate

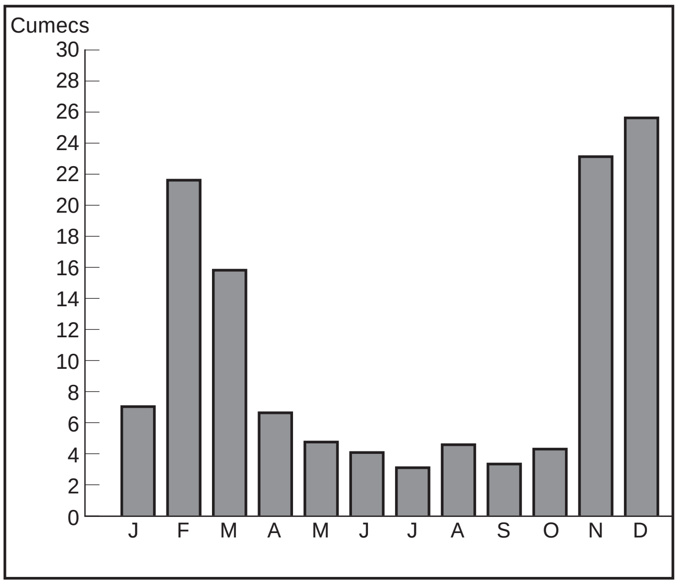

Figure 7: Mean monthly flow in the Stour basin, 1997
Source: Environment Agency

Activities

1 Use the terms 'Inputs', 'Transfers' and 'Outputs' as headings for columns in a table. List as many of these as you can for moisture in a river basin. Give your table the title: 'Inputs, transfers and outputs in a drainage basin'. This unit will help you (see Figure 1, for example), but you should also refer to a geography textbook.

2 Make a large copy of Figure 2, and complete your copy. Check the definitions of any of the terms you write on your graph, and make a list of these. Shade in the area that represents the extra runoff during a flood period.

3 Why may hydrographs for the same river vary from one season to another? Try to account for changes that are the result of climate and vegetation cover.

4 (a) On an outline map of the USA, mark the location of Nevada.
(b) How far is the westernmost part of Nevada from the ocean? Indicate this on your map.
(c) Give your map a title.
(d) In general terms, how does Nevada's location differ from that of the Stour basin in Dorset?

5 (a) Using the data for Las Vegas (Figure 4), plot a climate graph similar to the one for Southampton (Figure 6), showing bars for rainfall and a line for temperature. Make sure that you give your graph a title, and label the axes.
(b) Describe your graph – remember to quote figures.
(c) How does it differ from that showing the climate of Southampton? Quote figures!

6 (a) Using the data in Figure 5, draw a labelled graph to show the mean monthly flow of the Carson Desert basin in 1997. Give your graph a title.
(b) How does this graph differ from the one for the River Stour (Figure 7)? Quote figures!

7 Using a copy of Figure 8, and other information in this unit, prepare a display explaining why the pattern of flow in the River Stour is so different from the pattern of flow in the Carson Desert basin. You may have to guess at some parts of the answer, but there is enough material in this unit for you to make a broad assessment of why the two rivers flow as they do.

8 In groups, put yourself in the role of the water authority responsible for managing the River Stour drainage basin. What strategies would you introduce to:
(a) reduce the risk of flooding in winter
(b) reduce the risk of water shortage in the summer?

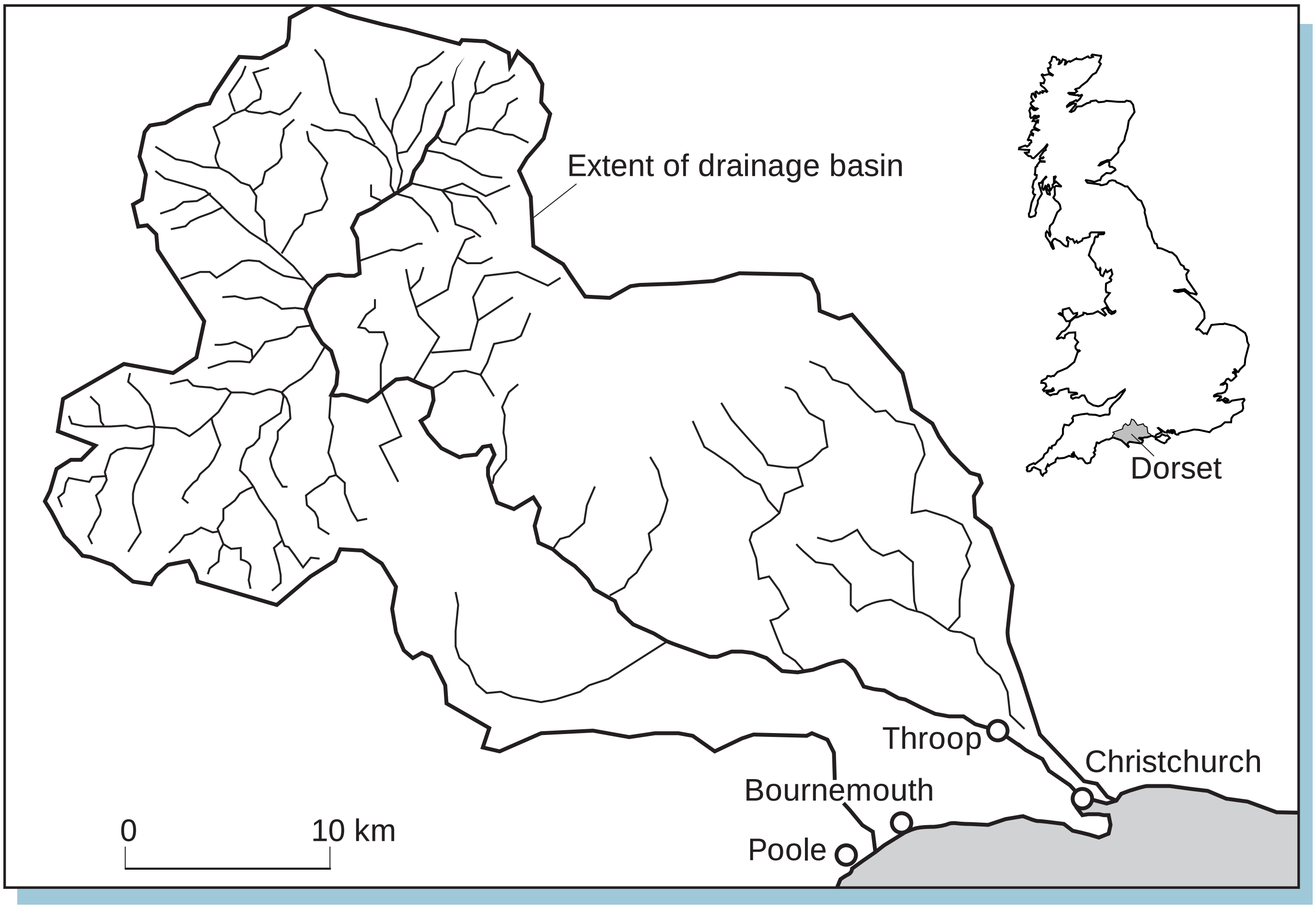

Figure 8: The River Stour basin