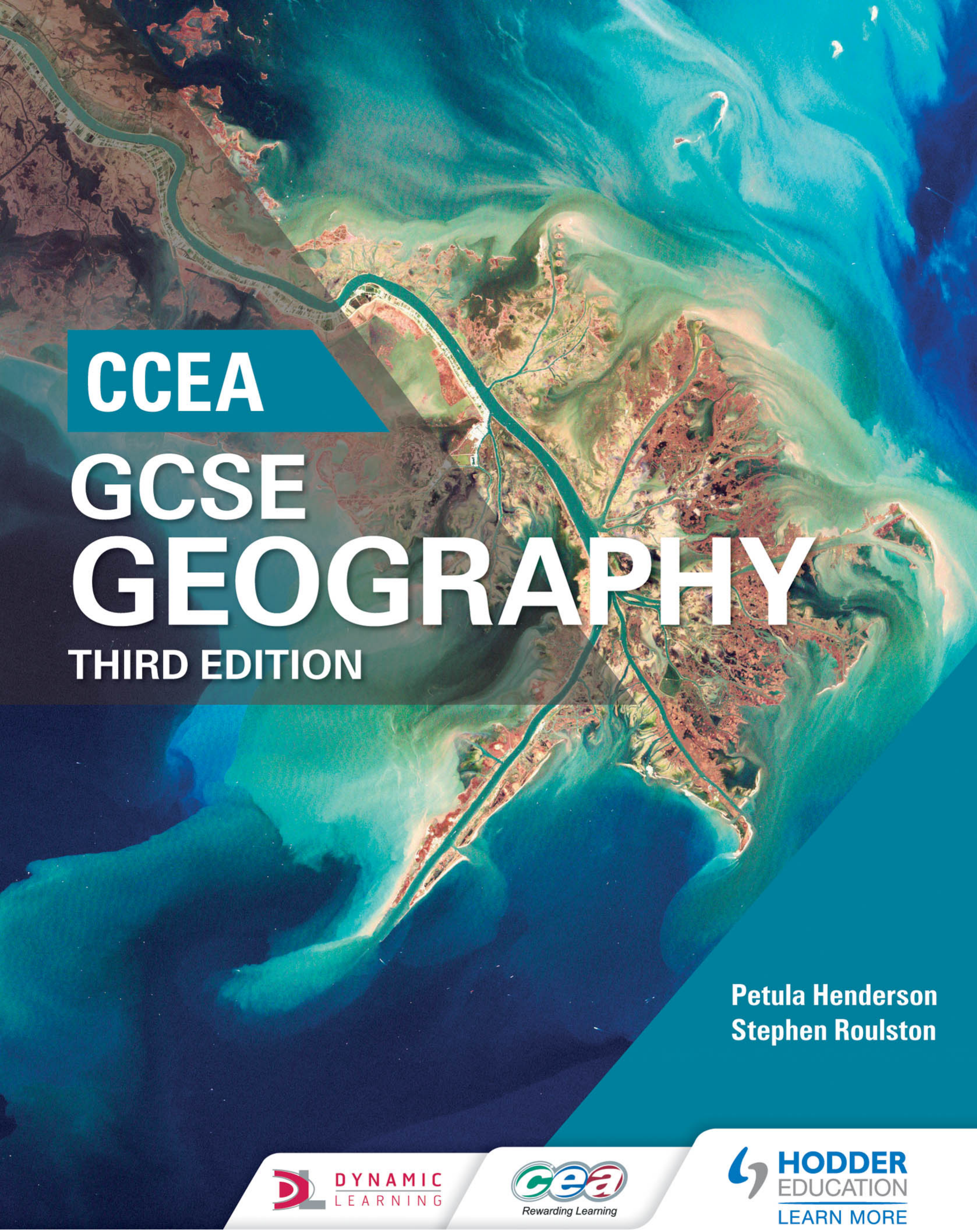

CCEA GCSE GEOGRAPHY

THIRD EDITION

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CONTENTS

UNIT 1

UNDERSTANDING OUR NATURAL WORLD

THEME A: River Environments

Niagara Falls, on the border between Canada and the USA.

How do rivers manage to create such a dramatic landform?

1 The drainage basin: a component of the water cycle

By the end of this section you will be able to:

- identify and define the characteristics of a drainage basin
- know and understand the elements of a drainage basin
- know and understand inputs, stores and transfers.

Tip

Make sure you know what all the main characteristics of a drainage basin are. Try using flash cards to help you revise them regularly.

Characteristics of a drainage basin

What are the characteristics of a drainage basin?

Water is a critical resource. The water that is most useful to humans is fresh water, although this only makes up 2.5 per cent of all the water on the planet, and only 0.1 per cent is stored in rivers and lakes. The rest of the fresh water on land is stored in ice sheets and glaciers, or in the soil and deeper down in the ground. The total amount of water on our planet never changes: in other words, none arrives from space, and none is lost to space. This is called a closed system. The water on Earth circulates between the sea, land and air (stores), being recycled in a natural process known as the hydrological cycle (**water cycle**).

On the land, water is stored on the surface as lakes and rivers. Each river is contained within its own **drainage basin**. This is the area of land drained by a river, from its **source** (where it begins) to its **mouth** (where it ends by meeting the sea, ocean or lake) and its **tributaries**. The boundary of a drainage basin follows a ridge of high ground, known as the **watershed**. A **confluence** is when a tributary meets the main river. In some cases, confluences can be very clear if the nature of the water in the two meeting rivers differs, like the confluence in Brazil where the River Negro and the River Solimoes meet. This and other features of the drainage basin are summarised in Figure 2.

Figure 1 The confluence of a river.

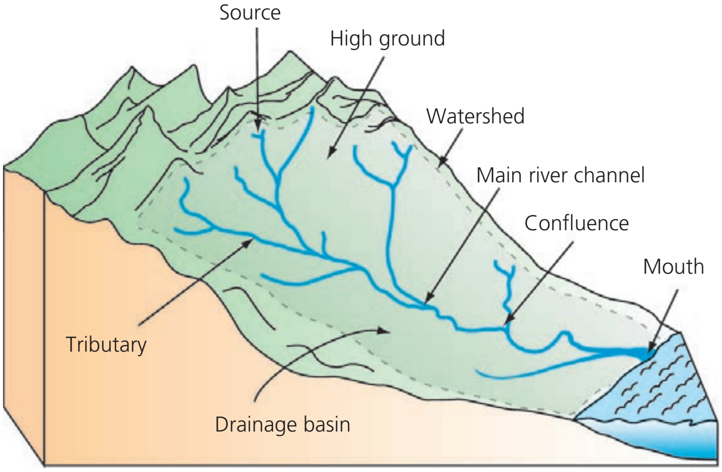


Figure 2 A generalised drainage basin.

The amount of water within a single drainage basin can vary, as it has inputs (from precipitation) and outputs (from **evapotranspiration**). Therefore this is an open system.

Inputs	Flows from store to store	Outputs
Precipitation	Surface runoff Soil (unsaturated) Ground (saturated) River channel	Evapotranspiration River discharge

Figure 3 A simple open system of the drainage basin.

What are the components of a drainage basin, and how do they relate to one another?

Water enters the drainage basin system as precipitation. This may be in any form, such as snow or rain. Most drainage basins have some vegetation. The precipitation may be caught on the leaves of plants. This is called **interception**. Generally, it is greatest in summer as this is when deciduous plants have leaves.

From the surface of the plant, the water may evaporate back into the air, or flow down the stem of the plant to reach the ground. At this point the water has moved from the store in the vegetation to be part of the surface storage. If conditions are right, it will then seep into the soil. This process is called **infiltration**. Soil normally has small pockets of air called pores, which allow the water to get into it. Once in the soil, gravity will pull the water downwards and it will move down through the soil as **throughflow**, until it reaches the water table, where all the pores in the soil, or rock, are already full of water, so it cannot move any further downwards. Instead it now flows laterally (sideways) into the nearest river as **groundwater flow**.

Any water that hits an impermeable surface, with no pores, such as tarmac, cannot infiltrate the soil below. It simply flows over the surface as **surface runoff** (also called **overland flow**) into the nearest river.

Although some precipitation can fall directly into the river, most water reaches a river by a combination of surface runoff, throughflow and groundwater flow. It takes water the longest time after falling to reach the river by groundwater flow, since it has had to flow through so many stores to get to the river channel.

Water may leave the drainage basin through the river by going out to seas, lakes or oceans. The rest is either stored within the basin or may be evaporated from the ground, vegetation or soil. Plants respire some of the soil moisture out through their leaves, a process called transpiration.

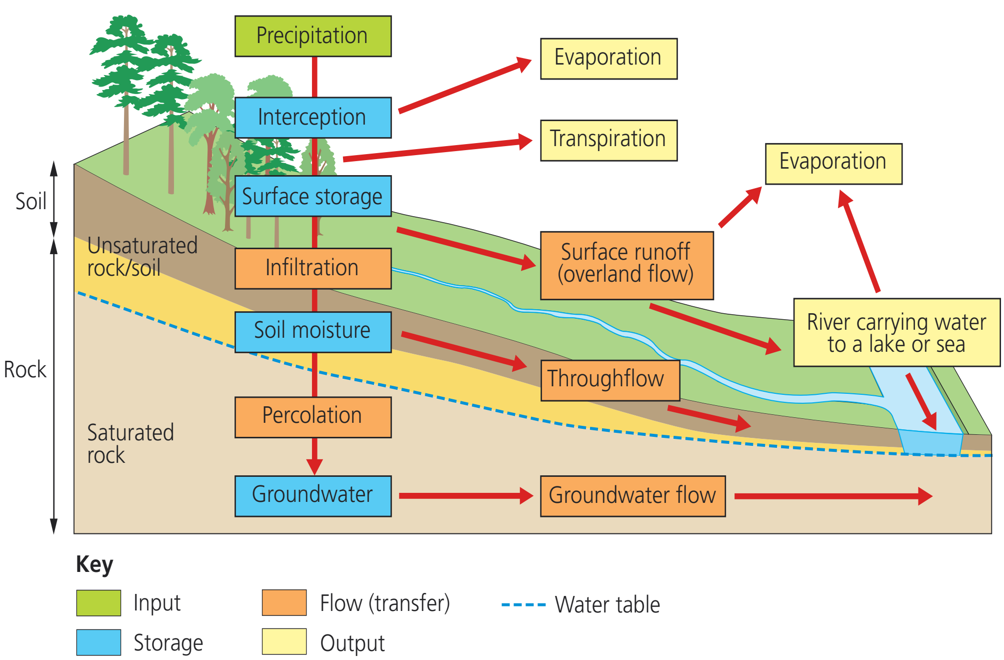


Figure 4 The drainage basin system.

Activities

1. Draw an unlabelled diagram of a drainage basin. Swap with a partner and see if they can fill in the missing labels.
2. After researching river sources, name three types of river source.
3. Describe the process of infiltration and suggest two factors which might influence the rate of infiltration.
4. Name and describe the slowest transfer process of water into a river.
5. Explain why rivers are more likely to flood after a long period of rainfall.

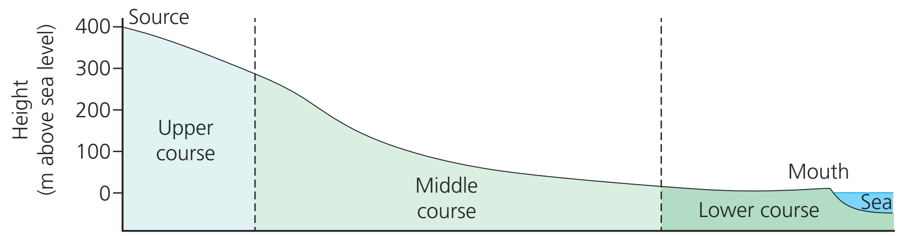
By the end of this section you will:

- understand how gradient, depth, width, discharge and load change along the long profile of a river and its valley.

Changes along the long profile of a river

What changes take place along the long profile of a river?

Rivers can be divided into upper, middle and lower courses. To investigate how a river can change downstream, it is possible to examine a local river like the Glendun River in County Antrim. The location of this river is shown in Figure 16 on page 18.



	Upper course	Middle course	Lower course
Expected characteristics	Narrow channel Shallow channel Vertical erosion Hydraulic action, abrasion and attrition Transport of load by saltation, some traction at high flow Large sized, angular load.	Channel widens due to lateral erosion Less hydraulic action All methods of transport can be seen, but suspension is most common Erosion and deposition seen on meanders Load becomes smaller and more rounded.	Channel is deepest and widest Some lateral erosion Deposition more common than erosion Load moved mostly by suspension Load is now small in size, mostly sand, silt and clay.

Cross section

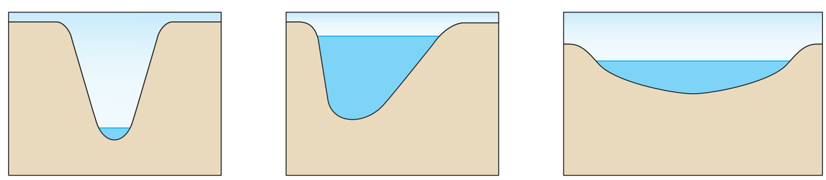


Figure 5 The typical long profile of a river.

The Bradshaw Model is another way of showing how a river's characteristics change upstream and downstream, given natural conditions. The wider the triangle, the more there is of that particular item. So, for example, the depth of the river channel is typically widest and deepest downstream, in the lower course, towards the mouth of the river. Of course, not all rivers follow these models.

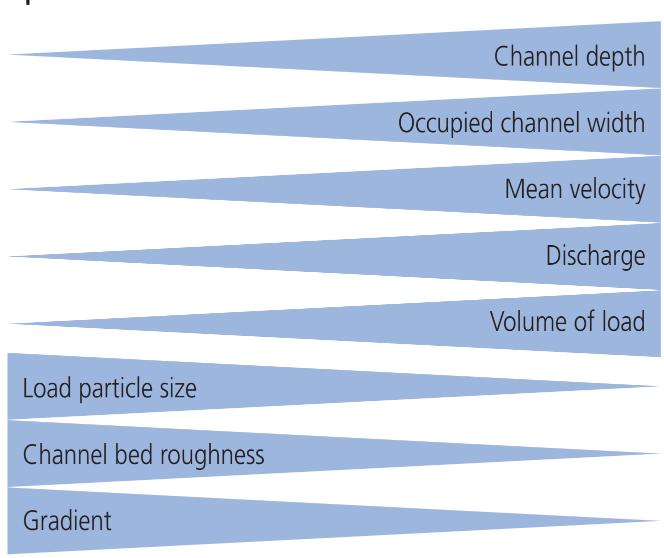


Figure 6 The Bradshaw Model.

Activities

1 State two river characteristics that typically increase downstream.
2 State two river characteristics that typically get smaller downstream.

Skills activity

Using a labelled diagram, describe the general characteristics of the lower course of a river.

How do a river's gradient, depth, width, discharge and load change?

Measuring the Glendun River

Various fluvial (river) characteristics are measured at regular points (every 1 km) along the Glendun River. This type of sampling is called systematic sampling and it allows the investigation of continuous changes as distance increases from the source of the river.

A group of pupils investigated this river. Figure 8 shows what the students measured.

Figure 7 Measurements being taken on the Glendun River.

Gradient

Gradient is a measure of the slope of the land. On a steep slope the gradient is high and on flat land the gradient is low. A river's gradient is measured using a clinometer and ranging poles over a set stretch of the river, such as 5 or 10 metres. Ranging poles mark out the stretch of river. The clinometer is placed against the height mark on the upstream pole and the angle is observed to the equivalent height mark on the downstream pole.

Depth

This is measured using a metre stick. The stick is lowered into the water every 10 cm, and the distance from the top of the water to the river bed gives the depth of water. An average of all these readings is taken.

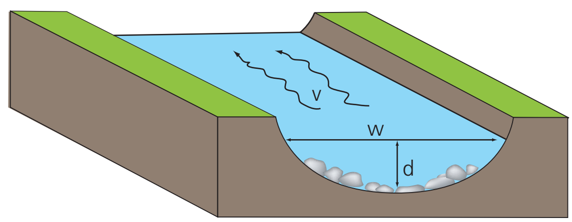


Figure 8 Aspects of a river that can be measured.

Width

This is measured by placing one end of a measuring tape at one side of the river channel, then pulling it out to the other side of the channel. The distance is the width of the river.

Discharge

Discharge is the amount of water passing any point in a river in a certain time, normally given as cubic metres of water per second (cumecs). It is calculated by multiplying the cross-sectional area of a river channel at a certain point by the speed (velocity) of the river at the same point.

The cross-sectional area is obtained by multiplying the width of the river by the average depth. The speed (velocity) of the river is recorded using a flow metre that when dipped into the river gives a digital reading of the speed of flow in metres per second.

Load

The load of a river is the material it is carrying, ranging from small sediment to large boulders. Load can be dissolved in the river water (solute load), be carried within the river water (suspended load) or lie on the bed of the river (bedload). It is very hard to measure the size of the load in suspension or solution, so, instead, we can concentrate on the load lying on the channel bed – called bed load. This load is measured for size and roundedness. By measuring the longest axis of 15 random samples at each point an idea of the size of the load is obtained. Each stone is then given a rating for roundedness.

Results of measuring the Glendun River

To help see the overall trends, here is a selection of results obtained from the Glendun river.

Table 1 Results of measuring the Glendun River.

	Upper course (Station 1: 1.5 km from source)	Middle course (Station 3)	Lower course (Station 6: 16.5 km from source)
Width (m)	2.7	10.4	14.2
Depth (m)	0.14	0.33	0.46
Discharge (cumecs)	0.08	0.2	5.1
Load – long axis (cm)	26	12	7
Load – roundedness	angular	sub-angular	rounded

Read pages 13–14 about **erosion**, **transportation** and **deposition** to help you interpret these results and understand the explanations below.

Going downstream from source to mouth, the Glendun River gets wider. At Station 6 (16.5 km from the source) the river is just over five times the width it is at Station 1, only 1.5 km from the source.

The river gets deeper. At the station in the lower course the river is 32 cm deeper than it is in the upper course. This can be explained by the fact that there is more lateral erosion and vertical erosion occurring downstream from the source.

The wider and deeper river channel size downstream relates well to the pattern of increasing discharge. Because discharge is calculated by multiplying the cross-sectional area of the channel by the river's velocity, then it follows logically that as the cross-sectional area increases, so does the discharge. The river is receiving additional water from the tributaries that are entering it at regular intervals within the Glendun valley: these will also cause the discharge to be greater downstream. In the upper course, by contrast, very few tributaries have contributed to the flow. Finally, the velocity of the river is also greater in the lower course as the water flowing in the river channel does not have to overcome as much friction as that in the upper course, which has angular rocks and a shallow channel.

Most of the weathering of bare rock happens in mountain areas, where it is exposed. This material can then fall down the steep valley sides into the upper course of the river. It is still very angular, as the results show. As it moves downstream it hits the sides of the river bed, and also other rocks that make up the load. This knocks the sharp edges off the material, smoothing its sides and making it rounded. The load of the river, therefore, is noticeably more angular in the upper course, but becomes rounded in the lower course – even on a relatively short river such as the Glendun.

Activities

1. Using graph paper or a computer, draw graphs to show how discharge and load size change along the long profile of the Glendun River.
2. Analyse how discharge and load size change by describing your graphs.
3. Interpret why discharge and load size change by explaining the river processes that have caused the changes.
4. Suggest suitable health and safety measures a group should take when doing a river study.

2 River processes and landforms

River processes

How does erosion work?

By the end of this section you will:

- understand how rivers erode, transport and deposit material.

All rivers contain minerals and solid material: this is known as the **'load'** of the river. When rivers have a large load made up of coarse materials these scrape or rub against the channel bed, eventually lowering the level of the bed, to create steep valley sides. This is called vertical (downward) erosion.

In sections of the river channel where the river is flowing particularly fast, the water has enough energy to wash away part of the bank of the river. This can lead to undercutting and collapse. As this is a sideways motion, it is called lateral erosion.

There are four main types of erosion:

Attrition is the collision of rock fragments (suspended in water) against one another. Rock particles are broken into smaller pieces and become smoother as the process continues.

Hydraulic action is a form of mechanical weathering that is caused by the force of moving water. It can undermine riverbanks on the outside of a meander or force air into cracks within exposed rock in waterfalls such as Niagara (see Figure 11).

Abrasion or corrasion is the grinding of rock fragments, carried by a river, against the bed and banks of that river. This action causes the river channel to widen and deepen. This grinding is most powerful during a flood, when large fragments of rock are carried along the river bed.

Solution or corrosion is the process by which river water chemically reacts with soluble minerals in rocks and dissolves them.

How does transportation work?

Weathered material falling into a river from the valley sides forms 90 per cent of the river's load. The remaining 10 per cent is the result of erosion caused by the river on its own banks and bed.

Rivers move their load through transportation in four ways as shown in Figure 9 (solution, saltation, suspension and traction).

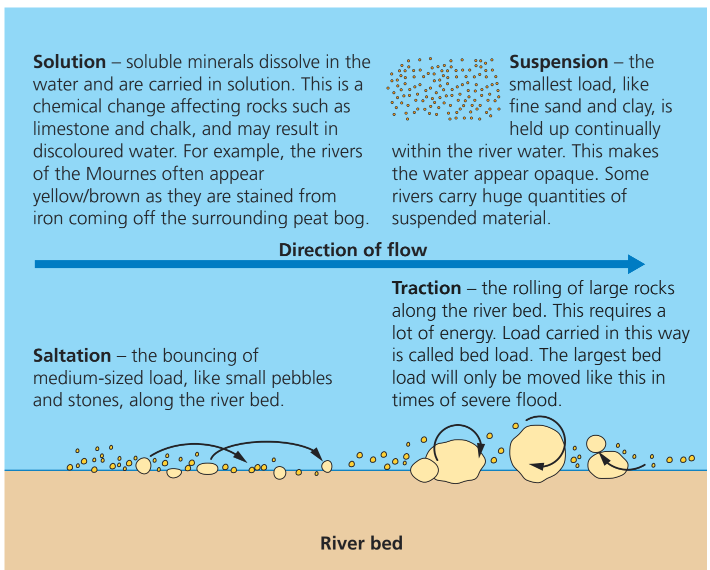


Figure 9 Methods that a river uses to move its load.

Tip

Try using a mnemonic or a rhyme to help you remember all the different types of erosion and transportation.

How does deposition work?

When the velocity of the river is reduced, the energy of the water decreases, and so the water can no longer erode or transport material. Instead, the load is dropped, starting with the largest (and heaviest) particles. This process is called deposition.

Conditions when deposition is likely to occur are shown in Figure 10.

It is the combination of erosion, transportation and deposition that creates the general landforms seen along a river channel.

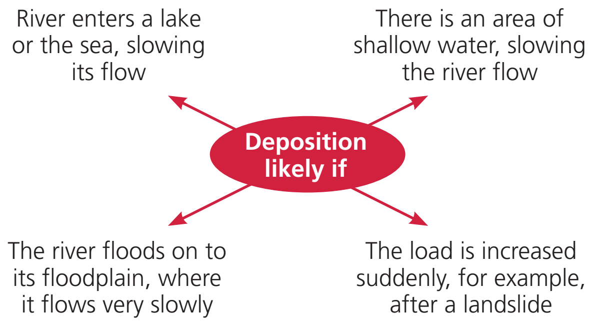


Figure 10 Conditions that are likely to result in deposition.

Activities

1. Make double-sided flash cards to explain the ways a river carries out the following processes. Use these with a partner in class to see if you can remember them all.
   - **a** erosion
   - **b** transportation
2. Explain why deposition is more likely to happen when the velocity (speed) of a river slows.
3. State three differences in the conditions of a river that lead to erosion or deposition occurring.

Figure 11 Niagara Falls.

River landforms

By the end of this section you will:

- understand how waterfalls, meanders and slip-off slopes form.

Waterfalls

Within the drainage basin, waterfalls are generally found in the upper course of a river. This is near the river's source area where the landscape is still quite mountainous.

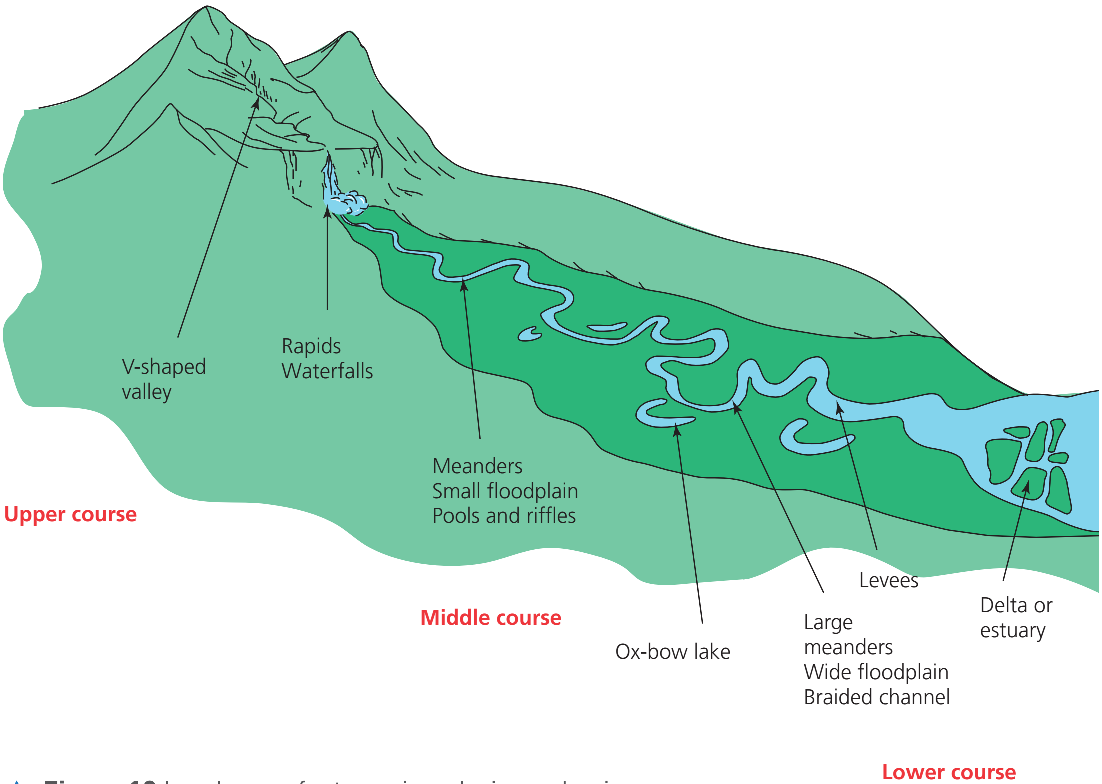


Figure 12 Landscape features in a drainage basin.

Waterfalls form where there are alternating layers of hard rock and soft rock. As the river passes over the exposed, less resistant soft rock on a river bed, it is able to erode it at a faster rate than the harder rock, so a step in the river bed develops. The force of hydraulic action and abrasion deepens this step until a waterfall is formed. Eventually, erosion makes a deep pool under the waterfall, called a plunge pool, and the hard rock will begin to hang over this pool. When it becomes too unstable, the hard rock overhang will collapse and the waterfall will retreat backwards, leaving a gorge.

One of the most famous waterfalls is Niagara, where hard limestone lies over softer shale (see Figure 11 on page 14).

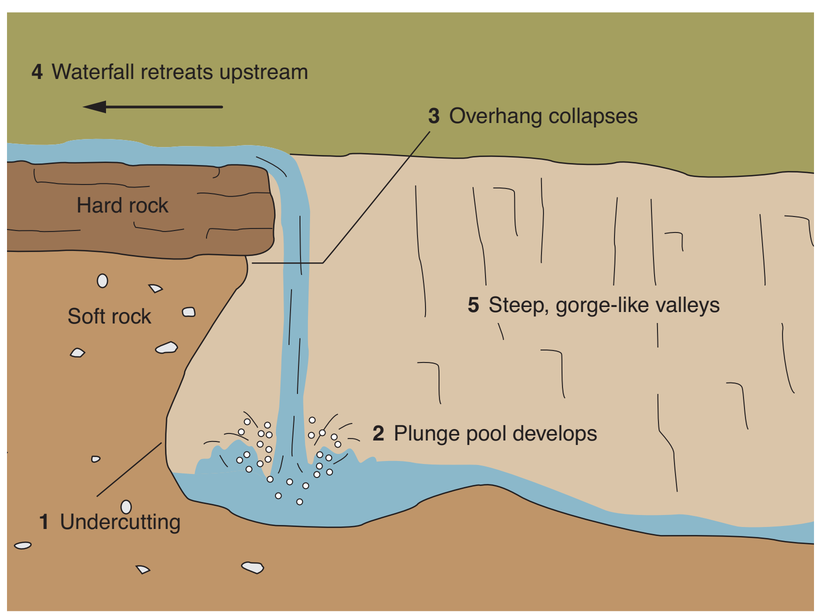


Figure 13 Formation of a waterfall (cross-section).