

River Systems

Rivers are part of the **hydrological cycle** - a **closed system** which moves water from the oceans, through the atmosphere, and back to the oceans.

River systems themselves, however, are open water-flow systems which drain an area of land. Water flows down from higher areas to lower areas and discharges into seas or lakes. Rivers are changed by the landscape through which they flow, and in turn change the landscape.

1. The hydrological cycle
2. The river system
3. The course of a river

1. The Hydrological Cycle

The **hydrological cycle** (or water cycle) is a **closed system** in which water is continuously moved from the world's oceans, through the atmosphere, falls to earth as rain, then travels back to the ocean in an endless loop.

A geographical system such as the hydrological cycle operates using a series of **flows** (or transfers) and **stores**:

Water flows or is transferred through the system in many ways. One way is via rivers, another way is through the soil. The movement of water through the soil is called **throughflow**.

Water is stored in a number of ways - for example, in lakes or as ice in glaciers.

2. The River System

A river system is an **open system**. An open system has inputs, processes and outputs. So unlike water in the **hydrological cycle**, where there is an endless cycle of rain, rivers, sea and evaporation, water in the river system enters the system, and eventually leaves it again. A river system operates inside a **drainage basin** (or river basin). A drainage basin is the area of land drained by a

river and its **tributaries**. Any water falling inside the drainage basin will find its way into the main **river channel** (unless it is taken out of the system - for example by being piped to a factory). The boundary of a drainage basin is called the **watershed**.

Draw a diagram of a drainage basin

The diagram below shows a drainage basin. Make sure you know all the key terms used when talking about river systems.

Like the **hydrological cycle**, water moves around the **river system** via a series of **flows** or transfers. Water can flow through the river system in the following ways:

Surface run-off - when water flows directly overland to the river (sometimes called overland flow).

Infiltration - when water passes through from the surface of the drainage basin into the soil layer.

Throughflow - the movement of water through the soil towards the river channel.

Percolation - the movement of water from the soil layer to the rock layer.

Groundwater flow - the movement of water through the rock layer (sometimes called base flow) towards the river channel.

Sometimes water is stored within the system - for example in a lake. Water can also be taken out of the system by humans for industrial uses. Water can also be intercepted by vegetation - that is, drunk by plants.

3. The Course of a River

The journey of river from source to mouth is sometimes called the **course** of the river. The course of a river can be divided into three main sections:

- The upper course
- The middle course
- The lower course

Rivers always flow downwards from highland areas to lowland areas, through the upper, middle, and finally the lower course.

Three courses of a river



As a river travels along its course, both the river and the landscape around it changes. On the one hand, the nature of landscape affects the river's course and flow - with hills, for example, making the river flow faster. On the other hand, the river will in its turn change the landscape - for example, carving out a deep valley or creating a flood plain.

River Processes

River processes are the means by which rivers change and shape the landscape around them. **Erosion** is the wearing away and breaking down of rock and soil. **Transportation** is the movement of river-borne material downstream. **Deposition** is the dropping or depositing of river-borne material.

River processes shape the land in different ways as the river moves from its source to its mouth.

1. Erosion
2. Transportation
3. Deposition

1. Erosion

Erosion involves the wearing away of rock and soil found along the river bed and banks. Erosion also involves the breaking down of the rock particles being carried downstream by the river.

There are four main forms of river erosion:

- Hydraulic Action** - river wears away the river bank from underneath
- Attrition** - rocks being carried by the river smash together and break into smaller particles
- Abrasion** - rocks carried along by the river wear down the river bed and banks
- Solution** - smaller particles are dissolved into the river.

Erosion shapes the land in different ways as the river moves from its **source** to its **mouth**:

Near the source of a river, in the upper course, erosion is vertical (downward). This is because the water is being pulled downwards by gravity. This forms deep V-shaped valleys.

Near the mouth of a river, in the lower course, erosion is lateral (horizontal or sideways). This forms a wide river channel.

2. Transportation

Rivers pick up and carry material as they flow downstream.

A river may transport material in four different ways:

- Solution** - minerals are dissolved in the water
- Suspension** - fine light material is carried along in the water
- Saltation** - small pebbles and stones are bounced along the river bed
- Traction** - large boulders and rocks are rolled along the river bed

Rivers need energy to transport material, and levels of energy change as the river moves from source to mouth. When energy levels are very high, large rocks and boulders can be transported. Energy levels are usually higher near a river's source, when its course is steep and its valley narrow. Energy levels rise even higher in times of flood.

When energy levels are low, only small particles can be transported (if any). Energy levels are lowest when the river enters the final stages of its journey (at the mouth).

When a river loses energy it deposits some of the material it has been carrying.

3. Deposition

When a river loses energy, it will drop or deposit some of the material it is carrying.

Deposition may take place when a river enters an area of shallow water or when the volume of water decreases - for example after a flood.

Deposition is common towards the end of a river's journey, at the mouth.

Deposition at the mouth of a river can form deltas - for example the **Mississippi Delta**.

River Features

Upper-course river features include steep-sided V-shaped valleys, interlocking spurs, rapids, waterfalls and gorges.

Middle-course river features include wider, shallower valleys, meanders, and oxbow lakes.

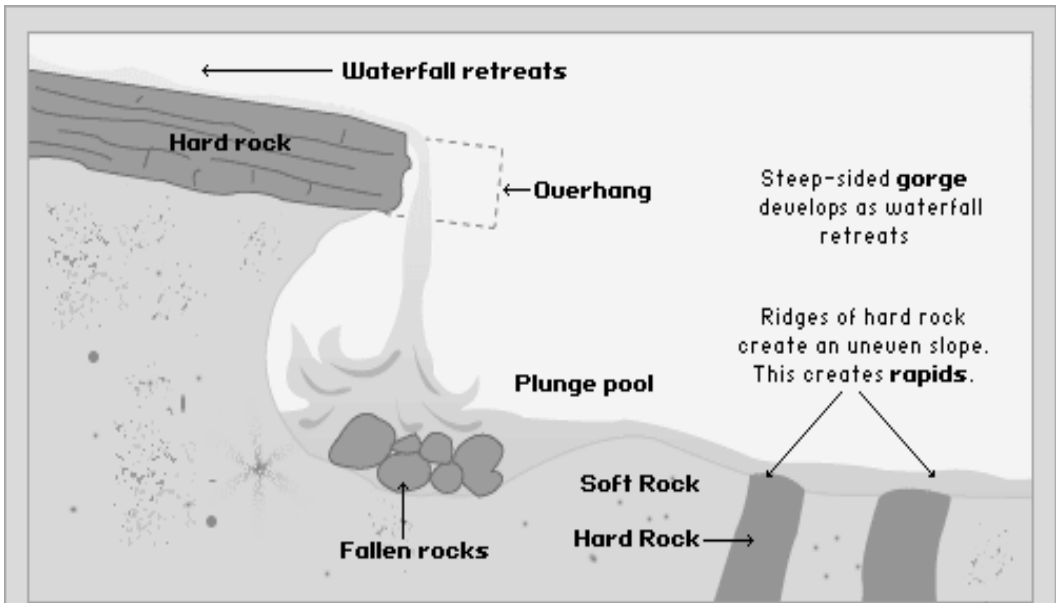
Lower-course river features include wide flat-bottomed valleys, flood plains and deltas.

1. Upper-course features
2. Middle-course features
3. Lower-course features

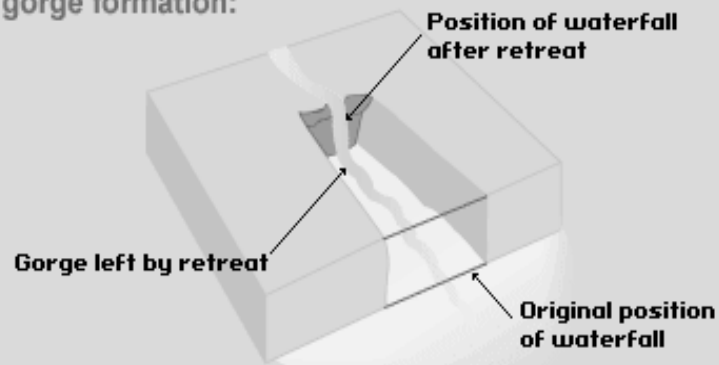
1. Upper-Course Features

As the river moves through the upper course it cuts downwards. The gradient here is steep and the river channel is narrow. Vertical erosion in this highland part of the river helps to create steep sided V-shaped valleys, interlocking spurs, rapids, waterfalls and gorges:

- As the river erodes the landscape in the upper course, it winds and bends to avoid areas of hard rock. This creates **interlocking spurs** which look a bit like the interlocking parts of a zip.
- When a river runs over alternating layers of hard and soft rock, **rapids** and **waterfalls** may form. The graphic shows how waterfalls and rapids are formed.



Block diagram showing gorge formation:



Waterfalls form because the river wears away the soft rock section of riverbed faster than the hard rock section.

2. Middle-Course Features

Meanders

In the middle course the river has more energy and a high volume of water. The gradient here is gentle and lateral (sideways) erosion has widened the river channel. The river channel has also deepened. A larger river channel means there is less friction, so the water flows faster:

- As the river erodes laterally, to the right side then the left side, it forms large bends, then horseshoe-like loops called **meanders**.
- The formation of meanders is due to both deposition and erosion.
- The force of the water **erodes** and undercuts the river bank on the **outside** of the bend where water flow has most energy.
- On the **inside** of the bend, where the river flow is slower, material is **deposited**.
- Over time the horseshoe become tighter, until the ends become very close together. As the river breaks through and the ends join, the loop is cut-off from the main channel. The cut-off loop is called an **oxbow lake**. The animation demonstrates how these features form.

Draw a diagram of a meander

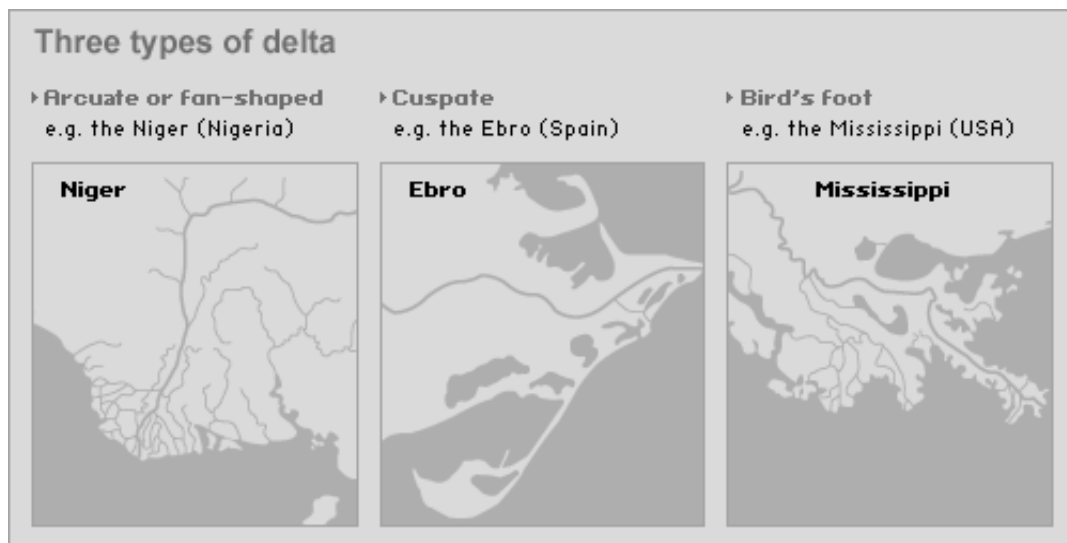
3. Lower-Course Features

In the lower course, the river has a high volume and a large **discharge**. The river channel is now deep and wide and the landscape around it is flat. However, as a river reaches the end of its journey, energy levels are low and **deposition** takes place.

The river now has a wide **floodplain**. A floodplain is the area around a river that is covered in times of flood. A floodplain is a very fertile area due to the rich **alluvium** deposited by floodwaters. This makes floodplains a good place for agriculture. A build up of alluvium on the banks of a river can create **levees** which raise the river bank.

Deltas are found at the mouth of large rivers - for example, the Mississippi. A delta is formed when the river deposits its material faster than the sea can remove it. There are three main types of delta, named after the shape they create:

- **Arcuate** - the land around the river mouth arches out into the sea, the river splits many times on the way to the sea, creating a fan effect.
- **Cusate** - the land around the mouth of the river juts out arrow-like into the sea.
- **Bird's foot** - the river splits on the way to the sea, each part of the river juts out into the sea, rather like a bird's foot.



Flooding

The likelihood of a river bursting its banks and flooding is determined by factors in the surrounding landscape, such as steepness of the river valley, the amount of vegetation and the prevailing rock-type.

Floods are usually triggered by heavy rainfall. A **flood hydrograph** shows the change in river **discharge** over a period of time after a storm.

Although the short-term impact of floods can be catastrophic, they can have positive long term effects as well, for example boosting soil fertility.

Flood management techniques include river engineering, afforestation, and planning controls to restrict urban development on flood plains.

1. Causes of flooding
2. Flood hydrographs
3. Case study: the Mozambique Floods
4. Floodplains and the impact of flooding
5. Flood management

1. Causes of Flooding

A flood occurs when a river bursts its banks and the water spills onto the **flood plain**. Flooding tends to be caused by heavy rain: the faster the rainwater reaches the **river channel**, the more likely it is to flood. The nature of the landscape around a river will influence how fast rainwater reaches the channel.

The following factors may encourage flooding:

- A steep-sided channel. A river channel surrounded by steep slopes causes fast **surface run-off**.
- A lack of vegetation or woodland. Trees and plants intercept precipitation (ie they drink water). If there is little vegetation in the **drainage basin** then surface run-off will be high.
- A drainage basin consisting of mainly **impermeable** rock. This will mean that water cannot **percolate**

through the rock layer, and so will run faster over the surface.

- A drainage basin in an urban area. Urban areas consist largely of impermeable concrete, which encourages overland flow. Drains and sewers take water quickly and directly to the river channel. Houses with sloping roofs further increase the amount of run-off.

2. Flood Hydrographs

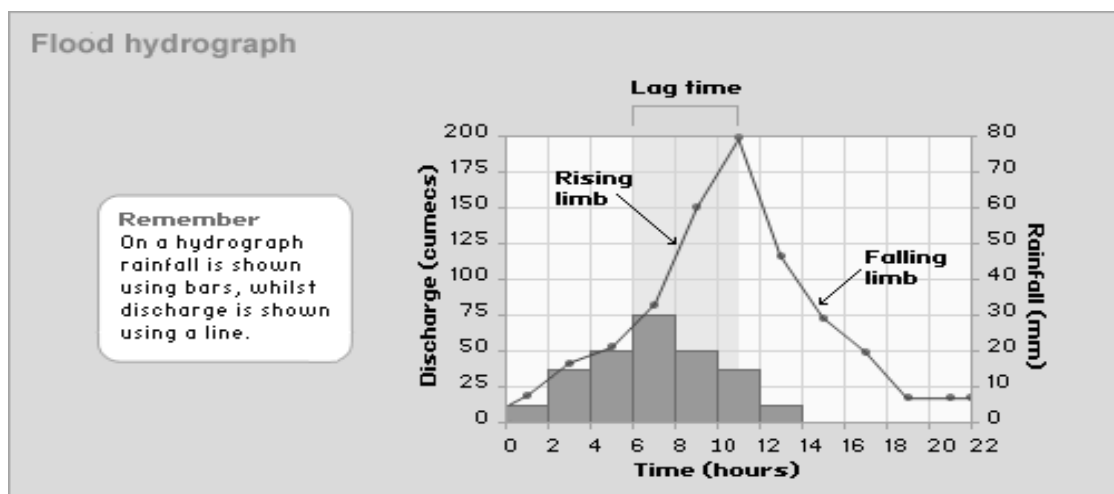
A **flood hydrograph** shows changes in rainfall and river **discharge** over time.

A hydrograph shows us the difference between the peak rainfall and peak discharge. This difference is called **lag time**. The greater the lag time, the less chance there is of a flood; while a short lag time shows that water has reached the river channel quickly.

A rise in discharge on the graph is called the **rising limb**; the **falling limb** shows a decrease in discharge.

The flood hydrograph below shows:

- rainfall peaking at six hours
- discharge peaking at 11 hours
- lag time - the time between peak rainfall and peak discharge - is five hours.



3. Case Study: the Mozambique Floods

The Mozambique floods of 2000 show that what happens in one country can very often affect another.

The flooding was triggered by exceptionally heavy rain in South Africa, lasting five weeks in early 2000. Botswana was particularly badly hit, receiving 75% of its yearly rainfall in three days. The rain from Botswana and other Southern African countries ran into the Limpopo, Zambezi and other rivers which flow through Mozambique to the sea. These rivers eventually burst their banks, causing severe flooding in Mozambique.

The results were disastrous: services were cut off, many people were stranded, lost their homes and died through drowning or disease. Urbanisation in South Africa may have contributed to the large quantities of surface water run-off swelling the rivers.

Draw a map of the southern part of Africa.

4. Floodplains and the Impact of Flooding

Floods can have many negative impacts, such as damaged homes, possessions lost and communications disrupted, but flooding can also have many positive impacts on an area as well - summarised in the table below.

Positive impact of flooding
Flooding deposits fine silt (alluvium) onto the floodplain, making it very fertile.
Fertile land is very good for agriculture.
People living near or on floodplains rely upon regular flooding to help support farming and therefore provide food.

LEDCs tend to be hit more badly than MEDCs by the effects of flooding. This is partly because LEDCs have more agriculture, and farming communities are attracted to fertile floodplains. LEDCs often do not have the resources to prevent flooding or to deal with the aftermath of flooding.



The Kariba dam on the Zambezi river. Part of its function is flood-control

5. Flood Management

Steps can be taken to manage flooding. Often these involve trying to lengthen the amount of time it takes for water to reach the river channel, thereby increasing the lag time. Flood management techniques can be divided into hard and soft engineering options.

'Hard' options tend to be more expensive and have a greater impact on the river and the surrounding landscape. 'Soft' options are more ecologically sensitive. The tables summarise the main flood management techniques.

(a) Hard Engineering Options:

<p>Dam construction:</p>	<p>Dams are often built along the course of a river in order to control the amount of discharge. Water is held back by the dam and released in a controlled way. This controls flooding.</p> <p>Water is usually stored in a <u>reservoir</u> behind the dam. This water can then be used to generate hydroelectric power or for recreation purposes.</p> <p>Building a dam can be very expensive, and sediment is often trapped behind the wall of the dam, leading to erosion further downstream. Settlements and agricultural land may be lost when the river valley is flooded to form a reservoir.</p>
<p>River engineering:</p>	<p>The river channel may be widened or deepened allowing it to carry more water. A river channel may be straightened so that water can travel faster along the course. The channel course of the river can also be altered, diverting floodwaters away from settlements.</p> <p>Altering the river channel may lead to a greater risk of flooding downstream, as the water is carried there faster.</p>

(b) Soft Engineering Options:

Afforestation:	Trees are planted near to the river. This means greater interception of rainwater and lower river discharge. This is a relatively low cost option, which enhances the environmental quality of the drainage basin.
Managed flooding (also called ecological flooding)	The river is allowed to flood naturally in places, to prevent flooding in other areas - for example, near settlements.
Planning	<p>Local authorities and the national government introduce policies to control urban development close to or on the floodplain. This reduces the chance of flooding and the risk of damage to property.</p> <p>There can be resistance to development restrictions in areas where there is a shortage of housing. Enforcing planning regulations and controls may be harder in LEDCs.</p>

Different interest groups have different views about flood management techniques:

- Governments and developers often favour large hard engineering options, such as dam building. Building a dam and a reservoir can generate income. Profits can be made from generating electric or leisure revenue.
- Environmental groups and local residents often prefer softer options, such as planting trees. This causes little damage to the environment and does not involve the resettlement of communities.

Water Management

Water is a finite resource, and the demand for it is growing all the time - hence the need to manage it. Water management means controlling the supply and distribution of available water, and monitoring water quality. In England and Wales this is carried out by local authorities.

Water supplies can be damaged by various kinds of pollution, and this can have a damaging impact on the environment and human health.




1. Demand for water
2. Managing water supplies
3. Damage to water supplies

1. Demand for Water

In all countries demand for water is growing:

- As technology and industry advance the demand for water grows.
- As LEDCs industrialise and urbanise their demand for water grows.
- Most MEDCs are becoming wealthier and so people are spending more money on technology and leisure. This increases demand for water.

The following table outlines some of the reasons why water is in high demand:

Demand for water	
	People demand water in their homes - this is called domestic demand .
	People demand water for industry - this is called industrial demand .
	People demand water for leisure and recreation uses e.g. swimming.

2. Managing Water Supplies

Water management involves:

- Providing people with a reliable source of water
- Maintaining the quality of water supplies

In places where there are persistent water shortages, managing the supply may also mean rationing water so that it is available to those who need it most.

In the UK there is enough water to meet demand, but water supplies are not evenly distributed around the country, and not necessarily located where demand is highest. For example some of the highest demand for water is in the highly-populated southeast of the country. However, the heaviest rainfall occurs in the relatively thinly-populated north and west. So in the UK water management means moving supplies around to meet demand.

In England and Wales, local water authorities manage water supplies. Each water authority is based around a major river basin. Each authority has responsibility for:

- collecting water supplies
- distributing water supplies
- monitoring pollution levels
- reducing pollution levels
- monitoring and regulating the use of rivers, lakes and reservoirs

There are several ways in which the water authorities can carry out their work:

- New reservoirs can be built to collect and store water
- Water can be transferred by pipe from a place of good supply to a place of high demand
- People can be educated to conserve water
- Maintaining pipe networks to prevent leakage
- Regulating and monitoring the amount of water people use through measures like hosepipe bans and water meters

3. Damage to water supplies

Water supplies can be damaged through pollution. The four main sources of water pollution are outlined in the table below:

Four sources of water pollution
Domestic sewage: Domestic sewage is taken from homes via pipes. It is piped to treatment plants. Sometimes leaks can occur and water can enter river drainage basins.
Agricultural waste: Chemicals used by farmers e.g. pesticides and fertilisers can enter water supplies by travelling to a river through the soil.
Industrial waste: Factories and industry premises often use a lot of water, e.g. for cooling. This water is often heated up because of its use by the factory. Warm water is then discharged back into the river. This can kill plant and animal life.
Waste produced by power stations: Like some factories, most power stations use large amounts of water for cooling. Again, warm water can be discharged into rivers. Power stations can also contribute to the problem of acid rain. This also pollutes rivers and lakes.

Water pollution can have a big impact on humans, animals and plants.

- The process of breaking down sewage can use up a lot of oxygen. This lack of oxygen in the water can kill plants and animals.
- River pollution can increase **nitrate levels**. Too many nitrates encourage the growth of **algae**. The algae use up oxygen supplies. Algae grows rapidly and blocks out valuable sunlight.
- Water pollution can also have an impact on human health. As well as affecting the quality of drinking water, pollution can also get into the human food chain - for example, via fish.