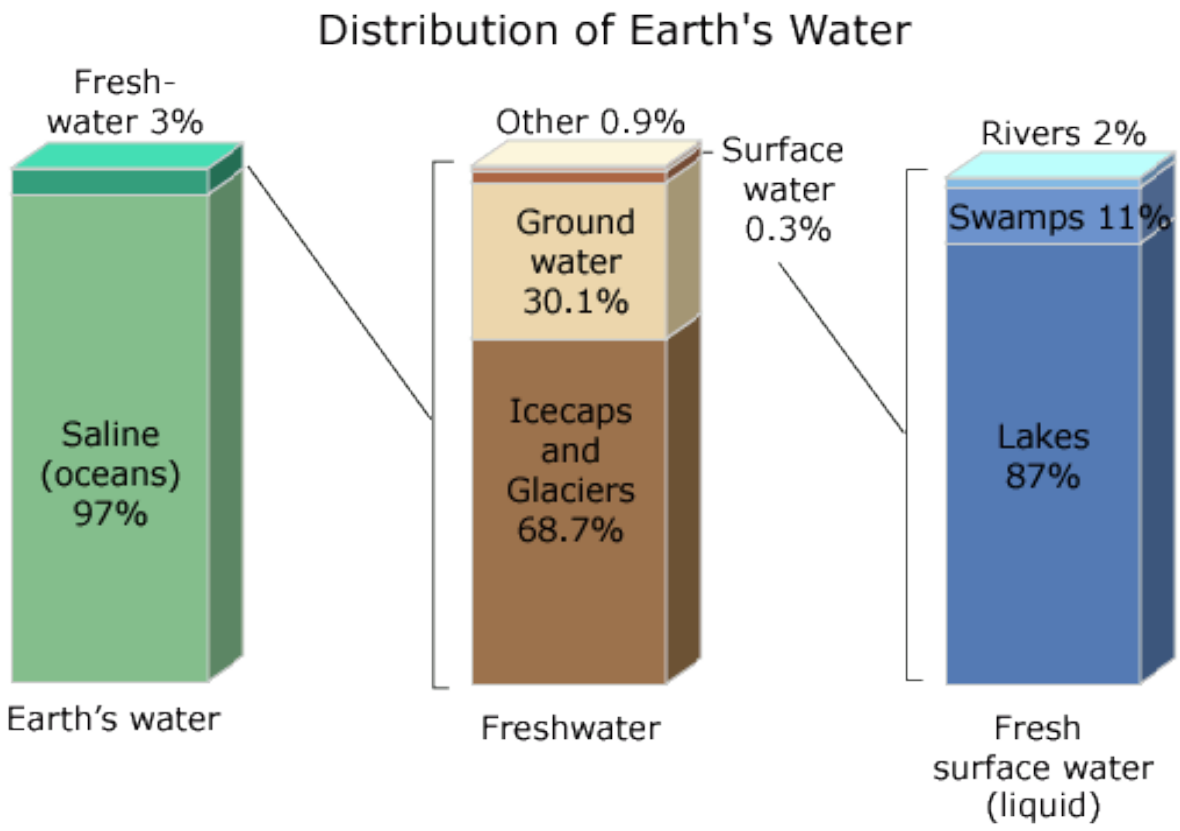
GCSE GEOGARPHY OCR B - REVISION GUIDE

Rivers and Coasts



- A system is a group of interacting, interrelated, or interdependent elements forming a whole.
- Open systems – exchange both energy and mass with their surroundings.

  The water system in your house is an example of an open system.
- Closed systems – are open to the transfer of energy only.

  The hydrological cycle is an example.

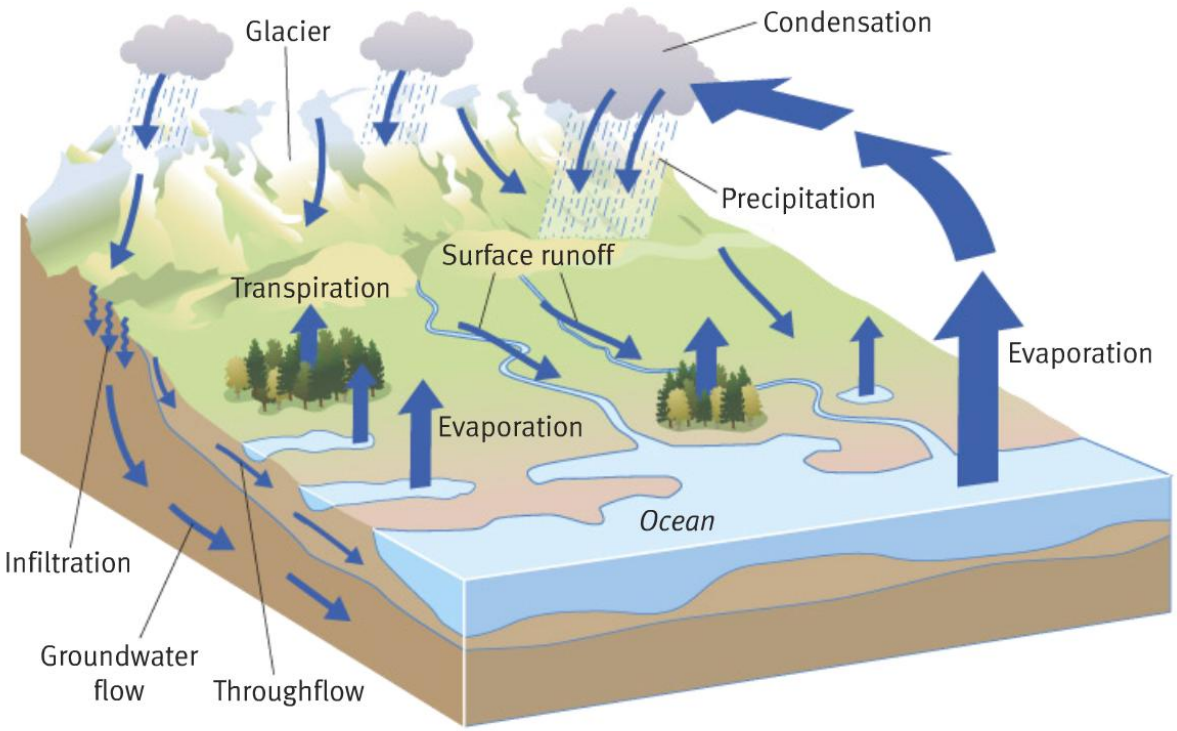


Figure 1.1 *The hydrological cycle.*

Evaporation	Water turning into water vapour
Transpiration	The loss of water from the leaves of plants
Precipitation	The deposition of water from the atmosphere in liquid (rain) or solid (snow) form
Surface Runoff	All water flowing on the earth's surface
Evapotranspiration	The sum of evaporation from the earth's surface together with the transpiration from plants
Infiltration	Seeping of water into the soil
Sustainable	Capable of existing in the long-term
Through-flow	Movement of water through the soil
Groundwater flow	The movement of water underground through rocks
Interception	Collection of water by vegetation
Water table	The upper level of underground water

Revision Task idea: Print off the table and cut it up – try to match the terms with the definitions

The River system/Drainage Basin System (OPEN)

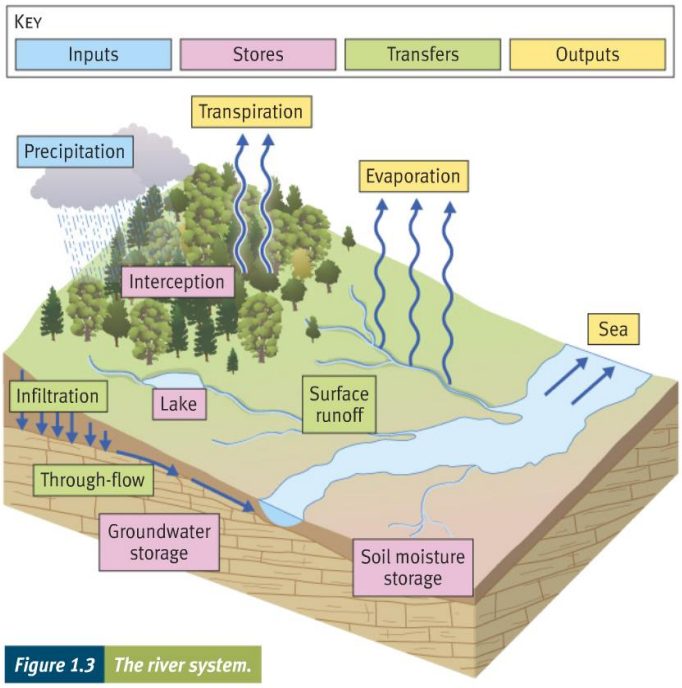


Figure 1.3 The river system.

The river system

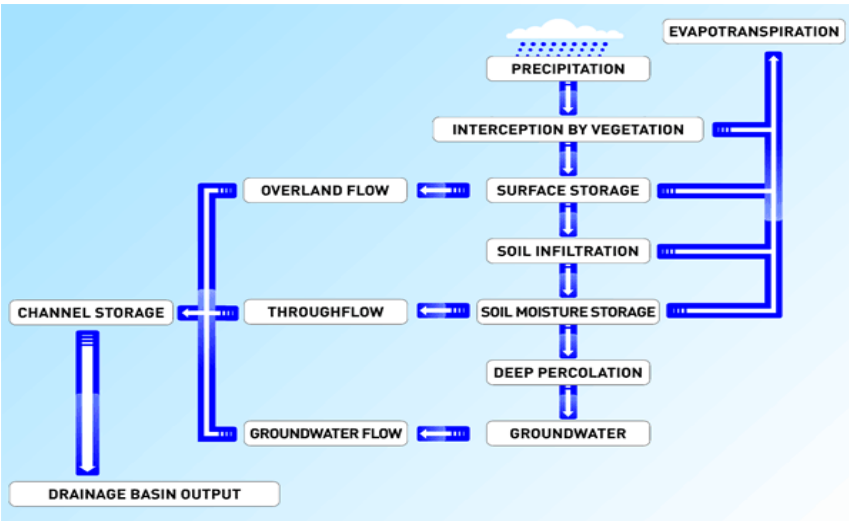
The river system is the part of the hydrological cycle operating on land. It is made up of four key parts:

1 **Inputs:** water entering the system through precipitation.

2 **Stores:** water stored in lakes, rocks, soil or vegetation. Storage can be temporary and is linked to the amount of rainfall.

3 **Transfers:** processes that move water through the system such as **surface runoff**, **infiltration** and underground flow.

4 **Outputs:** where water is lost to the system as rivers reach the sea or through **evapotranspiration**.



Revision Tip – draw the flow diagram opposite from memory and try and colour code store, inputs, outputs and transfers.

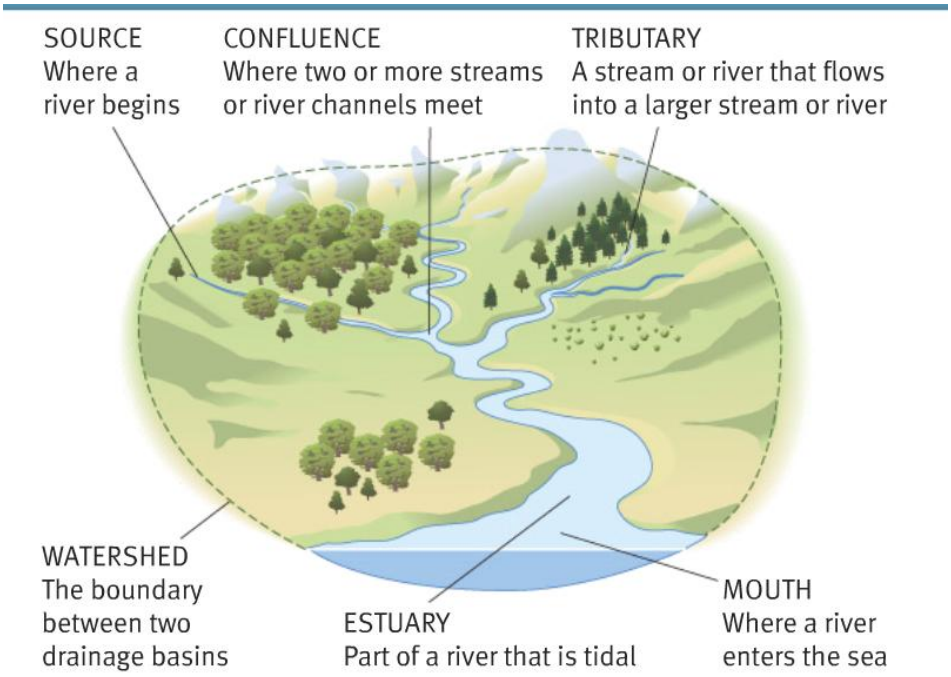
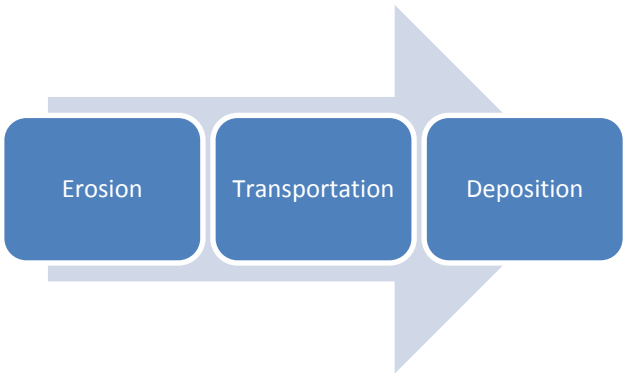


Figure 1.4 *Main features of a drainage basin.*



Processes within a river

Erosion

- **Hydraulic Action**

This process involves the force of water against the bed and banks.

- **Abrasion/Corrasion**

This is the process by which the bed and banks are worn down by the river's load. The river throws these particles against the bed and banks, sometimes at high velocity.

- **Attrition**

Material (the load) carried by the river bump into each other and so are smoothed and broken down into smaller particles.

- **Corrosion/solution**

This is the chemical action of river water. The acids in the water slowly dissolve the bed and the banks.

Transportation

How do rivers transport their load?

Bedload/ Traction	Boulders and pebbles are rolled along the river bed at times of high discharge.
Bedload/ Saltation	Sand sized particles are bounced along the river bed by the flow of water.
Suspension	Fine clay and sand particles are carried along within the water even at low discharges.
Solution	Some minerals dissolve in water such as calcium carbonate. This requires very little energy.

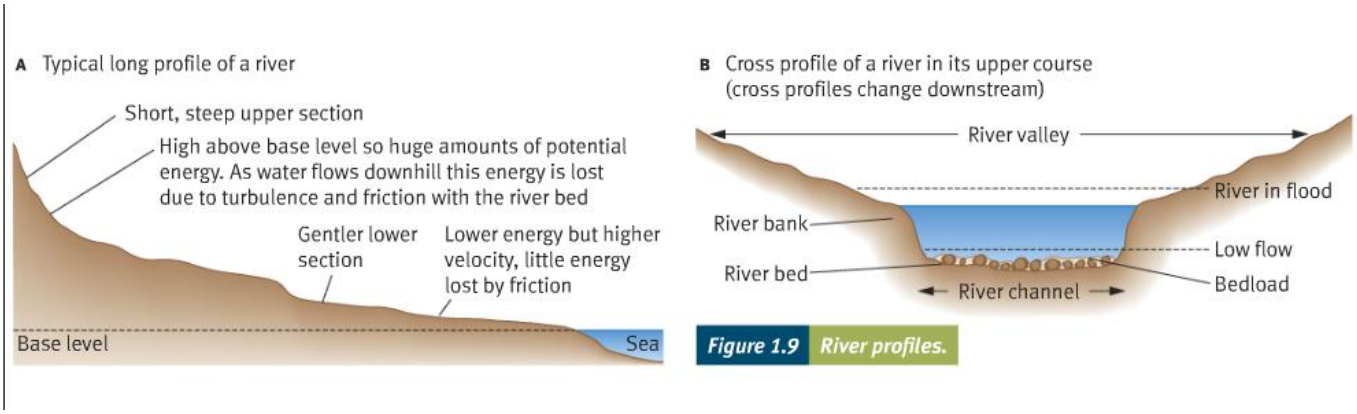
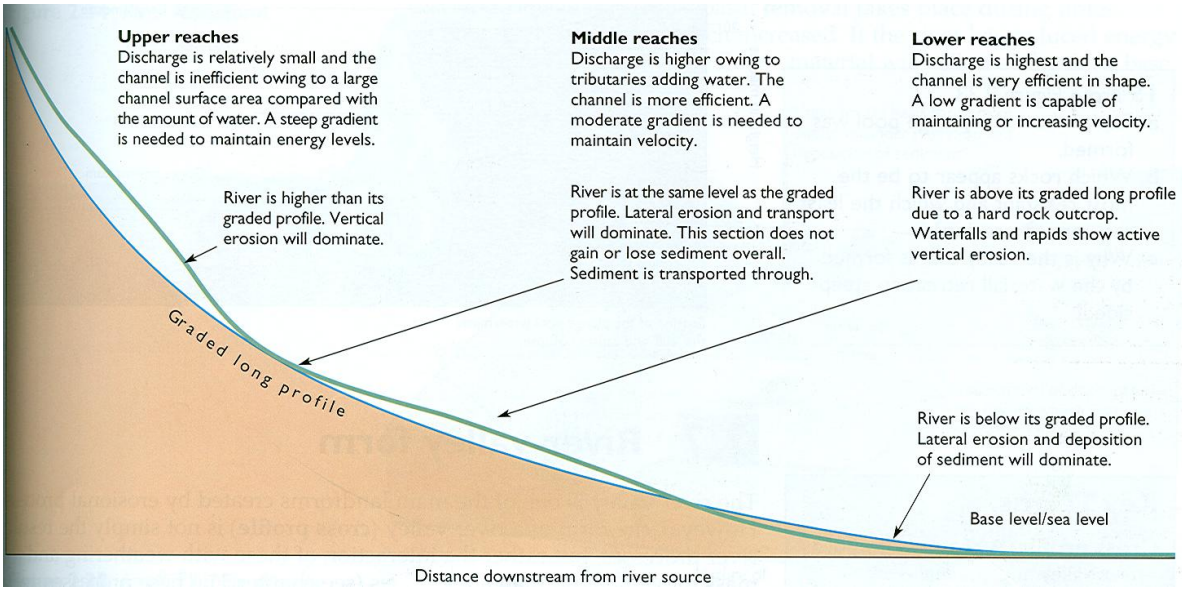
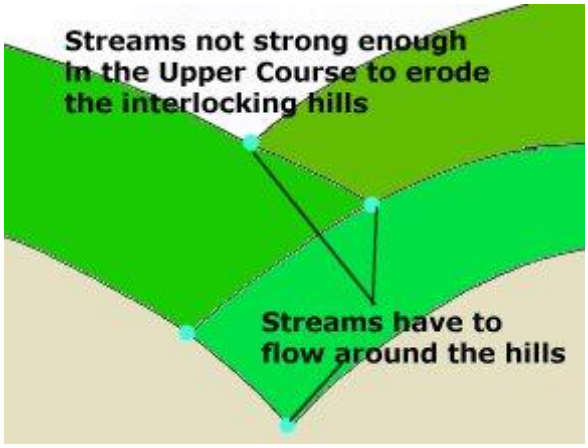


Figure 1.9 *River profiles.*



What landforms are created in the Upper Course?

1 - Interlocking Spurs



Interlocking spurs are alternate hills in the river valley. The river does not have a high water volume at this point and even though it is fast flowing, the river cannot laterally erode (sideways) to remove the spurs. Because of this, the river has to flow around the spurs, eroding vertically.

2 - Waterfall and Gorge

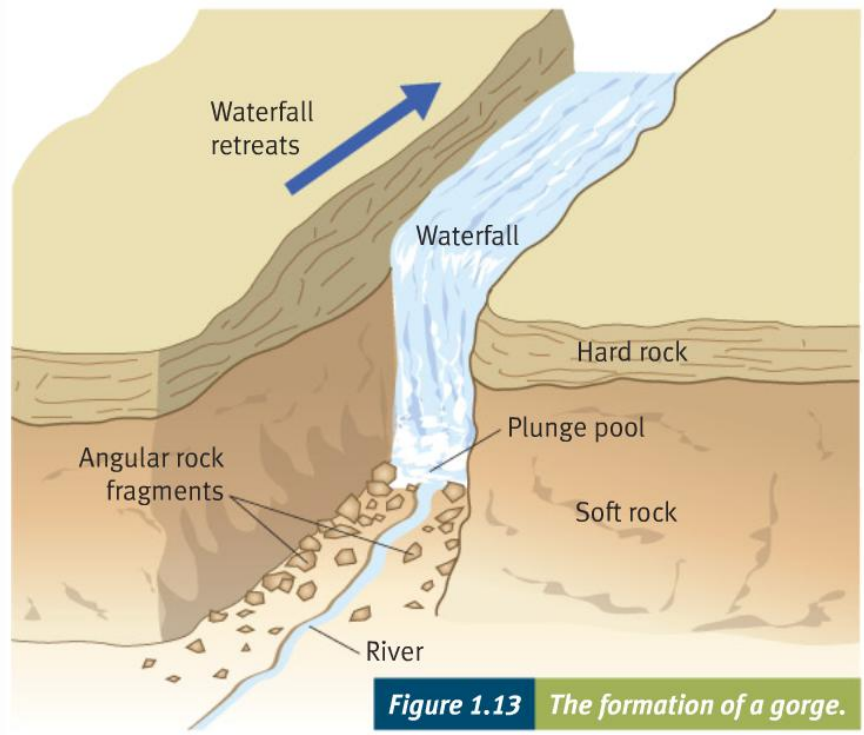


Figure 1.13 *The formation of a gorge.*

In the Upper Course, the river is not only eroding vertically (down) but towards its source (HEADWARD EROSION). This means the feature shown in the diagram above is created. The river erodes the softer rock underneath the harder rock on top faster, and this means the level of the land along the river's course becomes lower over time and the waterfall retreats back towards the source. The movement backwards leaves a second feature called a GORGE.

3 - V Shaped Valleys

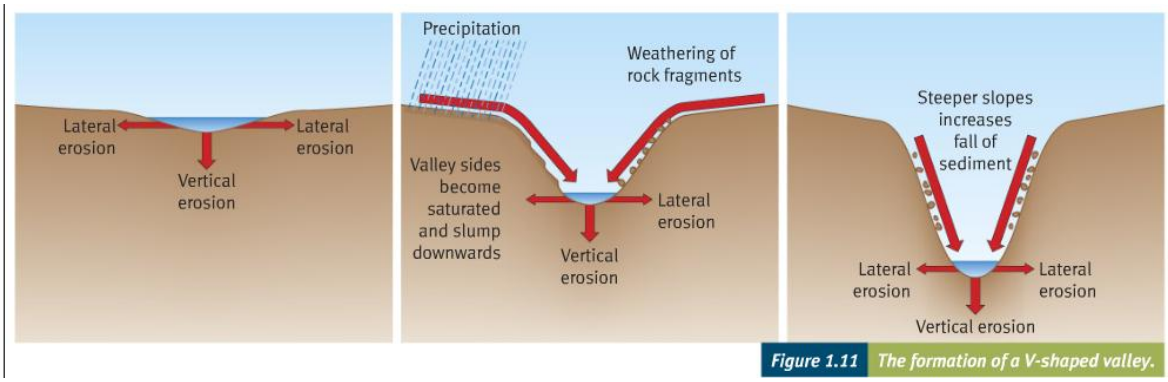


Figure 1.11 *The formation of a V-shaped valley.*

What landforms are created in the middle course?

1 - Meanders (1)

(Aerial View)

What is a meander?

Meanders are simply bends in a river's course. They usually occur in the middle and lower course of a river and because of the way they affect the structure of the water velocity in the river channel, meanders create specific features. The main two are slip-off slope and river cliff.

Slip-off slopes are features of deposition. They are formed on the inside of a meander where the velocity is slowest. The current swings to the outside of the bend (like a toboggan).

The river cliff is formed on the outside of the bend where the current is at its fastest. The current erodes (undercuts) the river bank and this collapses, leaving a vertical slope.

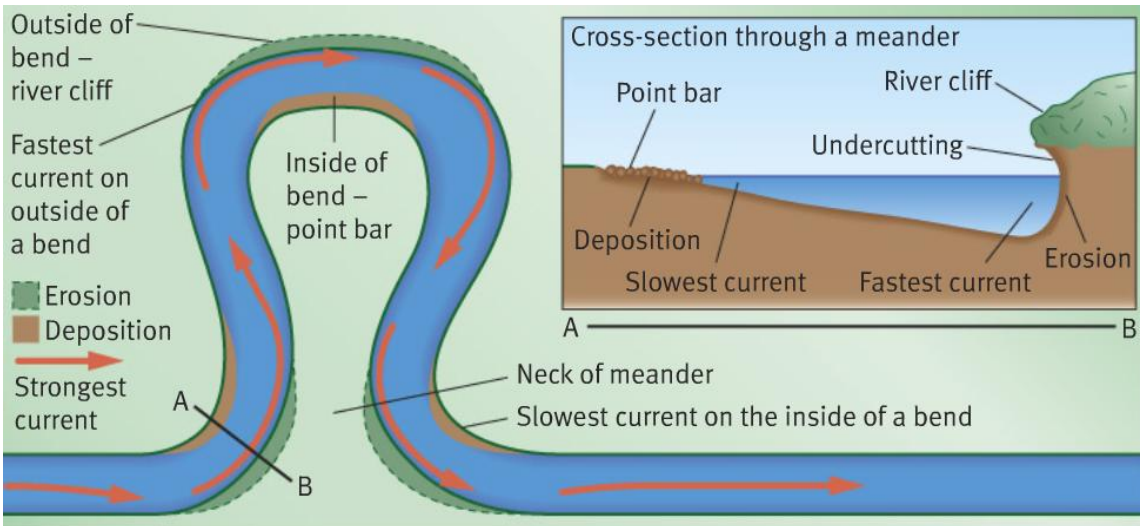
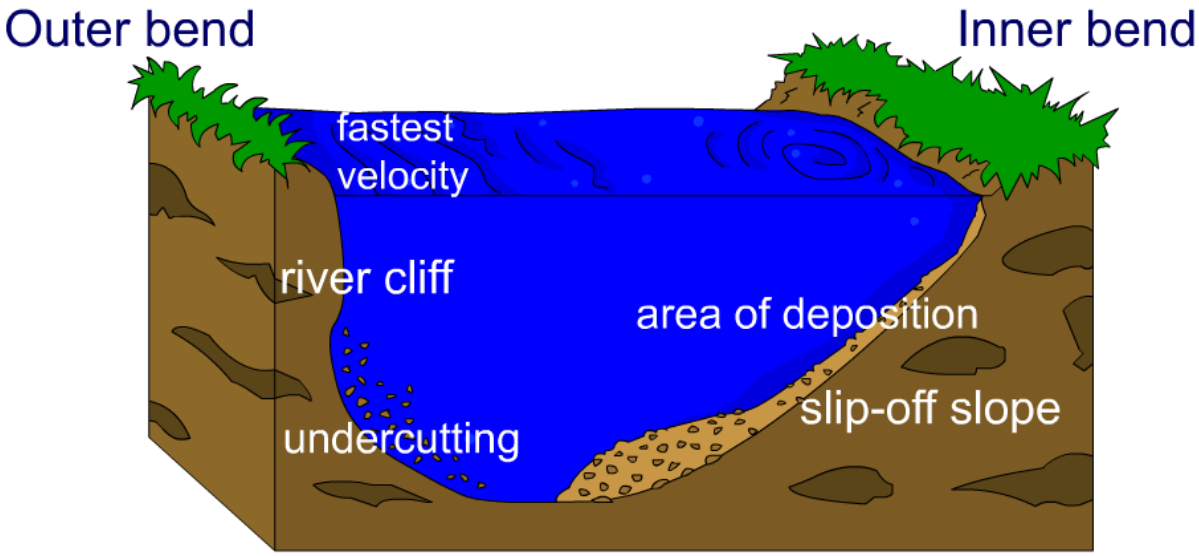


Figure 1.16 *The features of a meander.*

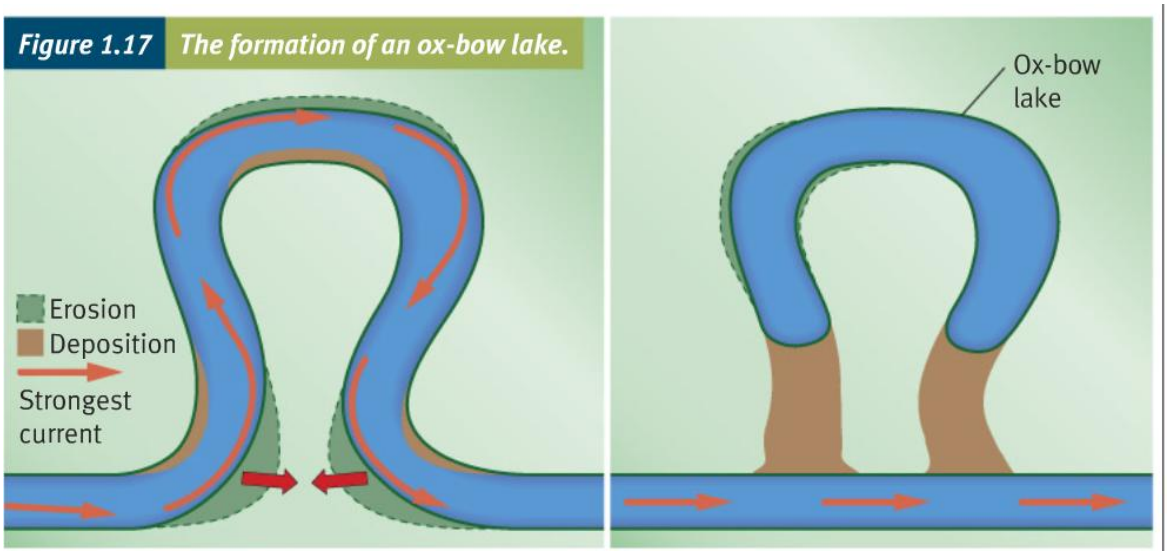
- Meanders are created by the lateral erosion that the river undertakes in this part of its journey to the sea.
- Water flows around the bend in the river and as it does so, it swings to the outside of the bend - this means the fastest flowing and highest volume of water is concentrated on the outside of the bend causing it to erode the bank at this point.

- On the inside of the, the flow is extremely slow and because of this lack of energy, the river is depositing.

1 - Meanders (2)



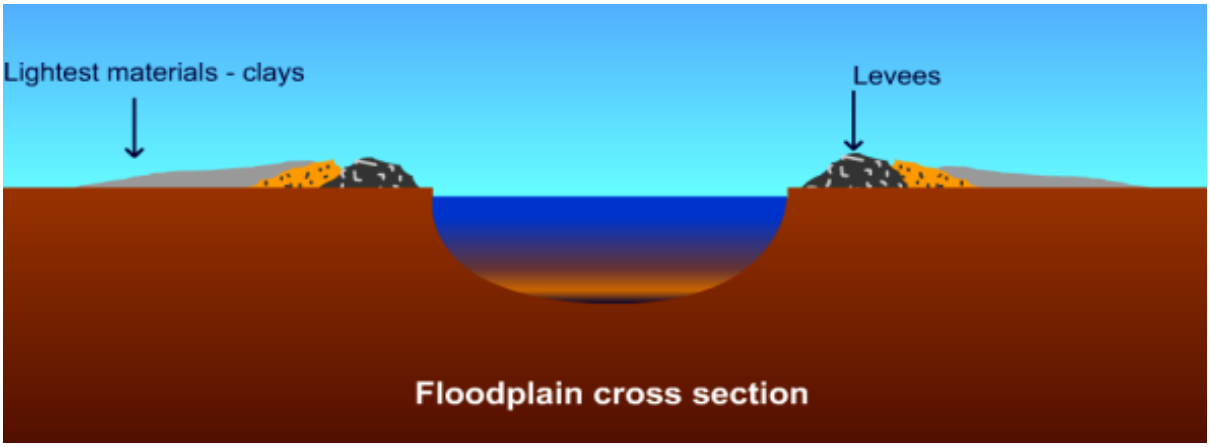
2 - Ox-Bow Lakes (Aerial View)



What landforms are created in the lower course?

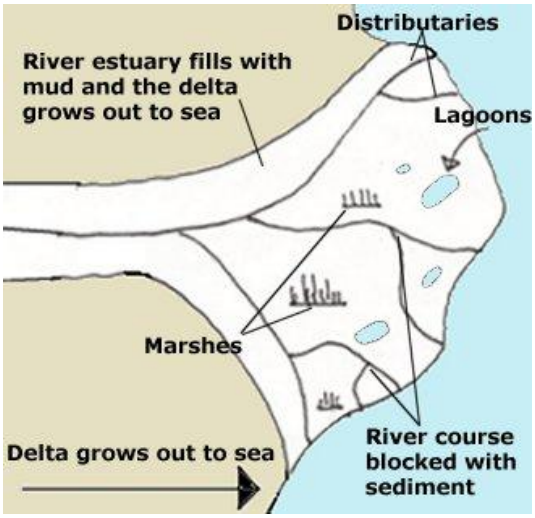
Floodplains

- **Floodplains and leveés are formed by deposition in times of river flood**
- **The river's load is composed of different sized particles**
- **When a river floods it deposits the heaviest of these particles first**
- **The larger particles, often pebble-sized, form the leveé**
- **The sands, silts and clays are sorted with the sands being deposited next, then the silts and finally the lightest clays**
- **Every time the river floods deposition builds up the floodplain**



3 - Delta

(Aerial View)

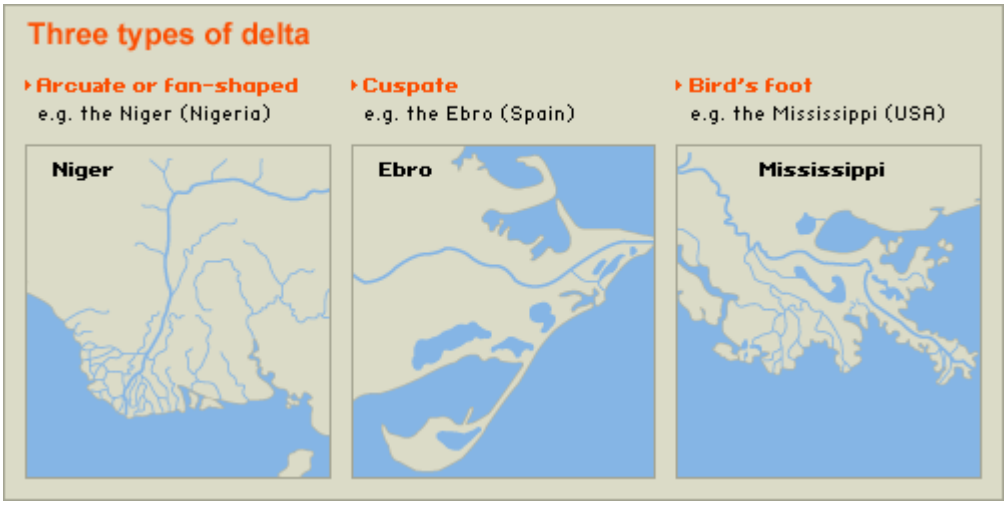


Delta are found at the **mouth** of a river, where the river meets the sea. At this point the river is carrying too much load for its velocity and so deposition occurs.

The top of the delta is a fairly flat surface. This is where the coarsest river load is dropped. The finer particles are carried into deeper water. The silt is dropped to form a steep slope on the edge of the delta while the clay stays in suspension until it reaches the deeper water.

Deltas are formed when the river meets the sea. The sea does not flow, so the river suddenly stops upon meeting the sea and loses its energy to carry load. The load is then deposited on the sea bed and over time, this builds up to form a new piece of land in the river mouth. The river then has to divert its flow into smaller 'distributaries' to reach the sea again. When it does so, more load is deposited and this builds the new delta out into the sea.

For a delta to survive, the river must bring a constant supply of material to deposit on the delta or it will be eroded away by the sea. Many human-made dams on rivers stop silt getting to deltas in this way.



- **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.
- **cuspate** - 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 reasons why some rivers flood

Rivers flood for many reasons. The main reasons are:

Precipitation:

Frequent cause of flooding = heavy rainfall over days

Ground becomes saturated and water runs over surface

Most serious flooding usually after short intense storms.

Flash floods usually occur after hot summer when ground dry so water can't infiltrate the surface.

Water held as snow also can cause floods when melts as temp' rises

Soil/underlying rock:

Rocks that let water through – Permeable

Rocks that don't let water through – Impermeable

Surface run-off and flood risk greater when river basin has impermeable soil and underlying rock.

Land use:

River basins with little vegetation cover = high flood risk

Forested basins = low flood risk

Human activity:

Deforestation (cutting down trees) and urban growth increasing flood risk

Bangladesh = increased flood risk due to deforestation in Himalayas

Impermeable tarmac surfaces and concrete surfaces are replacing fields and woodland – surface run-off increased

Flood Hydrographs

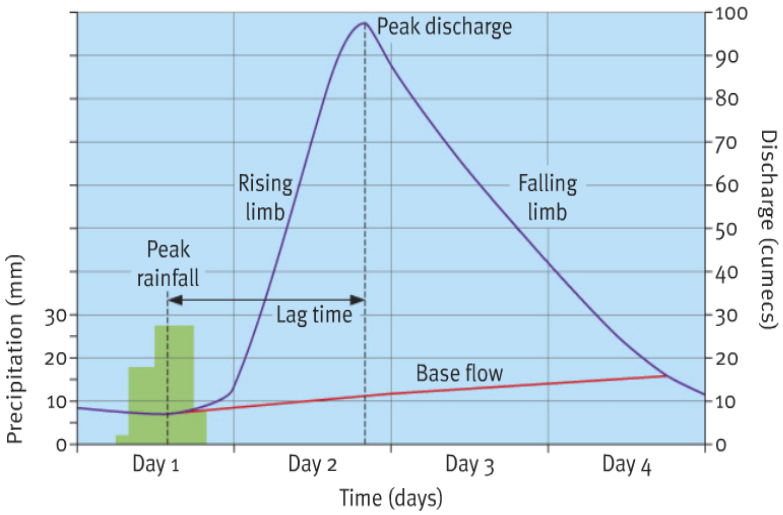
When it rains the water will either:

- be held in storage in lakes or the soil
- be lost through evapotranspiration
- make its way into rivers, either on the surface or underground.

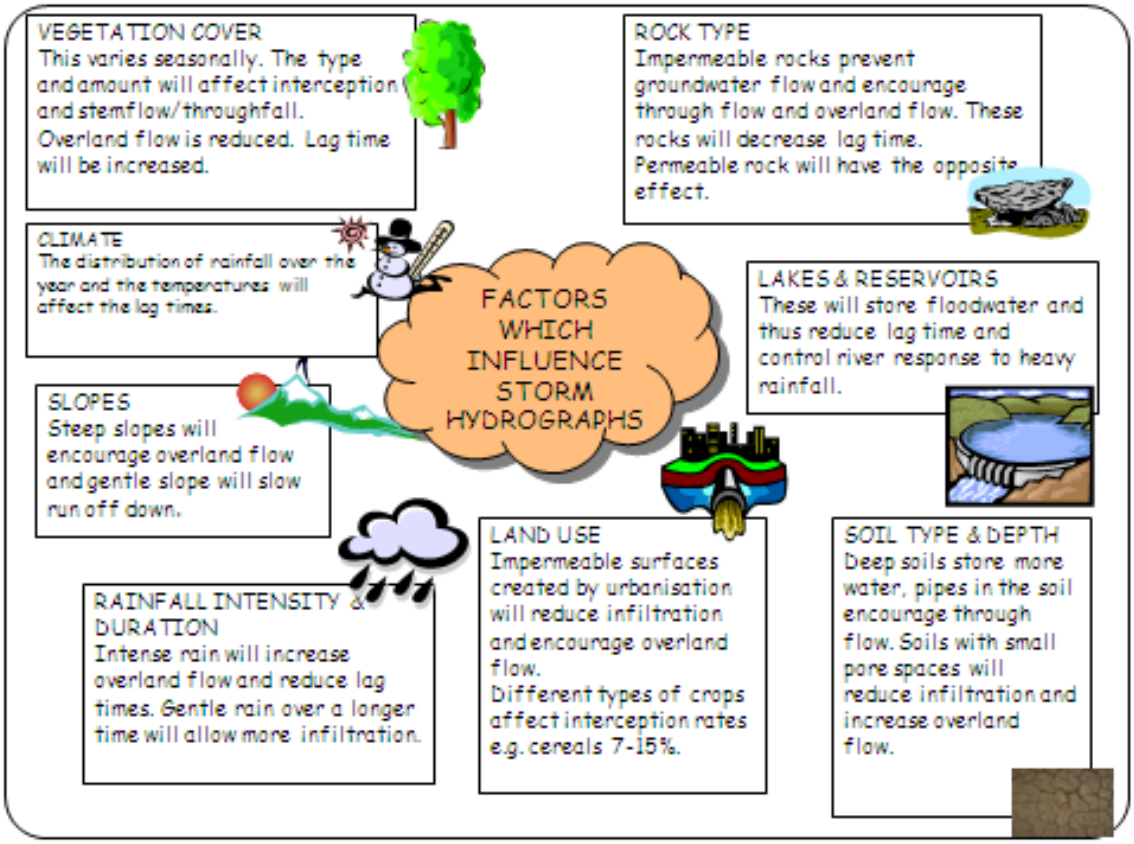
All precipitation that reaches a river is called runoff.

What is a hydrograph?

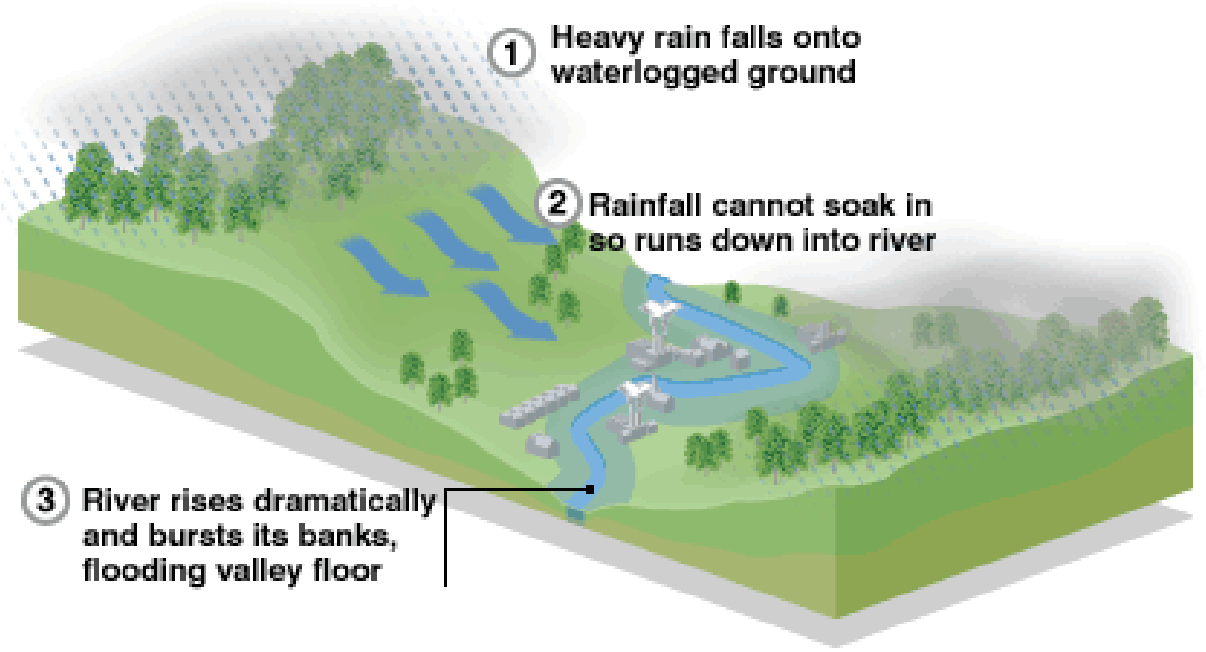
A hydrograph is used to show how the **discharge** of a river changes over time at a particular point on the river. A flood (or storm) hydrograph is usually drawn for a particular period of time when rainfall is unusually high. It shows how river discharge responds to short-term storm conditions (Figure 1.20).



Base flow – expected discharge for the time of year
Rising limb – increasing discharge as rainfall finds its way into the river
Falling limb – decreasing discharge as the river carries storm rainfall away
Lag time – time between the highest rainfall and the highest (peak) discharge



HOW FLASH FLOODS OCCUR



- The **Boscastle flood of 2004** occurred on Monday, 16 August 2004 in the two villages of Boscastle and Crackington Haven in Cornwall, England, United Kingdom.
- The villages suffered extensive damage after flash floods caused by an exceptional amount of rain that fell over the course of eight hours that afternoon.
- The flood in Boscastle was filmed and extensively reported but that in Crackington Haven was not mentioned beyond the local news. The Boscastle flooding was caused by rainfall which the river could not hold. The floods were the worst in local memory.

Rivers and Coasts

CASE STUDY The Boscastle flood 2004

Flash flooding in North Cornwall

GET STARTED

What impression does the term 'flash flood' suggest?

There are three main types of flooding event:

- **slow onset floods:** develop over a period of days and last a week or more
- **rapid onset floods:** occur more quickly, often in highland areas that feed large river catchments. This type of flood does not always last long, but can be destructive
- **flash floods:** an immediate response to short periods of intense rainfall. River levels rise without warning, often reaching a peak within minutes or hours. This type of flooding is very destructive and can cause a significant danger to life.

Fact file

The risk of flash flooding is increased by:

- building on flood plains
- **canalisation** of rivers, which increases flow rates
- development of catchments – especially on steep slopes
- removing trees and vegetation
- not maintaining drains and gullies.

Boscastle 2004 – a flash flood

The Boscastle flood of 2004, in North Cornwall, is an example of a flash flood – a rare event in the UK, where slow onset floods are more usual. The following article describes the day and the flood in Boscastle.

THINK ABOUT IT

In the UK freak storms are more likely to occur in June, July and August than in any other month of the year. Why do you think that is so?

Cornish village devastated by flash floods

The morning of 16 August started quietly for the residents of Boscastle, a village built at the confluence of the Valency and Jordan Rivers. Holiday-makers enjoyed the early morning sunshine as they sat and admired the beautiful scenery, or took time to shop for souvenirs in the local gift shop.

Within hours, the village was a disaster zone. At lunchtime, clouds began to gather and torrential rain fell on the surrounding hillsides. Within minutes, river levels rose and the three rivers that flow through Boscastle burst their banks – flooding the whole village.

It was estimated that over 300 mm of rain fell in 4 hours – creating a tide of water that swept through the village at nearly 40 mph, destroying everything in its path.

Figure 1.26 The village of Boscastle.

What were the causes of the Boscastle flood?

The natural characteristics of the area make the village of Boscastle vulnerable to flooding. The catchment is small (about 23 km²) and includes the relatively impermeable upland area of Bodmin Moor (Figure 1.27). Steep-sided valleys converge as they run towards the sea, funnelling water towards Boscastle. After heavy rainfall, surface run-off quickly reaches the rivers, increasing the likelihood of flash flooding.

During the summer of 2004, a number of unusual factors occurred. It had been an extremely wet summer, and by August the ground was saturated. On 16 August thundery clouds developed, the remnants of Hurricane Alex that had moved across the Atlantic Ocean. These clouds remained stationary over North Cornwall, because of converging winds. Throughout the afternoon an unprecedented amount of rain fell, estimated at over 1,400 million litres in just 2 hours – nearly 200,000 litres a second! The rainfall quickly made its way into rivers that rose at an alarming rate as they flowed towards Boscastle (Figure 1.28).

The flood risk in Boscastle had been increased by the amount of building alongside the river and also the construction of small bridges across it. These trapped material being washed downstream, creating a 'dam-like' effect.

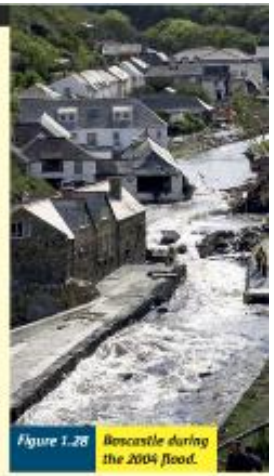


Figure 1.28 Boscastle during the 2004 flood.

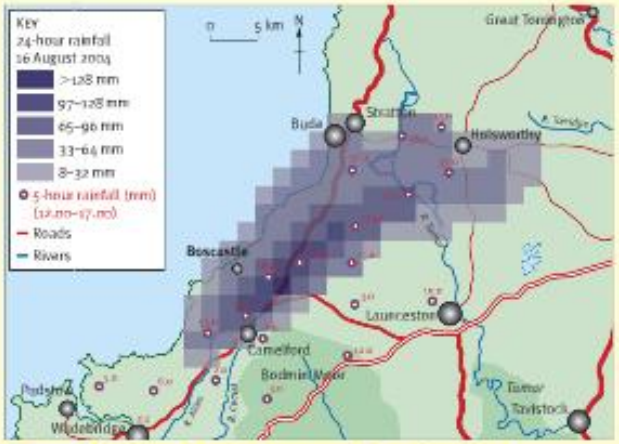


Figure 1.27 Rainfall map: Boscastle, 16 August 2004. (Source: Adapted from Crown Copyright data supplied by the MET Office)

Diary of events on 16 August 2004

12.15 Dry in Boscastle – dark clouds visible in Camelford.
12.30 Heavy rain begins to fall.
12.39 Flood-watch issued.
15.00 First of many power cuts caused by lightning.
15.30 River valency begins to flood.
15.46 Reported rise of 2 m in rivers in one hour.
15.53 Fire brigade mobilised.
16.00 All access roads closed.
16.30 A 3-m wall of water flows through Boscastle at 64 kph.
17.00 Floods reach peak level, cars swept away and buildings destroyed. Rain is so heavy that it is difficult to see.
17.10 Major incident declared – RAF search and rescue alerted.

ACTIVITIES

1 Why are flash floods the most dangerous type of flood?
2 Describe the village of Boscastle before the flood.
3 a Explain how both physical and human factors make Boscastle vulnerable to flooding.
  b What particular events in August 2004 triggered the flash flood?

RESEARCH LINK

Find out more about the Boscastle flood at the Met Office website.

PLENARY ACTIVITY

Could the Boscastle flood have been predicted? Would prediction have reduced the impact of the flood?

KEY TERMS

Canalisation – making a river more like an artificially built canal.

CASE STUDY Responding to the 2004 Boscastle flood

Reducing the impact of future floods

GET STARTED

View the video footage of the 2004 Boscastle flood on the internet. What evidence shows the power of the flood?

Boscastle had been affected by minor flooding events before 2004, but was unprepared for a flood of the scale that it experienced in August 2004.

The flood destroyed homes and businesses and swept away a hundred vehicles. Bridges and roads were damaged, and rescue services had to mount the largest peacetime rescue operation in Britain's history.

When the flood waters receded, thousands of tons of mud and debris were left throughout the lower part of the village. The effect on the local economy was devastating – the area relies on tourism for 90 per cent of its income, most of which is earned during the summer months.

Fact file

Effects of the Boscastle flood

- 25 business properties destroyed.
- 50 buildings flood damaged.
- 4 footbridges washed away.
- Visitor centre destroyed.
- Pavements and gardens damaged by the weight of the flood water.
- Stress and anxiety of local people.
- Insurance companies paid out an estimated £20 million to repair damaged property.

THINK ABOUT IT

It was estimated that the probability of a flood of the scale seen at Boscastle was 1 in 400 years!

Figure 1.29 *The effects of the Boscastle flood.*

Responding to the flood – planning for the future

After the 2004 flood in Boscastle the Environment Agency investigated the causes of the flood and found a number of human factors had added to the flood risk. These included:

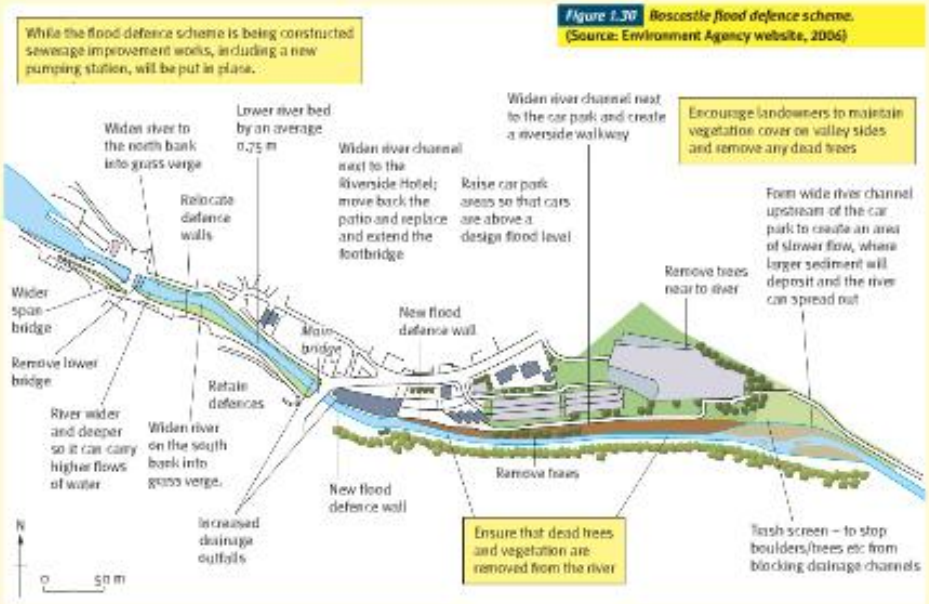
- the building of low bridges, which trapped boulders and trees that had been washed down the valley
- allowing trees to grow alongside the river; during the flood these were washed into the river, blocking channels
- artificially narrowing the river as it passed through Boscastle, reducing its carrying capacity
- building alongside the river and not allowing for its expansion during periods of high water flow
- removing vegetation from the sides of the valleys, which increased the rate of surface runoff and meant that rainfall reached the river very quickly.

In order to reduce the risks of future floods, a £4.6 million flood defence scheme was completed in 2008. The scheme aims to reduce the flood risk whilst preserving the character and amenities of the village. The main features of the flood defence scheme are shown in Figure 1.30.

RESEARCH LINK

Las Vegas (US) has been the victim of flash floods. Use the internet to investigate the causes and the impacts of flooding in Las Vegas.

Figure 1.30 *Boscastle flood defence scheme.* (Source: Environment Agency website, 2006)



ACTIVITIES

1 a Using Figure 1.29, describe the effects of the flood on the village of Boscastle.
  b Suggest how the flood affected the local economy.
2 Explain how the development of Boscastle increased the flood risk.
3 Explain how any five parts of the flood defence scheme might reduce the risk of future flooding.

PLENARY ACTIVITY

Explain the following statement: 'The flood defence scheme in Boscastle will not stop a flood event on the scale of 2004, but should reduce the impact'.

CASE STUDY Flooding in Bangladesh

Why is Bangladesh vulnerable to flooding?

GET STARTED

How would a serious flood in your local area affect your day-to-day life?

Bangladesh is one of the world's poorest and most densely populated countries. Its 140 million people live mainly on the flood plains of the rivers Ganges, Brahmaputra and Meghna. Over thousands of years, these three rivers have deposited millions of tons of silt, creating one of the most fertile areas in the world.

Bangladesh is affected by two types of flood:

- **river floods:** these happen every year and are a part of the natural cycle of snow-melt and **monsoon** rainfall. In some years, the monsoon rains are exceptionally heavy or prolonged – this is often the main cause of extreme flood events
- **coastal floods:** these are created by cyclones that build up in the Indian Ocean and move towards the Bay of Bengal. Water is funnelled toward Bangladesh creating a **storm surge** that may reach 6 m in height, flooding large areas of land. When combined with heavy rainfall and river flooding, the effects of cyclones can be totally devastating.

KEY TERMS

Irrigation – artificial watering of the land.

Monsoon – annual period of heavy rainfall in Asia.

Storm surge – extreme storm waves created by strong winds and low pressure, leading to higher sea levels and flooding.

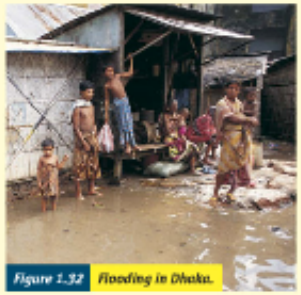


Figure 1.32 Flooding in Dhaka.

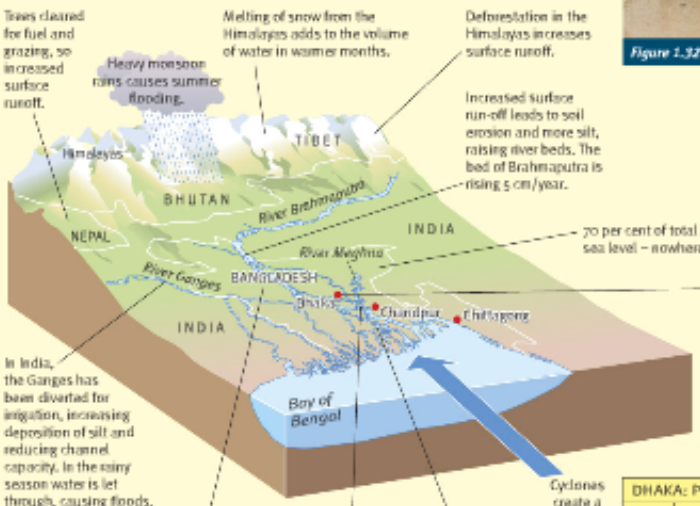


Figure 1.31 Causes of flooding in Bangladesh.

DHAKA: POPULATION	
1981	3.4 million people
1991	6.9 million people
2001	9.9 million people
2011	14.0 million people (estimated)

What factors increase the risk of flooding in Bangladesh?

Although physical factors increase the risk of flooding, there is an increasing number of human influences.

River floods

River flooding in Bangladesh is an annual occurrence linked to the rainfall pattern of the monsoon. The yearly flooding brings with it millions of tons of silt that adds to the soil's fertility. Flood water is used to **irrigate** farmland and is an important part of the yearly cycle of agriculture.

In a normal year, flood waters can be mostly controlled by using storm drains and embankments, and few people are badly affected. However, in some years the volume and pattern of rainfall is extreme and water levels rise dangerously high, inundating towns and cities and covering vast areas of the country. The most recent severe floods were in 1998 and 2004.

The 1998 flood

In 1998, the rains were exceptionally heavy and water levels reached record heights. The resulting floods covered nearly 60 per cent of the country and all the main river channels were flooded. The capital city of Dhaka and a number of regional cities were badly affected, with many parts of cities under water for weeks. Hundreds of people were killed and millions made homeless. Agricultural land and crops were lost or contaminated by polluted water. Over 900 bridges and 15,000 km of roads were destroyed by the floods. An investigation was carried out after the 1998 flood to try to assess the impact. Some of the results are shown in Table 1.1.

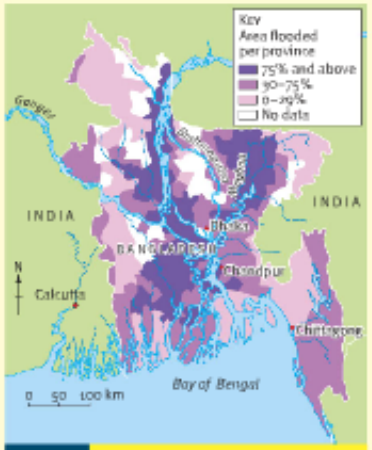


Figure 1.33 The 1998 flood.

PLENARY ACTIVITY

Why is monsoon flooding both a necessity and a threat to Bangladesh?

Table 1.1 Impact of the 1998 flood in Dhaka

Items affected	Percentage of people affected by the flood in Dhaka			Recovery after 1 year
	Fully affected	Partly affected	Not affected	
Loss of food	1	16	83	Fully recovered – 40%
Loss of clothing	4	26	70	Partly recovered – 43%
Loss of housing	17	61	22	Not recovered at all – 17%
Loss of income	28	42	30	

ACTIVITIES

1 a Use the following data to draw a climate graph for Bangladesh (line graph for temperature, bar graph for rainfall).

Table 1.2 Temperature and rainfall, Bangladesh

Month	J	F	M	A	M	J	J	A	S	O	N	D
Temperature (°C)	22	24	28	32	32	30	29	30	30	29	25	24
Rainfall (mm)	10	25	40	50	140	290	320	330	250	120	40	5

b In which months of the year are river levels likely to be highest?

2 Why do so many people live in areas that are prone to flooding in Bangladesh?

3 Draw a table with two columns headed 'Physical' and 'Human' and complete it by identifying the physical and human causes of flooding in Bangladesh.

4 Describe the effects of the 1998 flood in Bangladesh.

Fact file

- During the last 50 years, at least eight extreme flood events have occurred in Bangladesh, each one affecting over 50 per cent of the total land area.
- Extreme flood events usually last between 15 and 45 days.

CASE STUDY Responding to the flood hazard in Bangladesh

How can the risk of flooding in Bangladesh be reduced?

GET STARTED

How would your life be affected if your area had a severe flood every year?

The river floods in 2004

In 2004, the monsoon arrived early and heavy rain fell from late June. By early July, the Brahmaputra and Meghna Rivers had risen above their danger levels. A week later, the flood waters had drained southwards and the capital city of Dhaka had begun to flood. The flood waters over-topped many flood protection embankments, inundating areas not provided with storm drainage systems. By mid-August, the flood waters had fallen in most areas, leaving contaminated mud and general destruction. Government figures estimated that the flood had affected 36 million people.

UN fears malnutrition after flooding in Bangladesh

Up to 1.5 million women and children are at risk of 'acute malnutrition' after Bangladesh's worst floods for six years, two UN agencies said yesterday.

Monsoon rains and floods inundated half the country in July and August, killing 766 people and affecting more than 30 million.

Without intervention, the number of 'acutely malnourished children' in the flooded areas could rise to more than a million within eight weeks, a joint statement by Unicef and the World Food Programme said.

It said that more than 500,000 pregnant women and breast-feeding mothers were likely to face 'serious malnutrition', and that babies born to malnourished women were more likely to become ill.

(Source: Guardian website, 2004)

Aftermath of the 2004 Bangladesh flood: WaterAid report

Dhaka, the capital of Bangladesh, was a city swimming in sewage. More than half the city was submerged when the floodwaters began pouring, first from the swollen rivers as they burst their banks, then from overburdened sewers disgorging back on to the streets.

(Source: WaterAid website)

THINK ABOUT IT

The word 'monsoon' comes from the Arabic word for 'season'. Looking back at Table 1.2, which months are the monsoon months in Bangladesh?

RESEARCH LINK

Use the internet to find out more about the causes and effects of the 2004 flood in Bangladesh.

Reducing the flood risk

Historical records show that the frequency and scale of flooding in Bangladesh has increased in the last 50 years, increasing the need for flood planning and preparation. However, despite more use of flood control measures, the cost of damage caused by flooding has steadily risen.

The following examples look at two approaches to flood management: Figure 1.34 describes part of the 'Preparedness Programme' being supported by Oxfam. Figure 1.36 shows part of the Dhaka Integrated Flood Protection Project, a $100 million government project that includes a number of **hard engineering** methods.

Fact file

Cities where over 60 per cent of the land is covered by roads and buildings are six times less likely to flood if they have a storm drain system.

KEY TERMS

Hard engineering – use of concrete barriers to control water

- **Cluster villages:** a cluster village is a village that has been raised 2 m above water level. Each village houses between 25 and 30 families.
- **Raised homestead:** individual homes are raised 2 m above water level on earth banks. The earth banks are planted with grass to prevent erosion.
- **Flood shelter:** around 2 hectares of raised land where people can bring livestock. Each shelter has space for over 100 families and includes a community room and toilets.
- **Rescue boats:** rescue boats are located around the areas most at risk from flooding and near to flood shelters
- **Radios:** radios given to each 'preparedness committee'. Flood warnings can be issued and the preparedness plan put into action.

Figure 1.34 Part of the Preparedness Programme.

ACTIVITIES

1. Describe the immediate and longer-term effects of the 2004 floods in Bangladesh.
2. Explain how the Dhaka Flood Protection Project will reduce the risks of flooding.
3. Describe and explain how the Flood Preparedness Programme will help people in rural areas.

PLENARY ACTIVITY

Why are developing countries often more badly affected by floods?

Figure 1.36 Dhaka Integrated Flood Protection Project. (Source: Asian Development Bank, 2002)

There is an ongoing debate about which method of flood protection should be used. Hard engineering can control large amounts of water, but it is expensive and can create environmental problems – for example, building embankments may reduce the flow of water to farming areas. Smaller-scale projects can be used across a wider area, but may have limited effect in large urban areas.

River Management

Steps can be taken to manage flooding. Often these steps 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.

Hard engineering options

Dam construction	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. Water is usually stored in a reservoir behind the dam. This water can then be used to generate hydroelectric power or for recreation purposes. Building a dam can be very expensive. 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.
River engineering	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. Altering the river channel may lead to a greater risk of flooding downstream, as the water is carried there faster.

Geography

River flooding and management issues

Page:

River management

Hoover Dam from the air

Steps can be taken to manage flooding. Often these steps 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.

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Hard engineering options

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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	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. 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.

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. Soft options cause little damage to the environment and do not involve the resettlement of communities.

- Effective flood management strategies should be economically, environmentally and socially sustainable. Sustainable strategies allow management without compromising the needs of future generations.

Glossary of terms

Term	Definition
Hydrological cycle	The cycle by which water moves between the earth's surface and the atmosphere
Closed system	No loss occurs from the system. The cycle does not lose any water, it has a fixed amount
Open system	Loss of matter occurs from the system, water lost from the drainage basin system
Drainage basin	The area of land drained by a river and its tributaries
Watershed	Boundary of the drainage basin. A ridge of high land. It separates one drainage basin from neighbouring drainage basins
Inputs	Water enters system through precipitation
Outputs	Water is lost from system by rivers carrying it to the sea or by evapotranspiration
Precipitation	Process by which water is transferred from the atmosphere to the earth's surface in the form of rain, snow sleet or hail
Interception	Incoming precipitation is trapped by vegetation and/or buildings
Overland flow or surface run-off	Process by which water moves downslope over the earth's surface
Infiltration	Process by which water enters the earth's surface
Percolation	Process by which water moves vertically downwards through soil and rock
Throughflow	Process by which water moves downslope through the soil under the influence of gravity
Water table	The line marking the upper limit of saturation in the ground
Groundwater	Water filling all pore spaces below the water table
Groundwater flow	Process by which groundwater moves downslope below the water table under the influence of gravity
Transfers	Water moves through the system from one place to another
Storage	Water is held within the system
Source	A point at which a river begins
Tributary	A small stream or river flowing into a main river
Confluence	A place where a tributary joins the main river
Mouth	The end of a river where it meets the sea
Attrition	Material is moved along the river bed. It collides with other

	material and breaks into smaller pieces
Corrasion	Fine material rubs against the river bank. The bank is worn away and collapses
Corrosion	Some rocks forming the banks ands bed of a river are dissolved by acids in the water
Hydraulic action	The sheer force of water hitting the river banks
Traction	Large rocks and boulders are rolled along the river bed
Saltation	Smaller stones are bounced along the river bed in a leap-frogging motion
Suspension	Fine material, light enough to be carried by the river
Solution	Dissolved material transported by the river
Meander	Sweeping curve in the course of a river
Oxbow lake	Curved lake found on the flood plain of a river. Caused by the loops of meanders being cut off at times of flood and the river subsequently adopting a shorter course
Lateral erosion	Erosion that occurs sideways instead of vertically
Levees	Naturally formed raised bank along the side of river channel
Flood plain	Area that suffers periodic flooding along the course of the river.
Delta	Feature composed of silt formed when sediment is deposited at the mouth of the river, caused by the slowing of the water on entering the sea.
Distributary	River that has branched away from a main river.
Aquifer	A rock which stores significant amounts of groundwater in its pore spaces
Evaporation	Process by which water is transferred from the earth's surface to the atmosphere
Transpiration	Process by which water is transferred from vegetation to the atmosphere via stomata on leaves
Evapotranspiration	The total output of water vapour from the drainage basin system to the atmosphere through the combined processes of evaporation and transpiration
Storm hydrograph	Graph showing discharge against time following a single precipitation event. Comprises of a rising limb and a recession limb
Lag time	The time between peak precipitation and peak discharge
River discharge	The volume of water passing a given point at a given time. Calculated by multiplying cross-sectional area by average velocity. Expressed in cumecs (m/s^3)

Suspended load	Solid particles carried within the current, but not touching the bed
Bedload	The coarser material carried along the bed of a stream by the force of the water.

Rivers and Coasts