Topic 4
The UK's evolving physical landscape

Your exam

- Topic 4 The UK's evolving physical landscape makes up Section A in Paper 2, UK geographical issues.
- Paper 2 is a 90-minute written exam and makes up 37.5% of your final grade. The whole paper carries 94 marks (including 4 marks for SPaG) – questions on Topic 4 will carry 27 marks.
- You must answer all parts of Section A. Section B contains questions on The UK's evolving human landscape (pages 88–108), and Section C contains questions on fieldwork, where you have a choice of questions (pages 109–129).

Tick these boxes to build a record of your revision

Your revision checklist

Spec Key Idea	Detailed content that you should know	1	2	3
4.1 Geology and past processes have influenced the physical landscape of the UK	• Role of geology, tectonic and glacial processes in upland and lowland landscapes			
	• Characteristics and distribution of sedimentary, igneous, and metamorphic rocks			
4.2 A number of physical and human processes work together to create distinct UK landscapes	• Processes forming distinctive upland and lowland landscapes			
	• Why distinctive landscapes result from human activity			
4.3 Distinctive coastal landscapes are influenced by geology interacting with physical processes	• How geological structure and rock type influence erosional landforms			
	• How climate and erosional processes create coastal landscapes and retreat			
	• How sediment transport and deposition influence coastal landforms			
4.4 Distinctive coastal landscapes are modified by human activity interacting with physical processes	• How human activities affect coastal landscapes			
	• How physical and human processes change one named coastal landscape			
4.5 Human and physical processes present challenges along coastlines, with a variety of management options	• Why there are increasing risks from coastal flooding			
	• Costs and benefits of managing coasts using hard and soft engineering, and more sustainable approaches			
4.6 Distinctive river landscapes have different characteristics formed by interacting physical processes	• Channel size and shape along upper, middle and lower courses of rivers			
	• Erosion, transport and depositional processes in river landform formation			
	• How climate, geology and slope processes affect river landscapes			
	• Storm hydrographs			
4.7 River landscapes are influenced by human activity interacting with physical processes	• How human activities affect storm hydrographs			
	• Processes leading to flooding on one UK river			
4.8 Some rivers are more prone to flood, with a variety of river management options	• Risks and threats of river flooding			
	• Costs and benefits of managing floods using hard and soft engineering			

You need to know:

- how geology and past processes have created upland landscapes in the UK.

Student Book
See pages 112–113

Explaining the past

Malham Cove in the Yorkshire Pennines is a spectacular UK upland area which was once a huge waterfall higher than Niagara Falls. It is formed of limestone, made up of crushed coral shells. So how did this get to be 300 m above sea level?

The landscape around Malham Cove results from three factors, summarised in Figure 1.

Geology	• **Carbon dating** has proved that fossils in the limestone at Malham Cove lived in the tropical seas that covered the UK during the Carboniferous period. • The limestone was formed by compaction of skeletons of marine organisms. • Other strata were deposited on top of the limestone, e.g. sandstone and shale. • The highest peaks consist of rocks most resistant to **erosion** (Figure 2).
Tectonic processes	Over 300 million years ago, tectonic processes affected the Pennines. 1. The plate on which the UK sits moved away from the tropics. 2. Convection currents uplifted rocks from beneath the sea to become land and caused rocks to snap, tilt and move along **faults**. Some parts were raised more than others, forming a fault scarp as at Giggleswick Scar.
Glaciation	The glaciers of the most recent Ice Age (10 000 years ago) caused: 1. River valleys to deepen and widen (Figure 2). 2. Features such as Malham Cove when they melted.

Figure 1 *Factors in the formation of the landscape around Malham Cove*

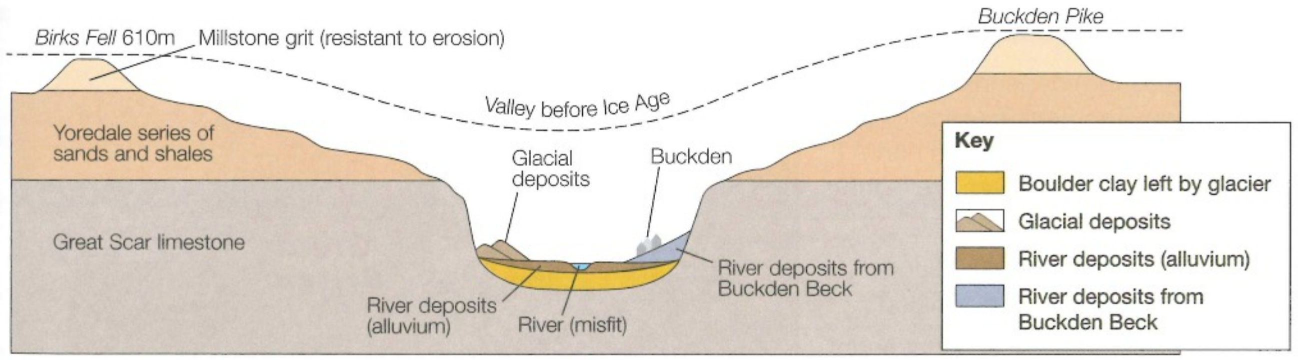


Figure 2 *Geological cross section of Wharfedale, a valley in the Pennines. Notice the U-shaped valley deepened and widened by a glacier.*

Big Idea

The UK's upland and lowland landscapes are the result of geology, tectonic processes and glaciation.

Upland and lowland landscapes

- Upland areas of the UK consist of resistant igneous, metamorphic and some sedimentary rocks.
- Lowland areas of the UK generally consist of younger, less resistant sedimentary rocks.

Six Second Summary

- The landscape around Malham Cove results from its geology, past tectonic and glacial processes.
- The limestone at Malham Cove was created in the Carboniferous period when the UK was covered by tropical seas.
- The Pennines were affected by three tectonic processes.
- Past glaciers changed the shape of river valleys and left features like waterfalls.

Over to you

Name **a)** three ways in which rock types influence the Pennine landscape, **b)** three tectonic processes which have affected the Pennines, and **c)** two effects of the most recent Ice Age.

You need to know:

- about the relationship between landscape and geology
- the characteristics and distribution of rock types in the UK.

Student Book
See pages 114–117

The shape we're in

The height and shape of the UK's landscape depends on the rocks from which it is formed.

Geology has played a role in the economy:

- Cornwall's tin and copper made it wealthy
- coal helped make the UK the world's first industrial nation.

Big Idea

There is a direct link between geology and the shape of the UK's landscape.

How do rocks differ?

There are three main types of rock (Figure 3).

- **Igneous** – the oldest rocks, formed from lavas and deep magmas. Most are resistant to erosion.
- **Sedimentary** – formed from sediments eroded and deposited by rivers or the sea. Some are resistant, others crumble easily.
- **Metamorphic** – sedimentary rocks that were heated and compressed during igneous activity. They are hard and resistant.

Rocks and landscape

Relief (landscape) depends greatly on rock type. The 'Tees-Exe line' on Figure 1 joins the River Tees in north-east England with the River Exe in the south-west. Notice that:

- west of the line is mainly upland
- east of the line is mainly lowland.

Now look at Figure 2. Notice that north and west of the Tees-Exe line:

- most rocks are older
- the most resistant igneous and metamorphic rocks are found
- there are more faults; these areas were uplifted by tectonic activity.

East of the line, most rocks are:

- younger
- weaker sedimentary rocks, which erode easily. The limestone here is younger and less resistant than Carboniferous limestone.

Figure 1 *UK relief map*

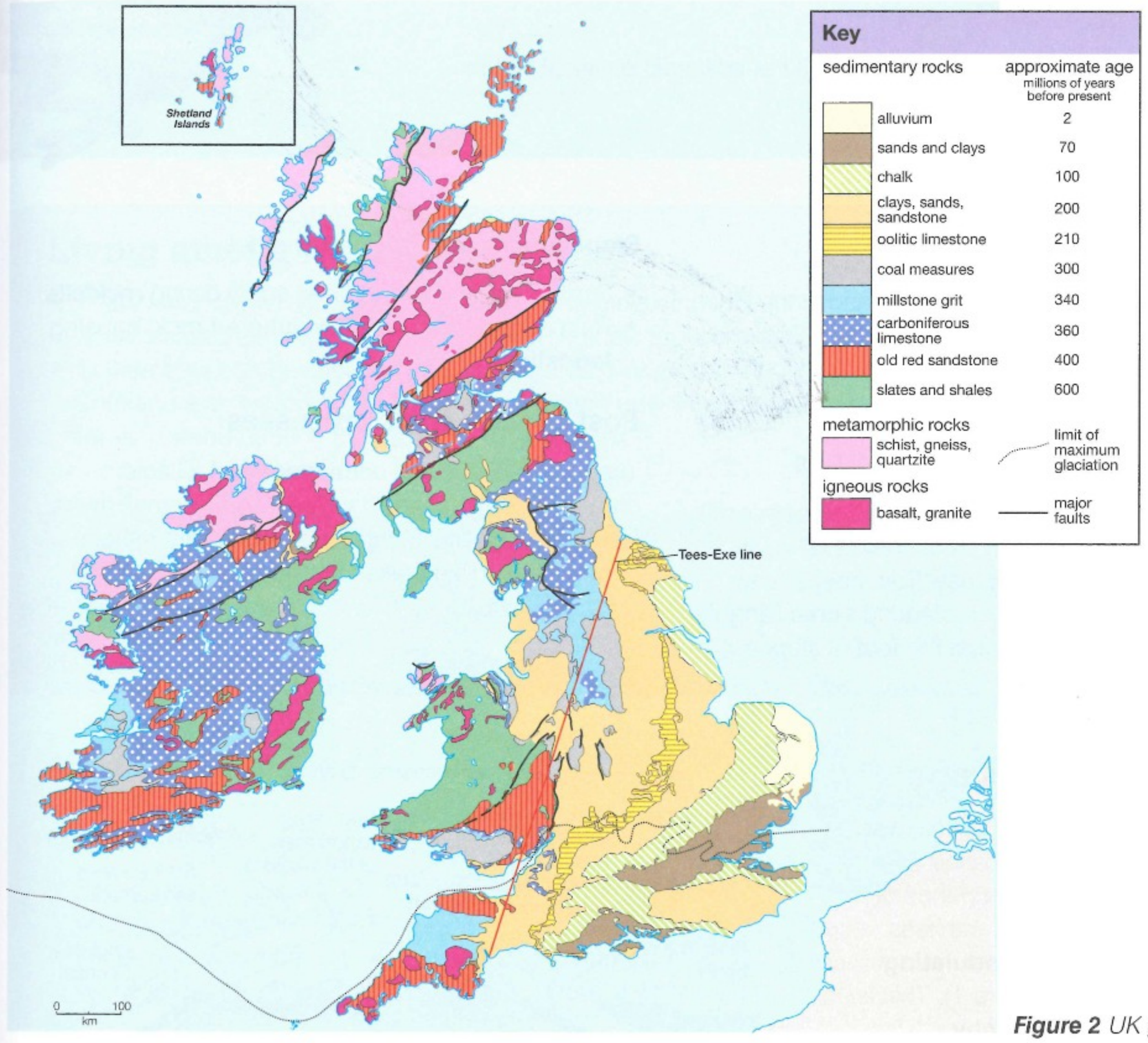


Figure 2 *UK geology map*

Igneous	How it was formed	Characteristics
Granite	From magma cooling deep underground.	Contains crystals of quartz, feldspar and mica. Very resistant.
Basalt	From lavas rich in metals.	Almost black, and heavy. Very resistant.
Sedimentary		
Chalk	A purer, younger form of limestone.	Very porous. Medium resistance.
Carboniferous limestone	From compacted skeletons of marine animals	Permeable. Generally resistant.
Clay (shale when compacted)	From muds deposited by rivers or at sea.	Soft and crumbly. Generally weak.
Sandstone	From sand grains compacted together.	Slightly porous. Weak (less than 100 million years old); and resistant (over 300 million years old).
Millstone grit	From cemented and compacted sandstone.	Very resistant.
Metamorphic		
Slate	From heated muds or shale.	Very resistant.
Schist	From further metamorphosis of slate, where it partly melted and solidified.	Very resistant.
Marble	From heated limestone.	Very resistant.

Figure 3 *Ten rocks you should know!*

Six Second Summary

- There are three main rock types: igneous, sedimentary and metamorphic.
- The different rock types formed in different ways, have different characteristics and are located in different parts of the UK.
- The UK's landscape (relief) depends largely on rock type.

Over to you

Make flashcards for each of the three rock types. Give an example of each one.

Physical processes in the landscape

You need to know:

- how upland and lowland landscapes result from different physical factors.

Student Book
See pages 118–119

An upland landscape

The Lake District in north-west England is the UK's wettest region, and colder than southern England. The landscape has been affected by physical processes.

Weathering and slope processes

Rainwater gets into cracks in rocks. It freezes and expands when temperatures fall below 0° C, and thaws when temperatures rise. This freeze-thaw **weathering** breaks up rock creating **scree** (angular rock pieces) which collect at the foot of slopes.

Slope processes affect valley sides.

- Scree is unstable and moves easily during **rockfalls**.
- Rain adds weight to the weathered rock, causing **landslides**.

Post-glacial river processes

The Lake District was once **glaciated**. Glaciers created deep U-shaped valleys. Today, small rivers (**misfits**) deposit silt and mud (**alluvium**) in these large valleys. This makes them fertile for farming.

A lowland landscape

The Weald, in Kent and Sussex, was once a continuous arch called an **anticline**. Erosion has left bands of resistant rock alternating with less resistant rock creating **undulating** (gently rolling) hills (Figure 1). This is **scarp and vale topography**.

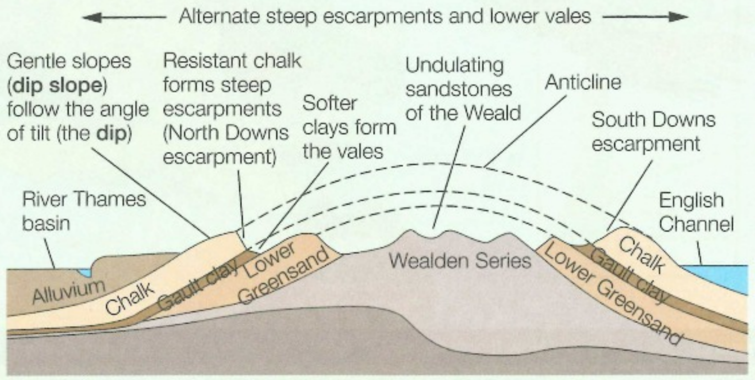


Figure 1 A cross section of the geology of the Weald

Weathering

Southern England is warmer than the Lake District, so different types of weathering occur (see Section 4.16), including:

- **chemical weathering** – e.g. solution of chalk
- **biological weathering** – e.g. tree and shrub roots break up solid rock.

Post-glacial river and slope processes

During, and after, the last Ice Age, water in the porous chalk froze, making it impermeable allowing rivers and valleys to form. As the climate warmed, the ice thawed and water seeped through the chalk leaving **dry valleys**. Clay is impermeable so rivers are common in vales.

Slope processes are slower than in the Lake District. The most common is **soil creep**, caused by rain dislodging soil particles (see Section 4.16).

Six Second Summary

- Weathering, slope processes and post-glacial river processes create different features in upland and lowland landscapes.
- Weathering is the physical, chemical or biological breakdown of solid rock.
- The Lake District is an upland landscape with high peaks, U-shaped valleys and misfit rivers.
- The Weald is an undulating lowland landscape with scarp and vale topography.

Over to you

Explain the differences between physical (freeze-thaw), chemical and biological weathering.

People in the landscape

You need to know:

- how distinctive landscapes result from human activity such as agriculture, forestry and settlement.

Student Book
See pages 120–121

Living among the trees

- Every landscape has been shaped by the original settlers – their activities and the way they made use of materials around them.
- Settlements can develop for specific reasons. For example, Ae in Scotland was created for workers who planted new woodlands, to replace wood used in the trenches in World War I.

Big Idea

Human activities have shaped the UK's landscape.

The Yorkshire Dales

Norse farmers and settlers of the 8th and 9th centuries left their mark on the Yorkshire Dales.

- Limestone and rocks left by melting glaciers (see Section 4.1) made excellent building stone.
- Land was cleared for farming, and the stone used as field boundaries.

Cold winters and a short growing season influenced farming.

- Sheep grazed upland fells and were brought to the valley in winter (as happens today).
- Winter feed was stored in stone barns, often in longhouses (a house and barn). This led to a dispersed pattern of isolated farms.

Figure 1 Settlers in the Yorkshire Dales used local materials to create dry stone walls and buildings

East Anglia

East Anglia is low-lying and generally flat. European Angles (hence its name) and Vikings settled there in communal villages.

- The surface geology is mainly glacial sands and clays (**till**) from the last Ice Age. Till produces fertile soil for arable (crop) farming, but little solid stone for building.
- Below the surface, the solid geology is chalk. Chalk is too crumbly for building, but contains pieces (**nodules**) of flint, a hard crystalline form of quartz. Many older buildings were built from this.

Figure 2 With little building stone, field boundaries are marked by hedges or ditches

Six Second Summary

- An area's landscape is influenced by people who settled there – through their economic activity and use of local materials.
- In the Yorkshire Dales, limestone is used for walls and farm buildings.
- In East Anglia, hedges or ditches mark field boundaries because there is little solid building material.

Over to you

Draw a table to show the influence of **a)** geology, **b)** human activity and **c)** settlement on the landscapes of the Yorkshire Dales and East Anglia.

You need to know:

- how geological structure and rock type influence coastal erosional landforms.

Student Book
See pages 122–123

Geology and rock type

Geology is the main influence on the characteristics of the **coastal zone**.

- **Hard rock coasts** consist of resistant rock, such as igneous granite, or sedimentary chalks (e.g. in Lulworth Cove in Dorset).
- **Soft rock coasts** consist of less resistant rock, such as sedimentary sands and shales (e.g. in Christchurch Bay in Dorset/Hampshire).

Big Idea

Coastal landscapes are influenced by the interaction of geology and coastal processes.

Rock structure

Rock structure means how rock strata (layers) are arranged, for example:

- at right angles to the coast (**discordant**)
- parallel to the coast (**concordant**).

Discordant coasts: headlands and bays

South-west Ireland is a discordant coast where resistant sandstones alternate with less resistant limestones (Figure 1). Waves have eroded limestone to form bays, leaving headlands of harder sandstone.

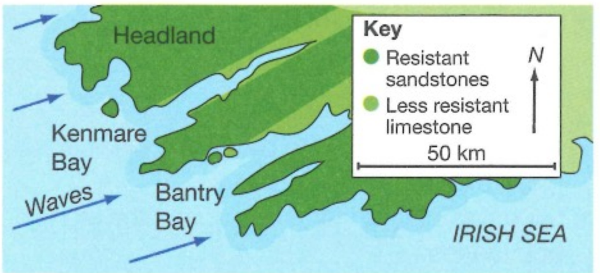


Figure 1 *The discordant coastline of south-west Ireland*

Concordant coasts: coves and cliffs

The coast at Lulworth Cove in Dorset is a concordant coast with unique geology (Figure 2).

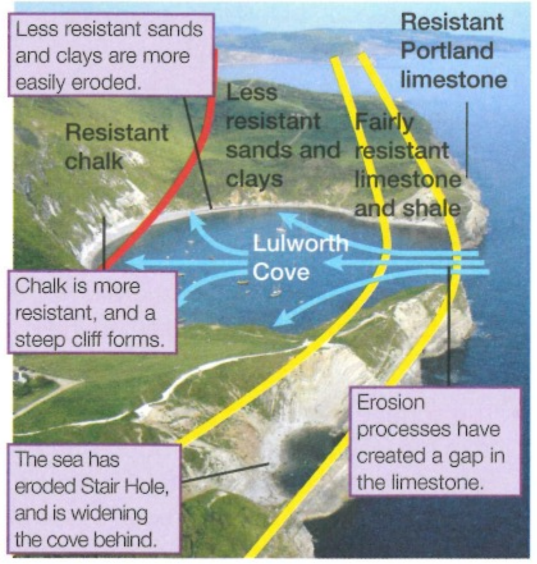


Figure 2 *Formation of Lulworth Cove on a concordant coastline*

Weaknesses in rock structure

Weakness in rocks influence coastal erosion. These are:

- **joints** – these are small, usually vertical, cracks
- **faults** – these are larger cracks caused by past tectonic movements.

Rocks with joints and faults are more easily eroded – a joint widens to form a **cave**; erosion creates an **arch** which collapses to form a **stack**. Eventually, this becomes a **stump**.

Six Second Summary

- Geology is the main factor influencing the coastal zone.
- A discordant coast is characterised by headlands and bays.
- Erosion of concordant coasts can produce coves.
- Joints and faults are weaknesses which can be eroded.

Over to you

Explain the differences between concordant and discordant coasts.

You need to know:

- how climate and erosion processes influence the shape of coasts.

Student Book
See pages 124–125

What causes waves?

Friction between wind and water surfaces causes waves. Wave size depends on:

- wind strength and duration
- the **fetch**.

Prevailing winds in the UK (those which blow most often) are from the south-west, so south-west facing coastlines feel the full force of autumn and winter storms.

Beach profile (shape)

How waves break determine the beach profile.

In summer, waves arrive slowly, with long wavelengths (the distance between them) and low amplitudes (or height); these are **constructive** or **spilling** waves.

In winter, strong winds result in waves with large amplitude and short wavelength; these are **destructive** or **plunging waves**). They arrive quickly.

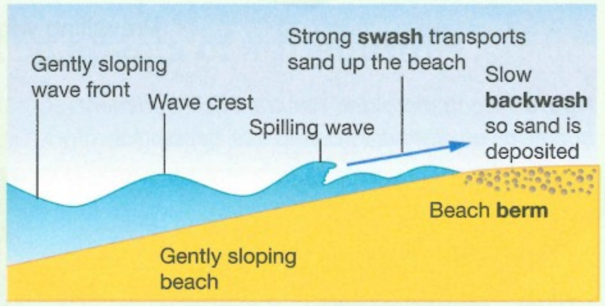


Figure 1 *Summer constructive waves build up a beach*

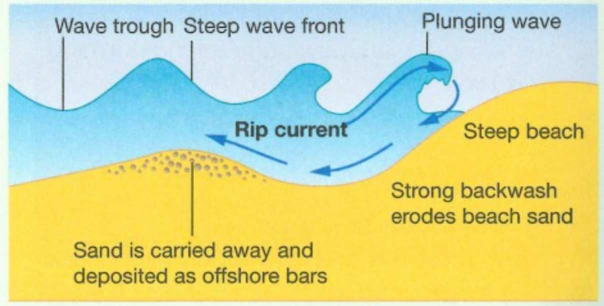


Figure 2 *Winter destructive waves erode beaches*

Coastal erosion

On coasts with resistant rocks, erosion is slow. Most happens during winter storms (Figure 3).

- **Abrasion** forms a wave-cut notch at the cliff base.
- As the notch grows, a cliff overhang develops.
- The overhang collapses. The resulting debris protects the base from further erosion.
- The rock debris is eroded, exposing the cliff to erosion again.

This causes the cliff line to retreat. A level area of smooth rock is left where the cliff line once was (called a **wave-cut platform**).

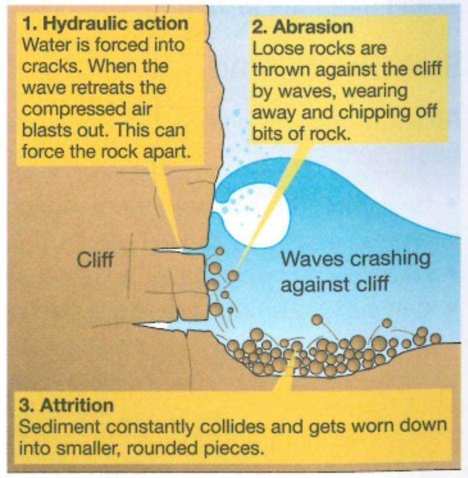


Figure 3 *The three main types of coastal erosion*

Six Second Summary

- Waves are caused by wind blowing over water surfaces.
- Wave size is determined by wind strength, duration, and fetch.
- In summer, constructive waves create gently sloping beach profiles.
- In winter, destructive waves create steep beach profiles.
- Abrasion, hydraulic action and attrition are types of coastal erosion.

Over to you

Memorise definitions for the words in bold on this page.

Test yourself tomorrow.

Coastal deposition

You need to know:

- how coastal processes create depositional landforms.

Student Book
See pages 126–127

Sediment transport

- Material eroded from cliffs is called **sediment** (see Section 4.7). It can be transported to new locations.
- The main way in which sediment is transported is by **longshore drift** (Figure 1).

Depositional landforms

If eroded sediment is trapped in sheltered areas (e.g. bays), a beach forms. Other sediment transported by longshore drift can create new landforms where it is deposited (Figure 2).

- Many **beaches** consist of sand and pebbles moved gradually by longshore drift.
- Onshore winds can blow sand inland, forming **sand dunes**.
- **Bars** of sand can extend across a bay (due to longshore drift). Behind the bar, a shallow **lagoon** forms.
- Where longshore drift meets an estuary, the river flow stops the drift and sand is deposited forming a **spit.**
- At high tide, the sea flows inland causing the spit to curve back on itself (a **recurved** end).
- The water behind a spit is sheltered, allowing **salt marshes** to form.

Stabilising sand dunes

As sand dunes develop, plants stabilise them, because they:

- have long roots to hold them in place in strong winds
- have tough, waxy leaves to resist sandblasting
- can survive being sprayed by salt water.

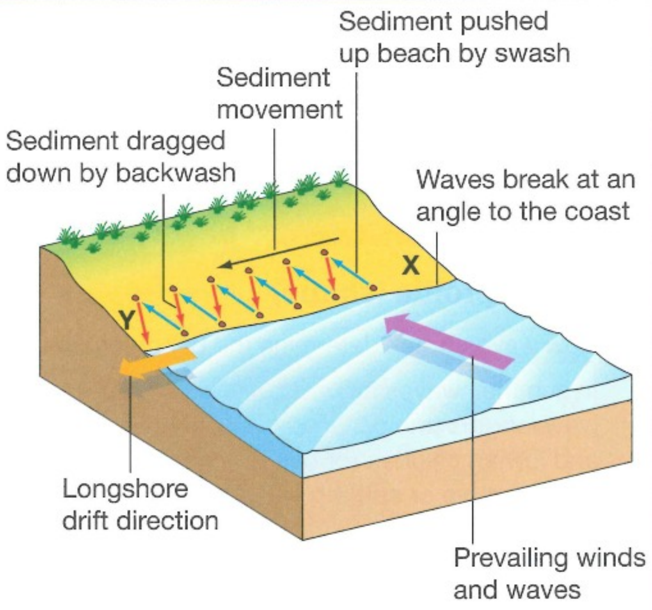


Figure 1 *Longshore drift can transport sediment hundreds of kilometres before it is deposited*

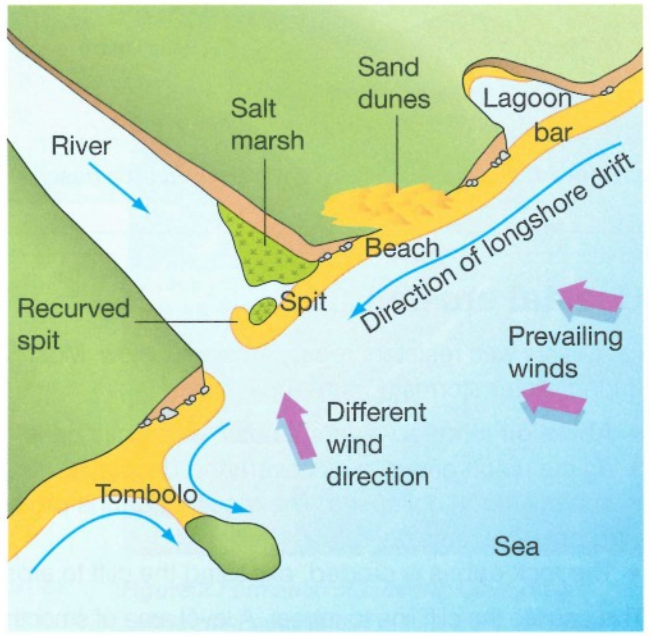


Figure 2 *Different landforms created by coastal deposition*

Six Second Summary

- Sediment results from cliff erosion.
- Longshore drift transports sediment along the coast.
- Beaches, spits, bars and sand dunes form where sediment is deposited.
- Vegetation can help stabilise depositional landforms.

Over to you

Draw a flow diagram to show how longshore drift forms a spit.

Human activities and the coast

You need to know:

- how development, agriculture, industry and coastal management affect coastal landscapes.

Student Book
See pages 128–129

The effects of development

Development can put pressure on a crowded coastline. It includes:

- Tourism – with demands for hotels and campsites in tourist areas.
- Housing – many London workers cannot afford housing there, so commute from coastal areas. Many retire to coastal areas.
- Offices and industry. The high cost of London property makes coastal locations popular with companies (e.g. bankers JP Morgan moved to Bournemouth in 2015).

The effects of agriculture

Romney Marsh in Kent is a wetland habitat for birds, and summer grazing pasture. It faces two pressures.

- The high cost of good farmland means farmers have to make best use of whatever extra grazing they can. This reduces natural wildlife habitats.
- Climate change and rising sea levels may lead to salt water floods during winter high tides, threatening pastures.

The effects of industry

Bacton gas terminal (Figure 1), on the Norfolk coast is next to a sandy beach. The beach is a popular tourist destination but being next to a gas terminal is not ideal. Similar industrial developments have taken place next to the rivers Solent (Southampton), Thames (London), Severn (Bristol), Mersey/Dee (Liverpool) and Tees (Middlesbrough) estuaries.

Figure 1 *Bacton gas terminal on the Norfolk coast*

Big Idea

Human activities affect coastal landscapes.

The effects of coastal management

Milford-on-Sea in Christchurch Bay in Hampshire has suffered from coastal erosion. Coastal management (Figure 2) is intended to prevent further problems. (Also see Section 4.12.)

Figure 2 *Milford-on-Sea. Coastal management has affected the coastline by trapping sediment.*

Six Second Summary

Human activities put pressure on coastal landscapes:

- Development (housing, offices and tourism) causes expansion of coastal towns and cities.
- Agriculture – wildlife habitats are threatened by demand for grazing; pastures are also threatened by flooding due to climate change.
- Industry – large industrial developments cause conflict with tourists.
- Coastal management alters the landscape.

Over to you

Look at Figure 2. How would the coastal management measures shown affect this and other coasts in the area?

The risks from coastal flooding

You need to know:

- how rising sea levels increase the risk of flooding and erosion on coastlines.

Student Book
See pages 130–131

Rising sea levels

Climate scientists believe that global warming is causing ice sheets to melt and sea levels to rise. This puts low-lying areas at risk, such as Bangladesh, and the south-eastern UK.

Big Idea

A sea level rise of 1m by 2100 would have major impacts on people in low-lying areas.

Flood risks and the future

Sea levels constantly change (Figure 1):

- twice a day with high tides, due to the gravity of the moon
- twice a month with exceptionally high tides (called spring tides)
- due to falling air pressure, which causes storm surges. They are more severe when they coincide with spring tides and large waves.

Global warming may result in more frequent and deeper low pressure weather systems, causing higher storm surges.

- In December 2013, high winds and a 7 m storm surge struck eastern and south-east England causing the worst coastal flooding since 1953.

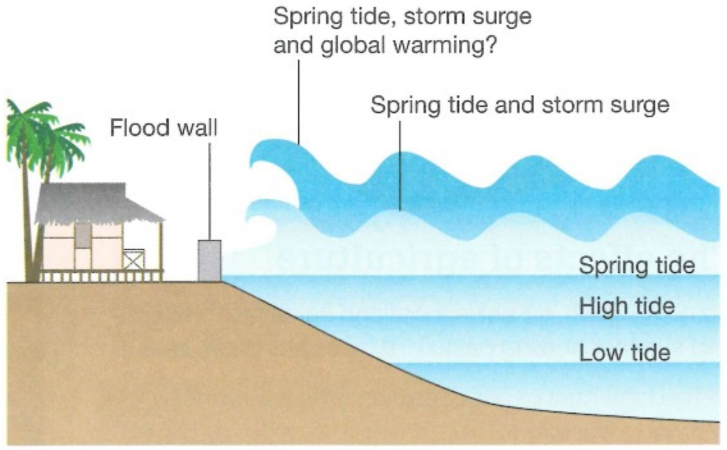


Figure 1 People will become increasingly vulnerable to spring tides and storm surges as sea levels rise due to global warming

What of the future?

The future holds several challenges:

- Events like the 2013 storm surge could become more frequent by 2050.
- Beaches, spits, and river deltas may be eroded faster, and become submerged.
- A sea level rise of 50cm would make sea defences in south and east UK useless. The only choice would be to build higher defences or abandon some areas to the sea.

Six Second Summary

- Global warming may cause sea levels to rise by up to 1m by 2100.
- Many low-lying areas are at risk from rising sea levels.
- A combination of spring tides, increased storm surges and rising sea levels put more people at risk from flooding.
- Higher sea levels, increased storm activity, storm surges and erosion of the coast could make sea defences useless.

Over to you

Create a spider diagram with 'Flood risk' at the centre. Add legs to summarise the factors that result in a risk of coastal flooding.

Falling into the sea

You need to know:

- why coastal erosion rates vary
- why cliffs collapse, and the impacts this has on people.

Student Book
See pages 132–133

The rate of coastal erosion

Different factors determine the rate at which coasts erode.

- **Geology**. Cliffs of resistant rocks withstand waves for long periods. For example, Dodman Point in south Cornwall has suffered little erosion in 3000 years. Meanwhile, weak geology causes rapid erosion, e.g. the Holderness Coast in East Yorkshire.
- **Cliff processes** (Figure 1). Areas of weak geology suffer from **cliff foot erosion** (caused by hydraulic action and abrasion) and **cliff face erosion** (caused by **sub-aerial processes** e.g. weathering and movement of materials downslope, called **mass movement**).
- **Waves**. Wave energy depends on the fetch over which the wave has travelled (see Section 4.7).

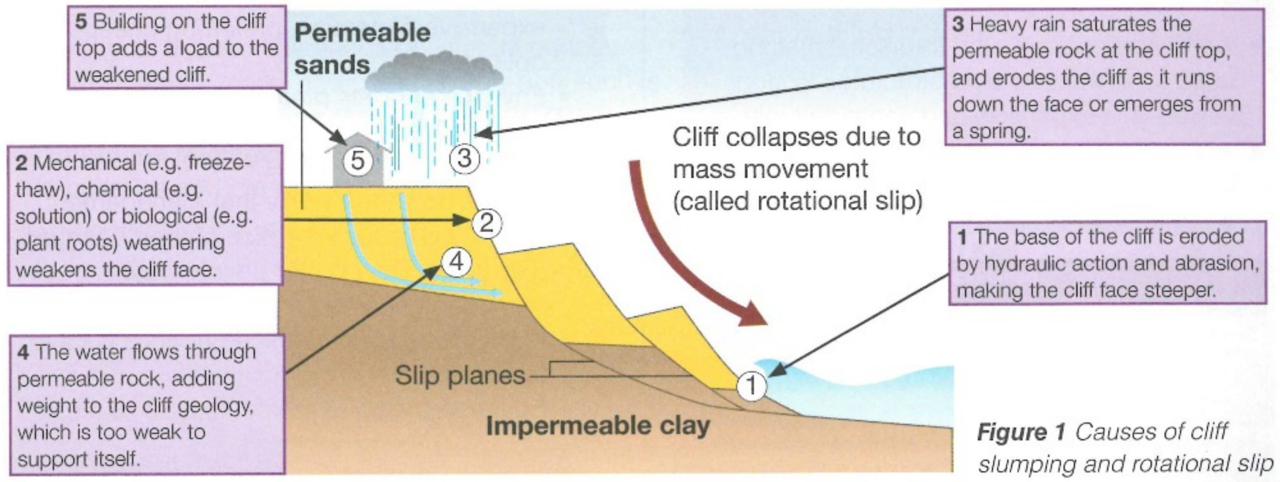


Figure 1 Causes of cliff slumping and rotational slip

Christchurch Bay

Managing erosion at Christchurch Bay on the UK's south coast is costly and difficult.

- Without it, cliffs would erode by over 2m a year, threatening residential areas such as Christchurch, Barton-on-Sea and Milford-on-Sea.
- At Barton-on-Sea, mass movement is the major problem, caused by weathering and water movement.
- Cliff foot erosion also plays a part, as the Atlantic fetch of 3000 miles brings big waves.

Impacts of erosion

Erosion in Christchurch Bay affects many people:

- Homeowners lose their homes to the sea. House values fall, and insurance is impossible to get.
- Rapid cliff collapses are dangerous for people on the cliff top, and on the beach.
- Roads and other infrastructure are destroyed.
- Erosion makes the area unattractive for tourism.

Local people argue that they need defences to protect the coast. But they are expensive, and there is no agreement about which works best (see Section 4.12).

Six Second Summary

- The rate at which coastlines erode varies.
- Geology, cliff processes and waves influence the rate of erosion.
- Cliffs collapse due to marine processes, sub-aerial processes and human actions.
- Cliff erosion at Christchurch Bay poses threats to many people.

Over to you

Classify the processes and actions in the text boxes in Figure 1 into:

- marine foot processes
- sub-aerial cliff-face processes
- human actions.

You need to know:

- what coastal management is
- how hard engineering protects the coast.

Student Book
See pages 134–135

Big Idea

The method of coastal management used depends on environmental and economic **costs** versus the **benefits** of what is saved (**cost–benefit analysis**).

Managing the coast

There are two types of sea defences:

- 'hard' engineering – the traditional method uses concrete and steel structures to stop waves. It is expensive and unnatural/ugly.
- 'soft' engineering – uses smaller structures, often built from natural materials, to reduce wave energy.

Type of defence	Cost/ metre	Benefits and problems
Sea wall	£2000	• Reflect waves back out to sea. • Can prevent easy access to the beach. • Suffer from wave scour (plunging waves attack the wall's foundations).
Sea wall with steps and bullnose	£5000	• Steps help to dissipate wave energy; the bullnose throws waves up and back out to sea.
Revetments (sloping structures at top of beach)	£1000	• Break up incoming waves. • Restrict beach access; look ugly. • Can be destroyed by big storms.
Gabions (rock-filled cages)	£100	• A cheap type of sea wall. • Absorb wave energy (they are permeable). • Not very strong.
Rock armour (rip-rap)	£300	• Easy to build. • More expensive if built in the sea. • Dissipates wave energy; looks 'natural'.
Groynes	£2000	• Prevent longshore drift. • Larger beach **dissipates** wave energy, reducing erosion. • May increase erosion downdrift (Figure 2).

Figure 1 *Different hard defences and their costs*

Conflict in Christchurch Bay

The coast around Barton-on-Sea in Christchurch Bay is eroding rapidly (see Section 4.11).

Most people favour hard-engineering management, but some disagree.

- Coastal residents/businesses want to protect their interests.
- Locals living inland don't want to pay for expensive protection, preferring cheaper options.
- Environmentalists prefer a 'do nothing' or soft-engineering approach which has less impact on habitats/ecosystems.
- People downdrift worry that management updrift will reduce the size of their beaches (Figure 2). They prefer an integrated management plan for all affected.
- Politicians want protection but don't want to favour one group or another.
- Boat users want to protect access to the sea.

Figure 2 *The stone groynes at Highcliffe have built up the beach, but have caused rapid erosion downdrift. This is called* ***terminal groyne syndrome****.*

Six Second Summary

- Coastal management includes hard and soft engineering.
- Hard engineering is costly and can be unattractive.
- A cost–benefit analysis helps to decide which type of sea defence should be used.
- Coastal management can lead to conflict.

Over to you

Draw a table to show advantages and disadvantages of hard-engineering methods.

You need to know:

- how coasts can be managed in a holistic, more sustainable way.

Student Book
See pages 136–137

Big Idea

Sustainable (or 'soft') methods of managing coasts tend to work with the environment.

Managing the whole coast

Holistic coastal management means looking at the coastline as a whole, so actions in one area don't cause problems in another.

- It takes into account the needs of different people, the environment, costs and benefits. This approach is **Integrated Coastal Zone Management (ICZM)**.
- A **Shoreline Management Plan (SMP)** sets out how the coast as a whole will be managed.

Coastal management – the choices

There are four choices for coastal management:

1. **Hold the line** – sea defences stop erosion (expensive).
2. **Advance the line** – sea defences move the coast further into the sea (very expensive).
3. **Strategic realignment** (**strategic retreat**) – gradually let the coast erode.
4. **Do nothing** – take no action; let nature take its course.

Figure 1 shows choices about coastal management along the Norfolk coast.

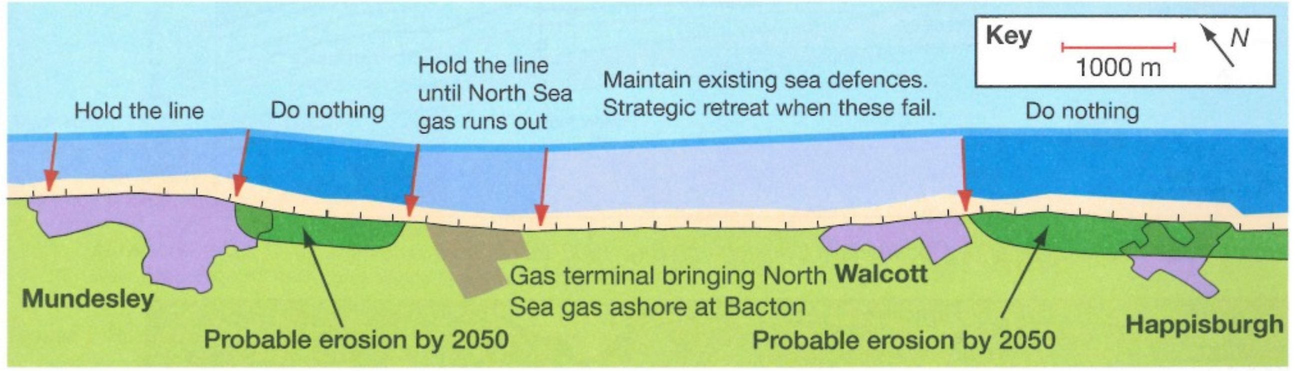


Figure 1 *Choices of coastal management along the Norfolk coast*

Soft engineering

Uses natural processes to stabilise beaches and cliffs, and reduce wave energy. It is often cheaper, less intrusive and more sustainable that hard engineering. Methods include:

- planting vegetation (£20 – £50/m^2)
- beach nourishment: (£500 – £1000/m^2)
- offshore breakwaters (£2000/m).
- cliff drainage (cost not available).

Planning for the future

The UK faces difficult decisions about how to protect the coast.

- It is too expensive to protect farmland and isolated houses.
- It is hard to persuade people that protecting their property is not sustainable.
- Planning defences is difficult if the impact of rising sea levels is uncertain.

Six Second Summary

- ICZM considers the needs of different people, the environment, costs/benefits.
- An SMP considers whole stretches of coast.
- Soft engineering uses natural processes to protect coasts.
- The UK faces difficult decisions about how best to protect the coast.

Over to you

Explain one advantage and one disadvantage of **three** methods of soft engineering.

You need to know:

- how to use your geographical skills to investigate coastal erosion in Christchurch Bay
- how to use 4- and 6-figure grid references and interpret an OS map.

Student Book
See pages 138–139

Geographical skills

Christchurch Bay: key points

Barton-on-Sea has no protection from the prevailing south-westerly winds and waves. By studying the rate of erosion before, and after, coastal management (Figure 1), we can work out whether:

- erosion has changed as a result of coastal management
- money spent on managing the coast is justified.

This allows **stakeholders** (people affected by what happens to the coast) to judge whether coastal management is working.

Big Idea

Map interpretation helps you to examine the impacts of coastal management and to predict possible effects of proposed schemes.

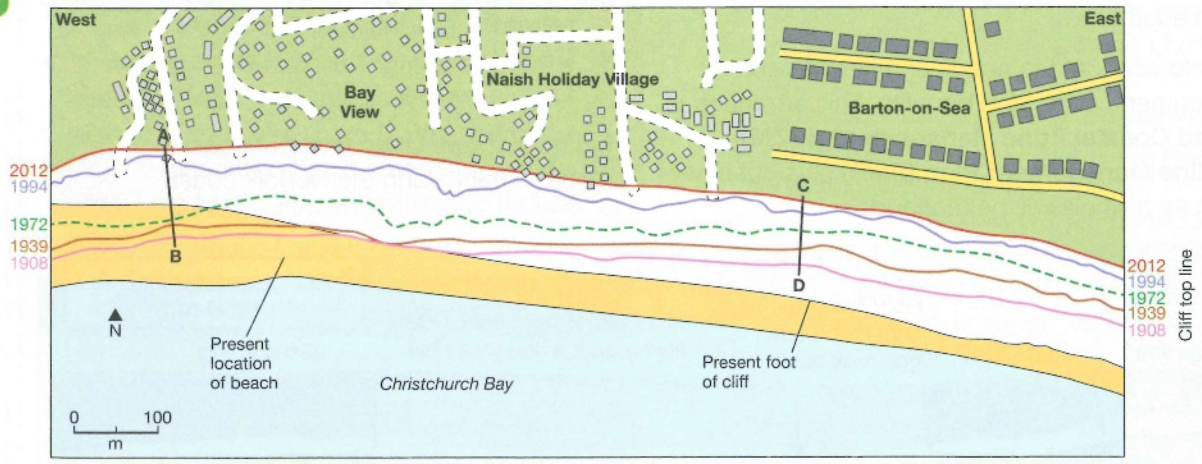


Figure 1 Rates of erosion at two locations in Christchurch Bay, 1908–2012

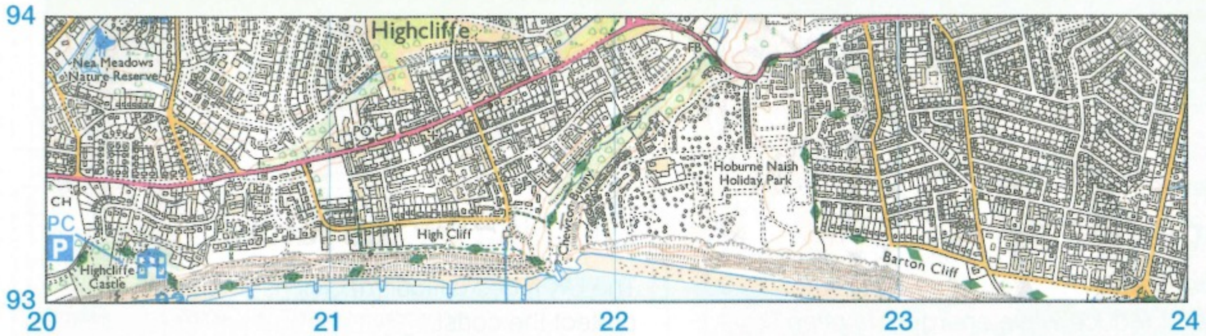


Figure 2 1:25 000 Ordnance Survey (OS) map extract of part of Christchurch Bay

Six Second Summary

- In parts of Christchurch Bay erosion has been a problem for over a century.
- Studying the position of coastlines over time can help identify whether coastal management has affected the rate of erosion.
- It can also help stakeholders to decide whether money spent on managing the coast is justified.

Over to you

- Look at Figure 1. Use the scale bar to work out by how much the cliff top has eroded between 1908 and 2012 at both A–B and at C–D.
- On Figure 1, at location A–B, during which years was coastal erosion the greatest?
- Using Figure 2, compare the beach at High Cliff and the Hoburne Naish Holiday Park. How has coastal management affected them differently?

You need to know:

- about river processes in upland areas.

Student Book
See pages 140–141

Buckden Beck

The small rapids and waterfalls in Figure 1 are typical of a river's **upper course**. Because of the **gradient**, the stream flow looks fast, but it is actually flowing slowly because of friction with the stream bed.

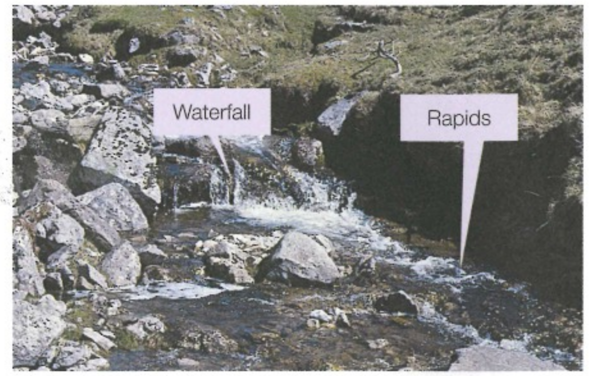


Figure 1 Upper course of Buckden Beck, a tributary of the River Wharfe in the Yorkshire Dales

Erosion and transport

- The material carried by the river (the **load**) are the tools which erode its bed and banks (Figure 2).
- Most load is **transported** by solution, suspension, saltation and traction (Figure 3).

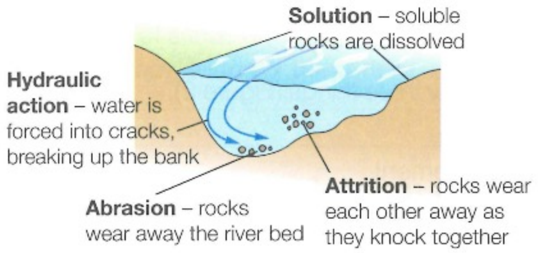


Figure 2 River erosional processes

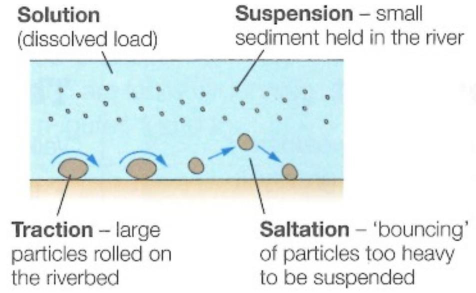


Figure 3 River transport processes. Most load is carried during periods of wet weather.

How does a waterfall form?

1. Waterfalls occur when a river crosses a bed of more resistant rock.
2. Erosion of the less resistant rock undercuts the hard rock above it. The river's energy creates a **plunge pool** at the foot of the waterfall.
3. Erosion of the less resistant rock creates a ledge, which overhangs and collapses.
4. The waterfall takes up a new position, leaving a steep valley or **gorge**.

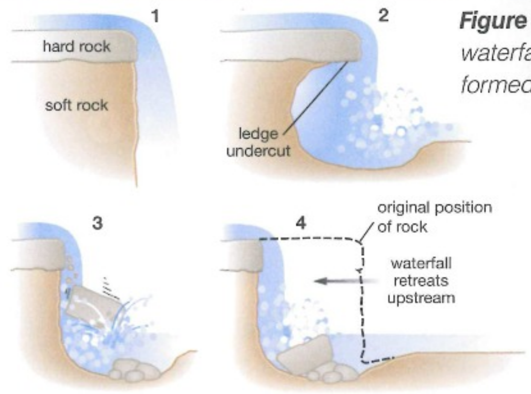


Figure 4 How waterfalls are formed

Six Second Summary

A river in its upper course:

- has a steep gradient with small rapids and waterfalls
- flows slowly because of friction with the bed
- carries its load by solution, suspension, saltation and traction
- erodes its channel by abrasion, attrition, hydraulic action and solution.

Over to you

Draw a table listing the processes of river transport in order of the size of the load carried. Include a brief description of each one.

You need to know:

- how river valleys develop in upland areas
- how weathering and mass movement affect the shape of a river valley.

Student Book See pages 142–143

The valley of Buckden Beck

Figure 1 is typical of a river's upper course in an upland area.

- It has steep valley sides and a narrow bottom (**V-shaped**).
- As the river cuts vertically into the resistant carboniferous limestone, it winds around areas of more resistant rock. This produces **interlocking spurs** – ridges that jut into the valley from both sides.
- Physical, biological, and chemical **weathering** of the valley sides are important in shaping the valley (Figure 1).

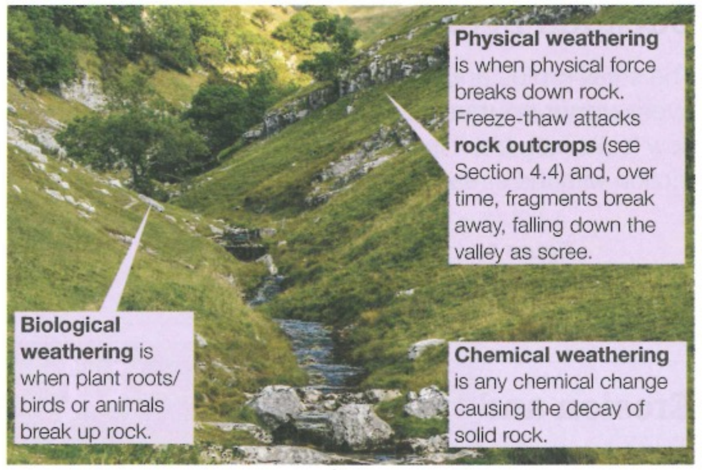


Figure 1 The V-shaped valley and interlocking spurs of Buckden Beck, and weathering processes

Mass movement

This is the movement of weathered fragments downslope by gravity. It can be rapid (e.g. **landslides** and **mudflows**) or slow (e.g. **soil creep**). The effects of soil creep are much less obvious than rapid movement. But over many years, it can cause walls, telegraph poles and trees to lean.

The shape of the valley

Valley shape is affected by three things (Figure 2):

- the rate of weathering
- the rate of mass movement
- how quickly the river can remove material. If the river has the energy, it takes the material and uses it to erode the valley, making it steeper. If flow is slow, weathered rock collects at the bottom of the slope, making the valley gentler and flatter.

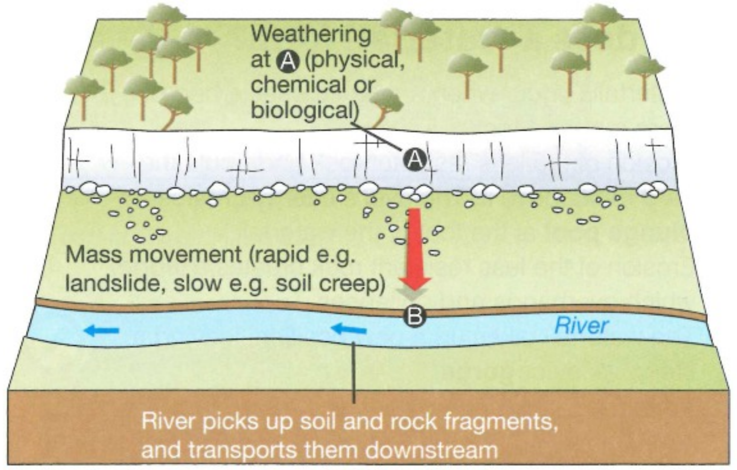


Figure 2 Weathering takes place at A, breaking down solid rock into fragments. Mass movement moves the fragments down slope to the river at B. The river uses them as tools to wear away (erode) the river bed.

Six Second Summary

- The valley in a river's upper course is V-shaped with interlocking spurs.
- Physical, biological and chemical weathering takes place on the valley sides.
- Mass movement moves weathered material downhill.
- Valley shape is affected by rates of weathering and mass movement, and how quickly a river can remove weathered material.

Over to you

Draw a sketch to show the features of a valley in a river's upper course.

You need to know:

- how rivers and valleys change in the middle course.

Student Book See pages 144–145

The River Wharfe in its middle course

Figure 1 shows the River Wharfe in its **middle course**. The river is different from the upper course, because it has:

- a gentler gradient
- a greater **discharge** (volume of water) because tributaries (like Buckden Beck) join it
- a smoother channel, because smaller pebbles, muds and sands have replaced stones and boulders
- faster **velocity** (speed) because there is less friction to slow down the river
- more energy to erode sideways (laterally).

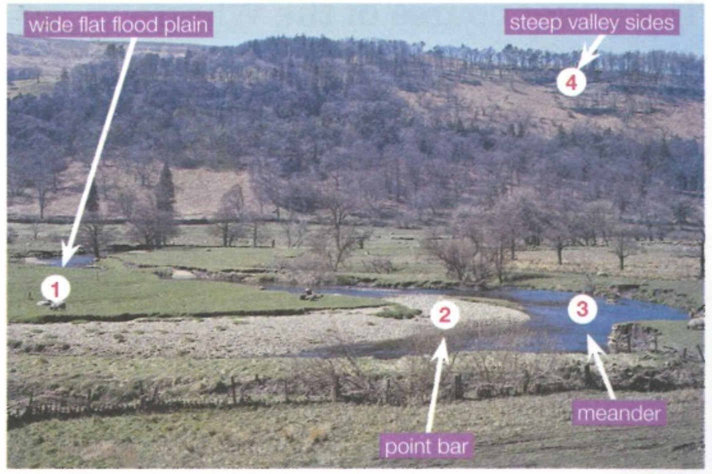


Figure 1 The valley of the Wharfe in its middle course. This is a meander and flood plain near Kettlewell in Wharfedale.

The valley shape also changes because:

- the **flood plain** widens the valley floor (the valley is now a U-shape)
- deposits of sands and clays (**alluvium**) fill the flood plain, and are fertile for farming
- the river now winds or **meanders**, creating **ox-bow lakes** (Figures 1 and 2).

How meanders change the valley

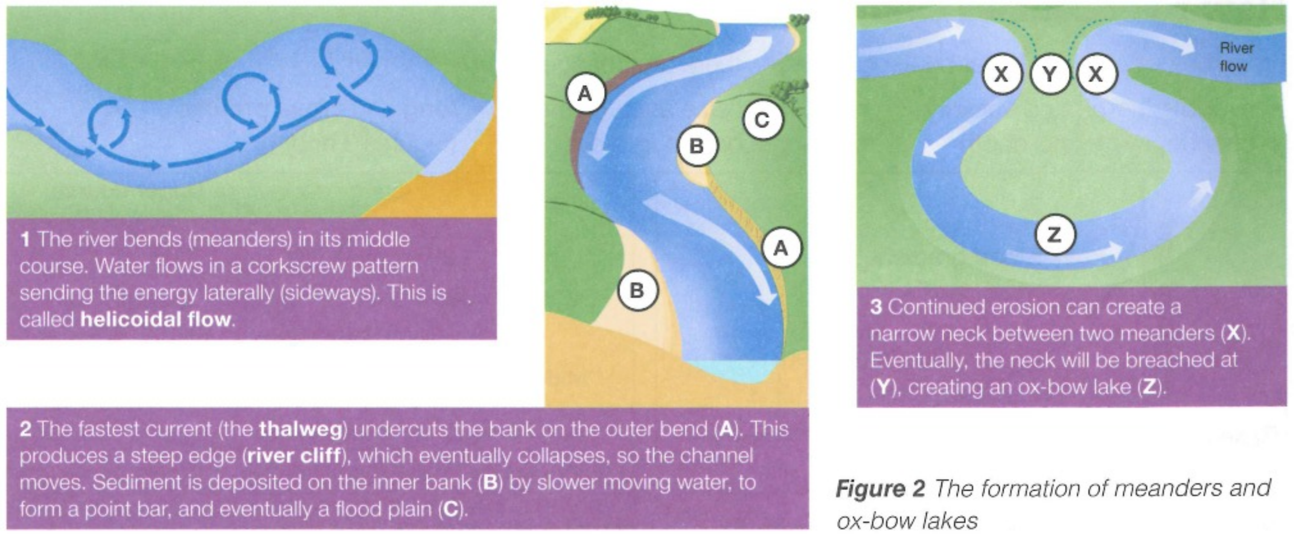


Figure 2 The formation of meanders and ox-bow lakes

Six Second Summary

- Increased discharge and velocity in a river's middle course provide more energy, and it erodes laterally.
- In the middle course, valleys are U-shaped with a flat valley floor.
- Flood plains covered in alluvium widen the valley floor.
- Meanders are natural bends in the river.

Over to you

Draw a table to compare **a)** the river and **b)** the valley shape, in the middle course with the upper course.

Rivers and valleys in the lower course

You need to know:

- how rivers and valleys change in the lower course.

Student Book
See pages 146–147

The lower course of the Wharfe

The river is:

- wide and deep, with a gentle gradient
- has a very large discharge
- floods easily and has a wide and almost flat flood plain
- has large, winding meanders
- is affected by tides from the sea.

The Wharfe joins the River Ouse, and then the Humber to form an **estuary** where it meets the sea. Here, the river is tidal, so:

- flow is **outwards** at low tide (to the sea) or **inwards** (from the sea inland) at high tide
- at high tide, incoming flow meets outgoing flow and sediment is deposited forming **mudflats** (Figure 1).

When mudflats extend beyond the coastline, a **delta** forms, e.g. the Wash in East Anglia.

- **Salt marshes** form when the sea submerges the estuary at high tide. They are important wildlife habitats but are threatened by industry and port activity.
- **Levées** form. These are embankments formed by deposition at the side of the river (Figure 2). They can prevent flooding.

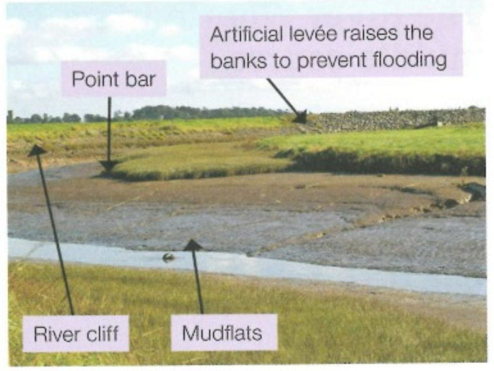


Figure 1 *Mudflats near the Humber estuary*

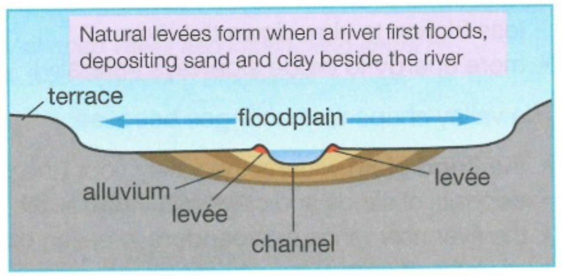


Figure 2 *The features of a flood plain*

How river courses change

From the upper to the lower courses of a river, there are changes in:

- river discharge and velocity
- channel width and depth
- sediment size and volume
- channel bed roughness
- **long** and **cross profiles** (Figures 3 and 4).

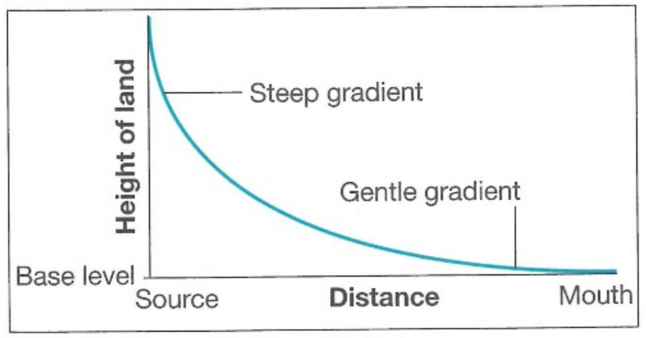


Figure 3 *The long profile of a river*

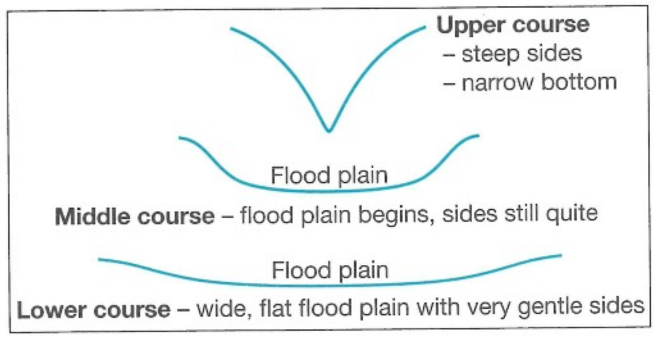


Figure 4 *The cross profile of a river*

Six Second Summary

- In its lower course a river is wide and deep with a flat flood plain.
- Where the river meets the sea it can form an estuary.
- Levées are embankments which help to reduce flooding.
- The different courses of a river have distinctive long and cross profiles.

Over to you

Draw a table to show the differences between **a)** rivers, and **b)** river valleys in their upper and lower course.

Geographical skills: investigating rivers and their valleys

You need to know:

- how to interpret diagrams and maps of river valleys
- how to draw a map cross section.

Student Book
See pages 148–149

Identifying river valleys and landforms

Looking at a map and visualising what the landscape looks like (Figure 1) is a key skill you need to develop.

Being able to draw a cross section from a map helps to start this process.

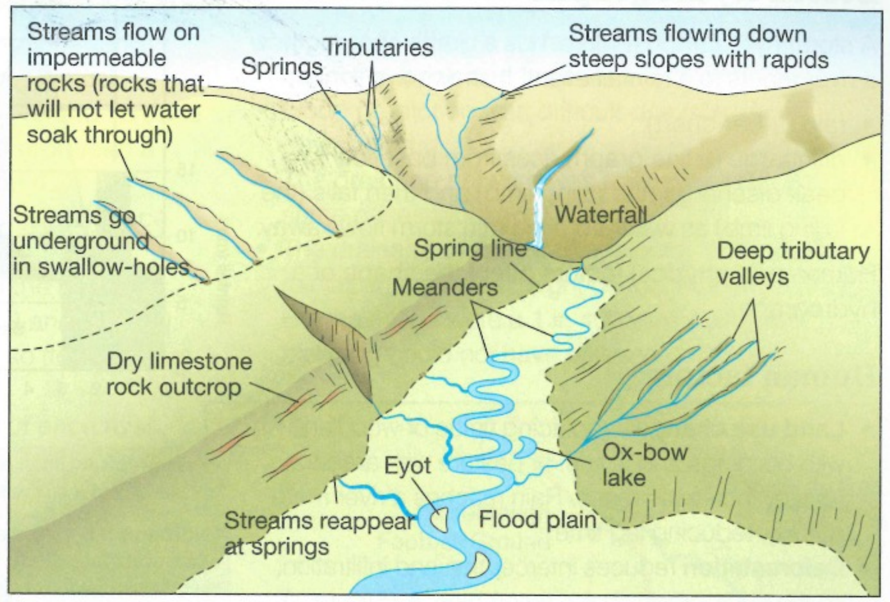


Figure 1 *Landforms of a typical upland region*

How to draw a map cross section

Stage 1

- Place a piece of paper wide enough to cover the length of the cross section on the map.
- Each time your piece of paper crosses a contour line, mark it with a pencil AND write down the height in metres. You can also mark on other features that the paper edge crosses (e.g. rivers, roads).

Stage 2

- Draw graph axes as wide as the cross section, and as high as the height of land needs (choose a suitable scale).
- Lay your paper on the *x*-axis (horizontal) and plot points on your graph.
- Join the points with a line which shows the relief of the landscape along the length of the cross section. How accurate that is depends on the scale of the *y*-axis (vertical).

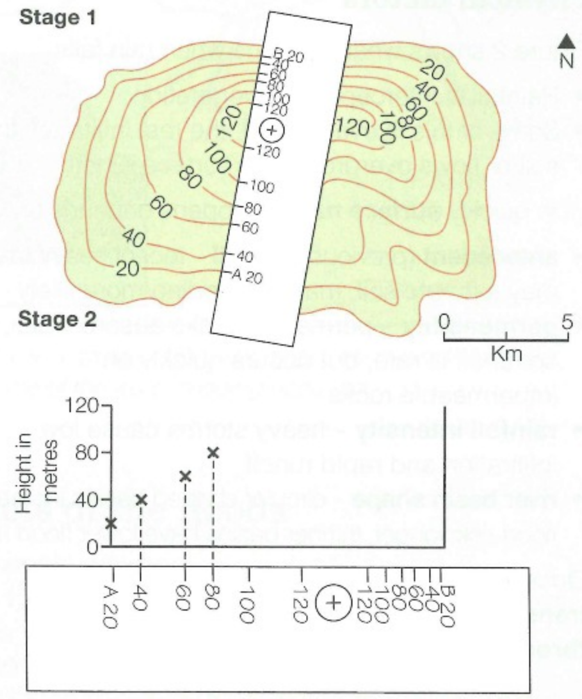


Figure 2 *How to draw a cross-section*

Six Second Summary

- Interpreting diagrams, sketches and maps is a key skill.
- A cross section of a map shows the profile of the area.

Over to you

Look at Figure 1. Sketch a contour map based on this diagram. Start by sketching the river and build up the contours on either side to show as many of the features as possible.

You need to know:

- how human and physical factors affect storm hydrographs.

Student Book
See pages 150–151

Storm hydrographs

A storm hydrograph (Figure 1) is a graph showing how a river reacts to a rainfall event. It shows two things:

- rain (a bar chart)
- discharge (a line graph) rises from baseflow to peak discharge (the rising limb) and then falls (the falling limb) as water from the rain storm flows away.

Human and physical factors affect the shape of a hydrograph.

Human factors

- **Land use change** – replacing fields or woodland with buildings and roads, or pasture with arable (crops) increases runoff. Rain reaches a river more quickly, reducing lag time.
- **Deforestation** reduces interception and infiltration, so the hydrograph shape resembles 'A' (Figure 1).

Physical factors

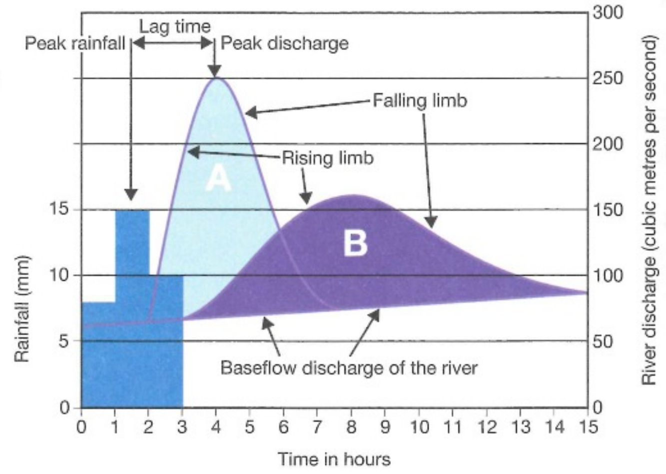
Figure 2 shows what happens when rain falls.

- Rainfall is intercepted by vegetation.
- Some of this is evaporated, the rest infiltrates the soil or flows overground as surface runoff.

How quickly **surface runoff** happens depends on:

- **antecedent** (previous) **rainfall** – recent heavy rain may saturate soil, making flooding more likely
- **permeability** – permeable rocks absorb water, so runoff is rare, but occurs quickly on impermeable rocks
- **rainfall intensity** – heavy storms cause low infiltration and rapid runoff
- **river basin shape** – circular shaped basins increase flood risk; longer, thinner basins have lower flood risk.

Once water infiltrates into the soil, it is either **transpired** by plants or reaches the river via **throughflow** or **groundwater flow** (Figure 2).



Hydrograph A Urban areas – little infiltration, rapid runoff and transfer of water to rivers. River levels rise quickly.

Hydrograph B In rural areas water is absorbed, or in summer water evaporates. Both increase the time water takes to reach a river; lag time is longer; peak discharge is lower.

Figure 1 *Hydrograph **A** shows a quick response to a rain storm; Hydrograph **B** shows a slow response*

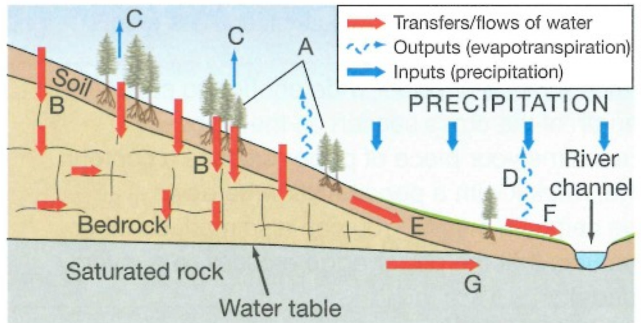


Figure 2 *Cross section of a river valley showing how water reaches a river*

A Intercepted by leaves and branches **(Interception zone)**
B Infiltrates (soaks) into the soil
C Transpires back to the atmosphere through leaves
D Evaporates back to the atmosphere
E Seeps through soil **(throughflow)**
F Flows over the ground as **surface runoff**
G Seeps through solid rock **(groundwater flow)**

Six Second Summary

- Rainfall is intercepted by vegetation, then infiltrates the soil or becomes surface runoff.
- Infiltrated water reaches the river through the soil (throughflow), or rock (groundwater flow).
- Storm hydrograph shape varies, depending on different factors (e.g. human activity).

Over to you

Draw a spider diagram to summarise the factors that affect the shape of a storm hydrograph. Split them into human and natural factors.

You need to know:

- how physical and human factors caused the Sheffield floods of 2007.

Student Book
See pages 152–153

Physical causes of the floods

- In June 2007 heavy prolonged (antecedent) rainfall fell across South Yorkshire. Almost 190 mm of rain fell on two days – 15 and 25 June (Figure 1). The saturated ground produced a hydrograph similar to **A** in Section 4.20.
- Sheffield is surrounded by steep hills. Surface runoff occurred quickly.
- The city lies at the confluence of the rivers Rivelin and Loxley (X on Figure 2) and Don (Y). Each river was filled to capacity so flooding was inevitable where they met.
- Reservoirs in the upper courses of each river overflowed.

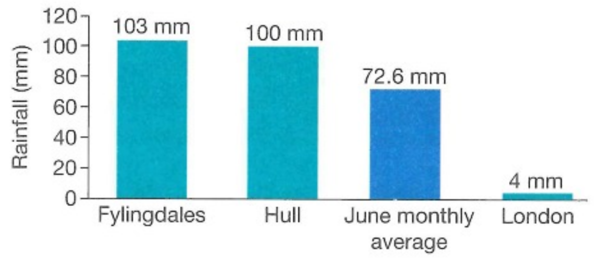


Figure 1 *Rainfall in Yorkshire on 25 June 2007 compared with the average for June, and London*

Human causes of the floods

- Most of Sheffield's surfaces are impermeable – concrete, brick and tarmac.
- Flood prediction was difficult due to sudden downpours.
- The drainage network was overwhelmed, and in some cases blocked.
- The drainage system was designed to deal with rainfall amounts that might occur once in 30 years. But the floods were a 1 in 400 year event, so planning could not have prevented flooding.

Figure 2 *The area around Hillsborough, north-west Sheffield, where some of the worst flooding occurred*

Six Second Summary

- The 2007 Sheffield floods were the result of physical factors (prolonged rain, the confluence of rivers and steepness of the landscape).
- Human factors contributed to the floods, (urbanisation, and drains being overwhelmed).
- The floods had impacts on people, businesses and transport.

Over to you

- List two human causes and two physical causes of the 2007 Sheffield floods.
- Classify the impacts of the floods into economic, social and environmental.

Impacts of the floods

- Two people drowned.
- Over 1200 homes flooded; 1000 businesses affected.
- Roads were damaged; rail links flooded.
- 13 000 people without power for two days.
- Hillsborough Football Stadium flooded and cost several million pounds to repair.
- Health risks as raw sewage escaped into floodwater.
- Meadowhall Shopping Centre was closed for a week, despite defences to protect it against a 1 in 100 year flood.

4.22 Flood threats and the future?

You need to know:

- about the increasing risks from river flooding.

Student Book
See pages 154–155

The Somerset Levels

The Somerset Levels are a low-lying landscape of wetlands in south-west England drained by seven rivers (Figure 1). Floods are common during spring tides in the Bristol Channel – but winter 2014 was one of the worst (Figure 2).

Figure 1 *The Somerset Levels; flooded areas are in blue*

Physical causes of the Somerset floods

The floods resulted from high level winds (**Jet streams**) bringing low pressure weather systems across the Atlantic to southern England, which caused:

- the stormiest UK winter for over 20 years
- the most rainfall since 1766 – 235% of average winter amounts!
- more rainy days than any time since 1961
- more days when high winds combined with very high tides and tidal surges.

Human causes of the Somerset floods

Human interference with rivers can make flooding more likely.

- **Dredging** creates levées and makes the channel deeper.
- However, during high rainfall, sediment is deposited on the channel bed, raising it to where it was before dredging!
- Levées make the problem worse by raising the river bed further, as the river naturally adjusts to the raised banks.

Figure 2 *The village of Moorland surrounded by floodwater in winter 2014*

The future

Climate scientists are clear that climate change will bring the following for the UK:

- more storms and damaging winds
- higher, longer-lasting floods
- higher spring tides
- more storm surges.

Six Second Summary

- In 2014, the Somerset Levels flooded, causing damage and leaving villages isolated.
- The Somerset Levels are one of the UK's lowest-lying areas.
- Spring tide in the Bristol Channel causes rivers to flood.
- A combination of physical and human factors caused the floods.
- Climate change will cause more flooding in the UK.

Over to you

List **a)** the physical, and **b)** the human causes of the 2014 floods in the Somerset Levels on sticky notes. Put them up on your wall and check you can remember them in a few days.

Managing the flood risk

You need to know:

- costs and benefits of both hard and soft engineering.

Student Book
See pages 156–157

The options ahead

There are debates about how to manage flood risks on rivers. Flood protection is carried out by the Environment Agency which chooses between hard and soft-engineering methods.

Hard-engineering methods

These include structures (e.g. flood walls, flood relief channels, levées) and ways of managing the channel (e.g. dredging) to defend areas from floodwater.

Method	How it works	How effective is it?	Cost per km
Flood walls	Increases river's capacity to prevent flooding.	• Cheap, 'one-off' cost – once built, it's done. • Useful in city centres, where space is limited. • Water dispersed quickly, increasing flood risk downstream.	Depends on type of wall and material used.
Construct levées	Usually built some distance from the river, increasing capacity.	• Expensive, but reduced fear of flooding for those close to river. • Can increase the flood risk downstream. • Can fail by overtopping (water rises over the levée), slumping, or by erosion.	Up to £1m depending on materials used.
Dredging	Increases channel capacity. Lining with concrete speeds up river flow to get flood water away quickly.	• Needs to be done often as the channel fills with sediment each time it rains heavily. • Concrete lining is expensive but cheap to maintain. • Speeding up flow increases the flood risk downstream.	£50 000
Flood relief channel	Create extra channels to divert excess water from city centre (e.g. in Rotherham and Exeter).	• Protects built-up areas but could cause flooding elsewhere.	• £14m/km in Rotherham 2008. • £4.3m/km in Exeter in 2015.

Figure 1 *Summary of hard-engineering methods used in flood protection*

Soft-engineering methods

These include solutions to adapt to flood risks and allow natural processes to manage rainwater. The Environment Agency now believes that:

- upstream, upland areas should be **planted with trees** to reduce surface run-off
- flood plains should be lowered or levées removed to encourage flooding over certain areas (called **flood plain retention**)
- river channels should be **restored** to their natural state (called **river channel restoration**)
- planning permission should **avoid building** near rivers.

Method	How it works	How effective is it?	Cost per km
Flood plain retention	• Flood plain is lowered, and surface restored to shrubs or grassland, so it retains water and releases it slowly into the river.	• Increased ability to store floodwater. • Reduced flooding in 2007 despite heavy rains. • The only flooding in Darlington in 2007 was caused by backlogged drains.	£1.2 million in total for a 2 km stretch.
River channel restoration	• Some meanders were rebuilt, slowing water down. • Banks were lowered so the park was flooded instead of Darlington. • Hard engineering materials were replaced with sediment, and planted with trees.	• Improved ecology with a 30% increase in birds and insects, within one year. • In a survey, 82% of people liked the more natural look 'mostly' or 'strongly'.	

Figure 2 *Summary of soft engineering methods used along the River Skerne in Darlington. The Environment Agency hopes to reduce the River Skerne's response so that it is more like hydrograph B (Section 4.20).*

Six Second Summary

- Hard engineering includes building structures to prevent flooding.
- Soft engineering involves allowing natural processes to deal with rainwater.

Over to you

Draw a spider diagram to show how different methods of hard engineering and soft engineering work.