OCR GCSE (9–1)

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GEOGRAPHY A

Geographical Themes

SECOND EDITION

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CHAPTER

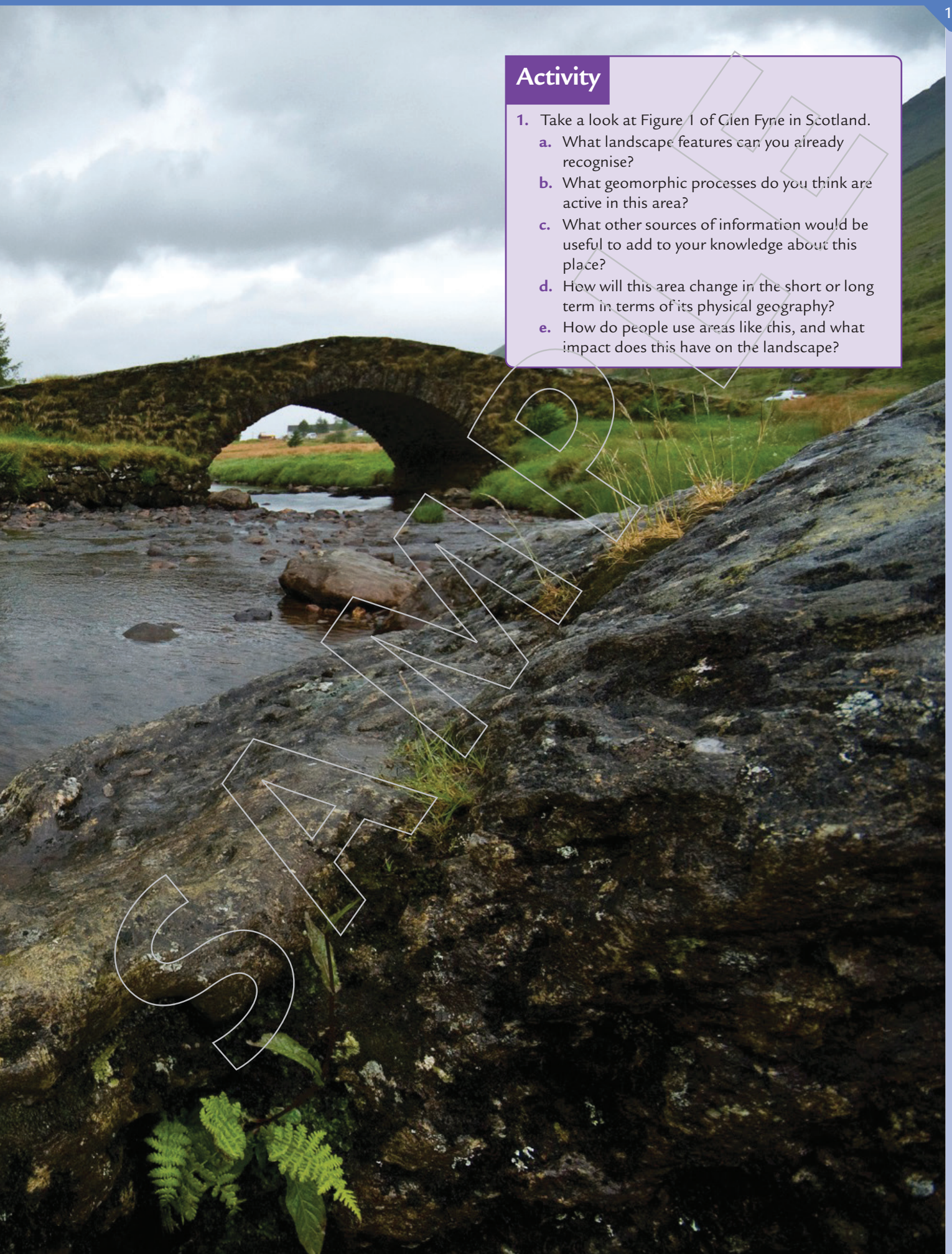
3 River landscapes

Key idea: Rivers create a range of landforms which change with distance from their source within a river basin.

➜ In this section you will study:

- ➜ the formation of river landforms – waterfall, gorge, V-shaped valley, floodplain, levee, meander, ox-bow lake
- ➜ a case study of the River Wye, a UK river basin, including: the geomorphic processes operating at different scales and how they are influenced by geology and climate; landforms and features in the River Wye; how human activity, including management, works in combination with geomorphic processes to impact the landscape.

▲ **Figure 1** Glen Fyne, Scotland



Activity

1. Take a look at Figure 1 of Glen Fyne in Scotland.
   - **a.** What landscape features can you already recognise?
   - **b.** What geomorphic processes do you think are active in this area?
   - **c.** What other sources of information would be useful to add to your knowledge about this place?
   - **d.** How will this area change in the short or long term in terms of its physical geography?
   - **e.** How do people use areas like this, and what impact does this have on the landscape?

What geomorphic processes shape river landscapes?

Rivers are surface drainage features which carry excess water to the sea. As they move, water and sediment are used to shape the landscape over and through which they flow. As a river changes, the power that it has to do this also changes, and results in a range of landscape features and associated landscapes.

Weathering

The geomorphic processes involved in the weathering of river landscapes are largely the same as those which shape coastal landscapes (outlined on pages 24–25).

Mechanical weathering and chemical weathering will take place on the slopes of river valleys, as well as on the exposed banks of the river. If features like waterfalls or gorges are created, these will also be subject to weathering.

Biological weathering can happen as a result of tree roots, which can damage river banks. Creatures such as water rats, voles and kingfishers may burrow into river banks to create their nests. Some invasive species also have an impact. Chinese mitten crabs have damaged the banks of the River Thames in several locations.

Mass movement

Mass movement refers to the sudden movement of material down a slope due to the pull of gravity. Heavy rain soaking into permeable rocks can add weight to them, and the water can also lubricate the boundaries where materials meet, so that flow is more likely as the material making up the river banks 'fails'. Rotational slumping occurs on the banks of rivers, where the bottom of the river bank slips into the river and other material slumps down the bank. Soft, clay river banks are particularly susceptible to slumping.

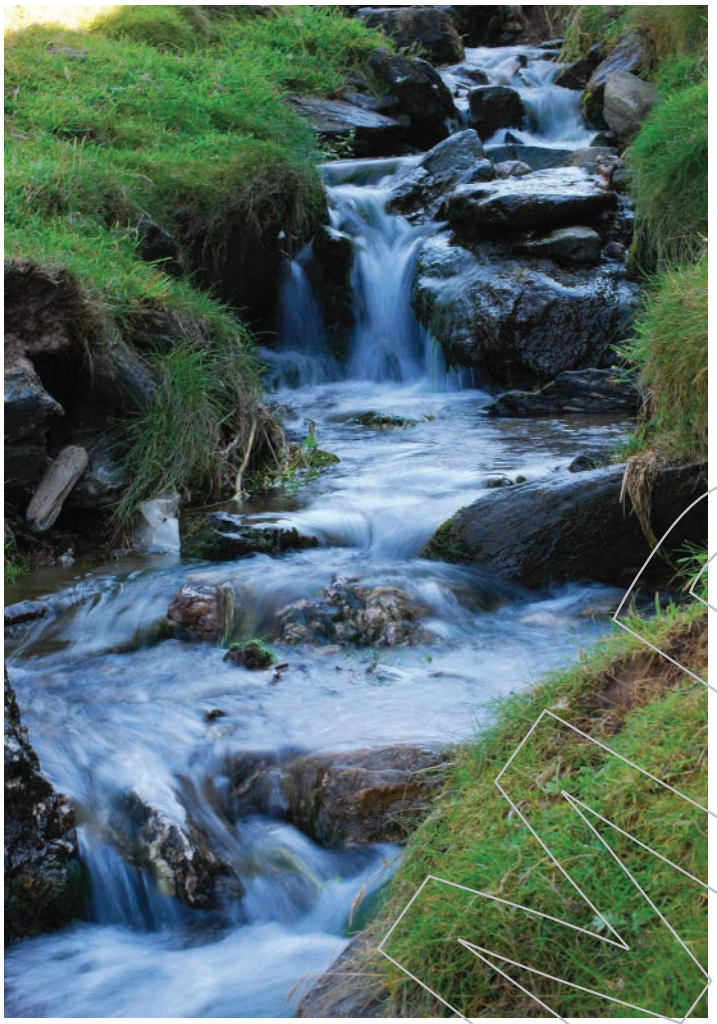
Erosion

Erosion is the wearing away of the river banks by a moving force. The main energy causing this erosive force is the moving water within the river channel.

The nature of the erosion will change with distance along the river's long profile (which is a graph to show the river's height with distance along its course). In the steeper sections close to the river's mouth, the river may erode downwards (vertical erosion) compared with the sideways erosion (lateral erosion) later in its course which widens the river valley.

- Water hitting the river banks will compress air into any cracks within it. The air in the cracks expands explosively outwards as the pressure is released by the receding water. This process, called hydraulic action, removes fine material and enlarges cracks which speeds up the erosion process. When the river is flowing rapidly and in a turbulent way, the bursting of bubbles may also help enlarge holes in the river bank in a process called cavitation.
- Water moves sand or pebbles which are then thrown or rubbed against the river banks, where the land is worn away by abrasion.
- Water can slowly dissolve certain rock types such as limestone by solution.
- Larger rocks in the river are broken down into small, more rounded sediment through attrition as the different rocks within the river hit each other.

Figure 2 Erosion along a river bank



▲ **Figure 3** The upper course of a river

Transportation

Water flowing downhill has the ability to carry sediment. The sediment carried by a river is called its load, and is added to the river by weathering and erosion on the valley sides, and of the river banks. This can vary from very fine silt particles, as well as large angular boulders which may remain in place until a flood has the energy to move them. The load is also used in the process of erosion. Different sizes of load are moved at different velocities. The River Wye (see page 18) drops by around 600 m during the first 80 km of its course, providing a fast-flowing upper course which moves sediment in four main ways (see Figure 4):

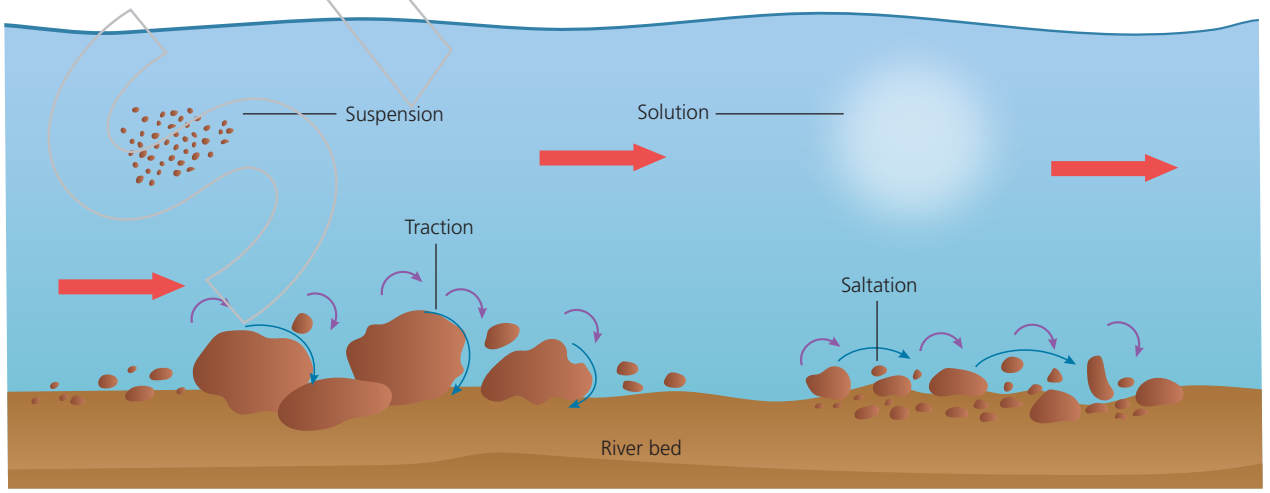
- **Traction:** large boulders and rocks are rolled along the river bed, scraping against it as they do so.
- **Saltation:** small pebbles and stones are bounced along the river bed in a series of short jumps.
- **Suspension:** very fine, light material is carried along in the water; clays tend to stick together but silts and fine sand are carried in this way and make the river 'murky'.
- **Solution:** some types of sediment, such as minerals, are dissolved in the water and carried along in solution.

Traction is only likely after heavy rainfall, when the river's discharge is at its highest. In the upper course of a river, the bedload tends to be larger, as can be seen in Figure 3.

Deposition

Deposition is the name for the process when rivers drop their load. As velocity falls, the larger particles will be dropped first, with the finest particles dropped last. This means that the bed of mountain streams is often full of boulders (see Figure 3). When the river slows down and loses energy, sediment, such as sand and pebbles, are deposited on the shallow bank of a river.

It is the balance of the energy of the river, the movement of water and the transport of sediment that creates all the features that are found along the course of a river.



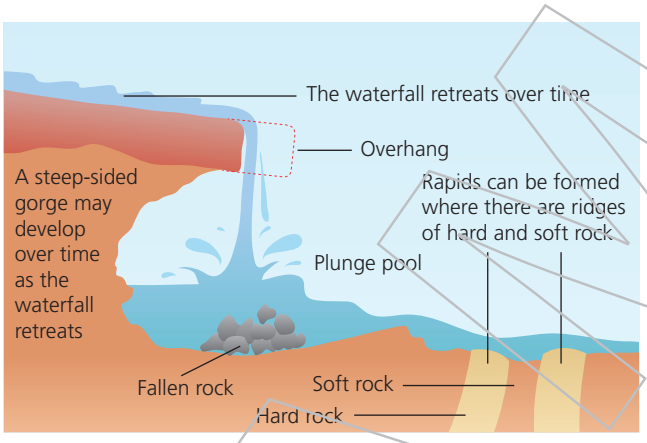
▲ **Figure 4** River transport processes

The formation of river landforms

Waterfalls

A waterfall is a feature where water drops vertically over a sudden change in gradient, sometimes from a height of tens of metres. They occur when a river flows over bands of rock which vary in their resistance to erosion (see Figure 5). Areas of weaker rock are eroded faster, creating a steep gradient between the hard and soft rock. This means that the river can flow faster, and as it flows over the sudden drops marked by the edge of the more resistant bands of rock, it creates rapids.

With time, the softer rock is eroded more quickly and the drop becomes steeper. This creates an overhang of hard rock. A deep plunge pool is formed at the bottom of the drop and turbulence in the pool erodes the back wall of the waterfall further.



▲ **Figure 5** Formation of waterfalls and rapids

Gorges

Gorges are narrow, steep-sided valleys which are formed when waterfalls retreat upstream. This happens when the overhang that forms collapses, and the process of erosion begins again. Gorges tend to have steep rock walls and are found in the upper part of a river's course. They are river channel landforms, but also have erosion and weathering occurring on them, as with valleys. The Upper Wye Gorge near Symonds Yat is a picturesque example (see page 19).

V-shaped valley

When it is nearer its source, a river is shallow and there is a lot of friction between the water and the river bed. This erodes the rocks beneath it, leading to a steeper gradient which in turn makes the water in the river descend quickly. This gives it the energy to erode the river bed further, producing a steep sided V-shaped valley.

Floodplain

A floodplain is a wide area of land on either side of a river which is prone to flooding. This is created due to centuries of lateral erosion by a river, which widens the river floor. It is also created by the deposition of fine sediment during floods.

As the river floods and flows outwards from the river channel, the flow has less energy, so it deposits the fine sediment (alluvium) being carried within it onto the surrounding area.

Interlocking spurs

Interlocking spurs are projections of higher land that come down into the narrow river valley on alternate sides of the channel in higher parts of the river's course. The river will wind around them as it doesn't have the energy to remove them yet.

▲ **Figure 6** V-shaped valley near the source of the River Wye on Plynlimon

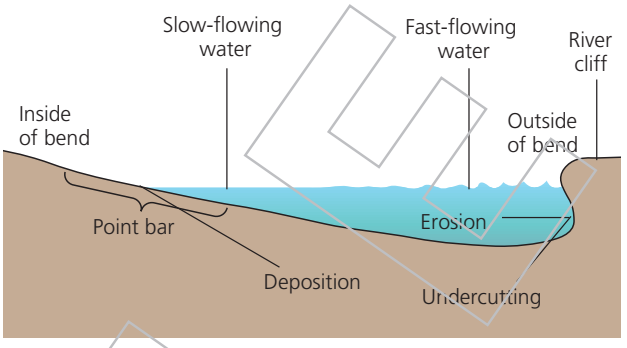
Rapids

Rapids are fast-flowing sections of a river, where the water flows turbulently over a relatively steep stretch of river bed. They occur where harder and softer rock make up the bed of the river in alternating bands, making it uneven. They are usually found in the upper course of a river and are used by canoeists on rivers such as the River Wye, or the River Severn near Ironbridge Gorge.

▲ **Figure 7** Canoeists on the River Wye rapids just below Symonds Yat

Meanders

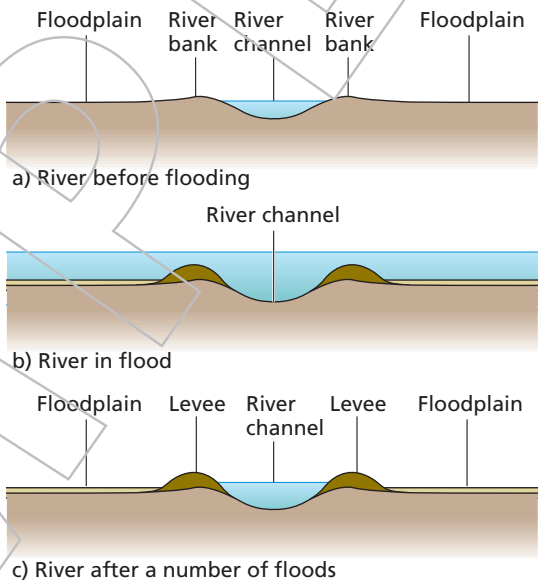
Meanders are bends in a river. They are a natural feature of the river, producing a sinuous form from above. They are caused by lateral erosion. As water flows around a meander, it flows faster on the outside of the slope, causing erosion which produces a river cliff. The water moves in a corkscrew motion, which moves any load eroded from the cliff and deposits it on the inside of the meander bend as a slip-off-slope. This results in a cross profile which is not symmetrical (see Figure 8).



▲ **Figure 8** A cross-section of a meander bend

Levees

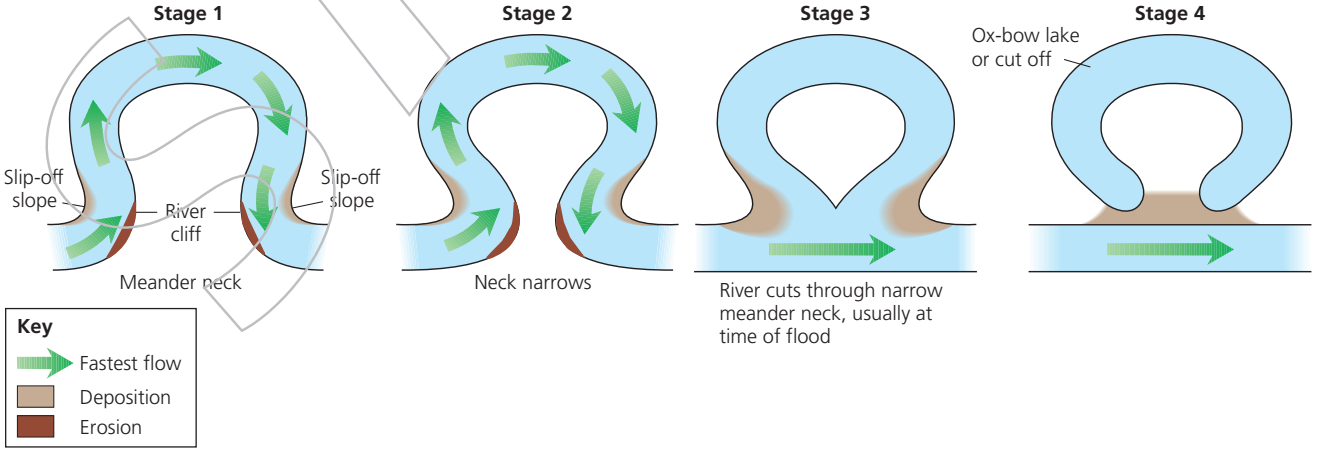
Levees are river banks which have been naturally raised from deposition. As the water that is on a floodplain starts to recede after a flood, the water drops the heavier material first. This means that more sediment is dropped closer to the river channel, and this starts to build up. After the river has flooded several times, this can build up to form levees (Figure 9). Over time, this can also raise the level of the river, as there is more room in the channel for water. In some places, these levees are artificially strengthened or enlarged as a flood defence.



▲ **Figure 9** The formation of levees

Ox-bow lakes

An ox-bow lake is a horseshoe-shaped lake which can be found close to a river channel. Over time, meander bends can become very large. Owing to the continual erosion, the ends of the meander bend can become closer and the neck of the meander will narrow. When the river floods, the river may then cut through the neck to take a shorter route and create a new channel. The old bend will be cut off from the main channel and eventually form a curving 'ox-bow' lake until continued deposition of sediment fills it in (see Figure 10).

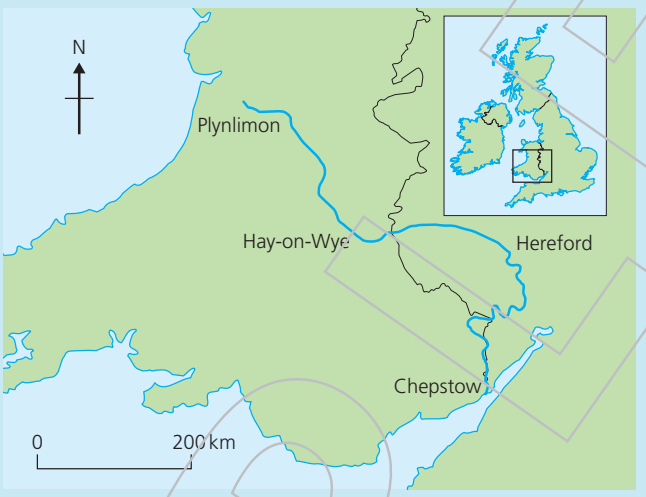


▲ **Figure 10** Ox-bow lake formation

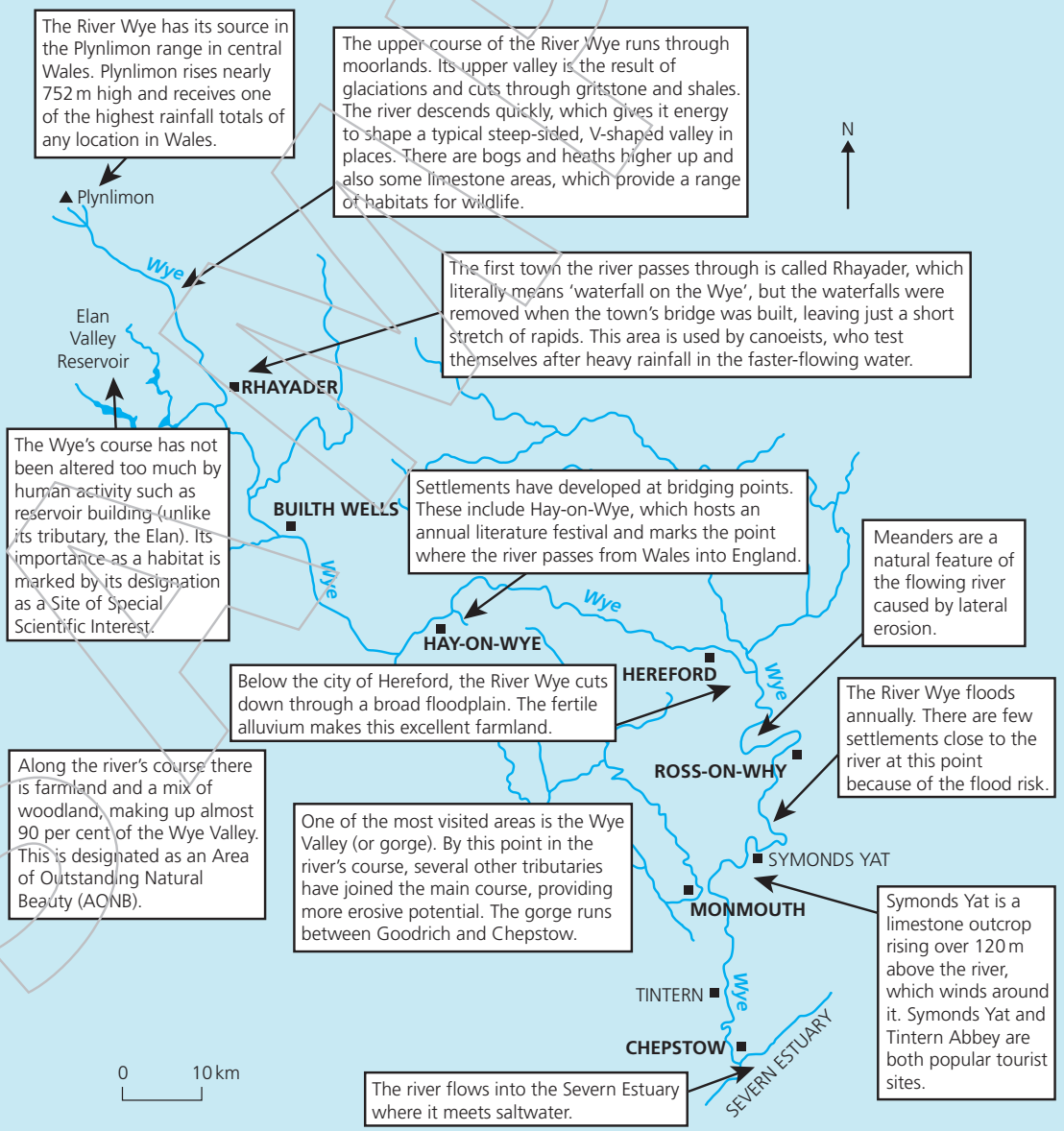
Case study: a UK river basin

The River Wye?

The River Wye is the fifth longest river in the UK, at over 130 miles (210 km) long.



▶ **Figure 12** The course of River Wye



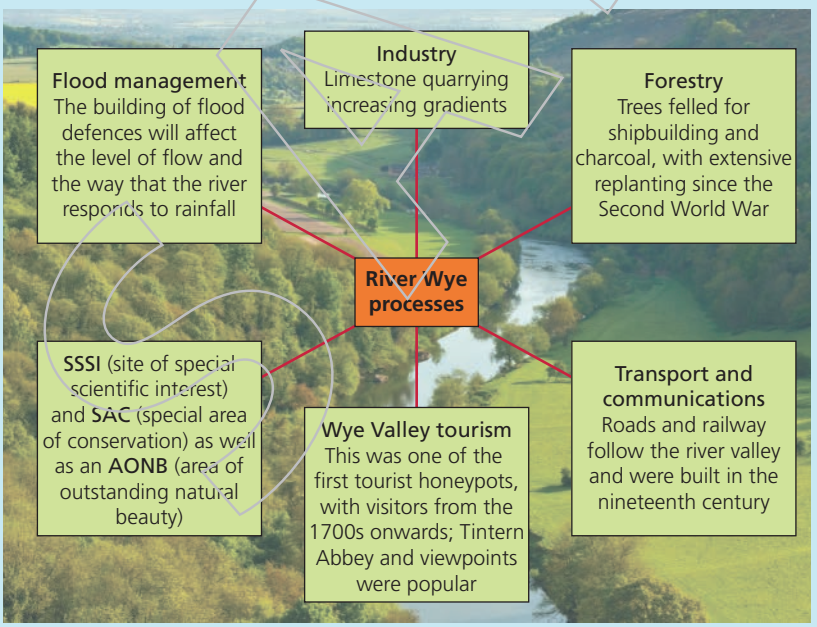
▲ **Figure 13** The course of River Wye, in detail

Managing the River Wye

All rivers require management to ensure that they do not impact on the environments through which they run. All major rivers, including the Wye, have a management plan produced by the Environment Agency in consultation with other bodies.

The Wye Valley is affected by a range of processes, both human and physical, some of which are historical, and have been in place for many years (see Figure 15).

▲ **Figure 14** Symonds Yat on the Wye Valley



▲ **Figure 15** Processes affecting the River Wye

Fieldwork ideas

- Primary data: if you have an accessible local river which is very shallow and easy to access, aim to collect data on the speed of the river flow using an appropriate technique. Consider what techniques you could use, and the limitations of them. River levels can also be viewed using the Gaugemap website: www.gaugemap.co.uk/.
- Secondary data: use the Environment Agency website http://apps.environment-agency.gov.uk/wiyby/134808.aspx to explore your local area further. Does the river have a history of flooding?

Urbanisation

Hard engineering may be required to protect settlements near to the river's channel from flooding. Over 200,000 people live in the Wye and Usk Valley, which includes large towns such as Hereford and Chepstow. These same urban environments may increase the flood risk by draining water more quickly into the channel. Around 9000 properties in the area are thought to be at particular risk of flooding. A number of strategies, including hard engineering, are used to protect these larger towns. People are also expected to be aware of methods to reduce their personal risk. Some areas of the floodplain have been zoned as being of high risk; construction is not permitted in these areas.

Agriculture

The predominant land use in the catchment is agriculture, which is a consumer of water from the river for irrigation. There are also high levels of biodiversity that need to be managed alongside the agricultural use of the land, such as controls on particular chemicals that may otherwise affect the river.

The geology along the course produces different soil types which result in changes to the land use. The light sandy soils near Ross-on-Wye are ideal for growing asparagus, a seasonal crop.

▲ **Figure 16** Flood defences at Hereford

> The light, sandy soil and south-facing slopes of the meandering Wye Valley capture the earliest spring sunlight, and create a microclimate that is perfectly formed to produce some of the earliest, and the best, produce in the UK.
>
> *Wye Valley Produce website*

Industry

Although this is not a heavily industrialised area, the presence of the river means that some industrial activity is inevitable. Quarrying for limestone, originally to provide limestone for Llanwern Steelworks in Newport, has changed the gradient of some areas. Tintern Quarry is now a rock-climbing activity centre but quarrying still takes place at Livox Quarry for Marshalls. The rock also contains metal ores including iron ore. Woodlands were also felled for shipbuilding and to support the charcoal industry.

Today, the tourist industry employs many people in the Wye Valley, and high-profile events such as the literary festival at Hay-on-Wye draw thousands of visitors to the area. The Forest of Dean has also been used for numerous TV and film location shoots, including the 2015 film, *Star Wars: The Force Awakens* and a new adaptation of *The Secret Garden* which was filmed in Puzzlewood, an ancient woodland near Coleford in the Forest of Dean. People are also employed maintaining fish stocks and managing the river habitats.

Geomorphic processes along the River Wye

The Wye starts on the slopes of Plynlimon, where impermeable mudstones and slates have led to the development of peat bogs which store huge amounts of precipitation and release them slowly, maintaining a good level of flow in the river. When these bogs are saturated, the river responds quickly to rainfall.

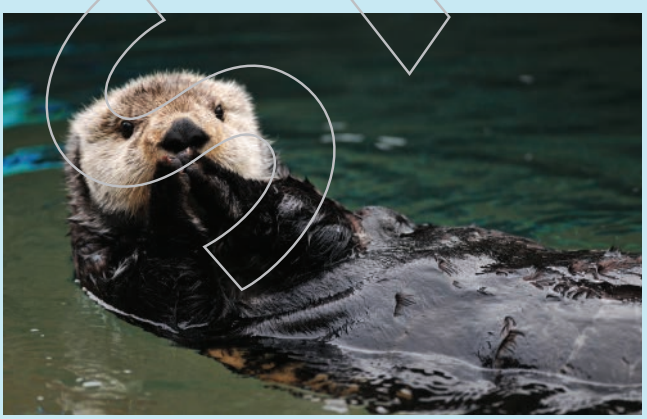
▲ **Figure 17** The Hay Festival at Hay on Wye, Wales, attracts 250,000 visitors to the area each year, bringing around £20 million into the local economy.

Heavy rainfall can speed up weathering processes such as frost action. Water draining through bogs may contain organic acids which speed up chemical weathering processes. Rocks which are resistant to erosion may constrain the channel in its upper course, with rocks such as limestone offering the potential for the river to broaden its valley further downstream at Symonds Yat.

Some areas use the landscape to reduce the impacts of flooding, by ensuring that excess water is able to flow into areas of the floodplain that are zoned for that purpose. Further downstream, the Letton Lakes take some of the excess water during flood events to protect Hereford.

Management has attempted to reduce the likelihood of flooding by slowing the rate that water enters the channel by surface runoff. Vegetation management reduces rates of runoff by increasing surface cover, and increasing interception storage. The risks of landslides or other mass movement may be reduced by planting trees which also intercept rainfall and help bind the soil surface together. There are few trees in large parts of the Wye's catchment, but other areas have seen new planting. Research conducted for the Environment Agency suggests that trees planted in the upper course of the river could reduce the height of flood water by 20 per cent by increasing interception storage. Trees also provide a local amenity for residents, as well as having an aesthetic value. Where river banks are stabilised, they can be more widely used by anglers or walkers. Otters are also returning to the upper course of the river as a result.

Stabilising the channel can assist with changing the river's response to rainfall, which ultimately helps settlements further downstream. It can also reduce the rate of river erosion, which reduces the amount of sediment being transported downstream. Soil erosion will also decrease due to vegetation reducing direct raindrop impact and overland flow. Ultimately this means that depositional features such as floodplains would have less sediment available to construct them. Artificial levees would also need to be constructed. The flow of the river is in a state of dynamic equilibrium (it will adjust to any change, to bring it back to a natural flow where possible), and human attempts to manage the channel can upset this balance in the long term if care isn't taken to work with the natural processes acting along it during river management.



▲ **Figure 18** Otters have returned to the upper course of the River Wye as river banks have been stabilised

Activities

1. Access the Wye Valley website at http://wyevalleyaonb.org.uk and produce an illustrated set of cards describing the different ways that the Wye Valley is used by people. How will each of these potentially affect the river?
2. Use the BGS map viewer to explore the changing geology along the course of the river. http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Geographical skills

1. Rivers react to rainfall as the water enters the channel. Some rivers rise more quickly than others after rainfall and may be more prone to flooding. The Environment Agency has provided data from its network of monitoring gauges. The ones along the River Wye can be viewed on this page: https://flood-warning-information.service.gov.uk/river-and-sea-levels

Each gauge can also be viewed on the GaugeMap website. The one at Hereford Bridge, on the River Wye, can be seen here: www.gaugemap.co.uk/#!Map/Summary/796/815

Each gauge can be viewed, and plotted, and even followed on Twitter.

2. Images of the Wye Valley, and other locations along the River Wye can be identified from the Geograph website. www.geograph.org.uk/of/wye+valley
3. Explore the Wye Valley virtually using Google Earth.

CHAPTER

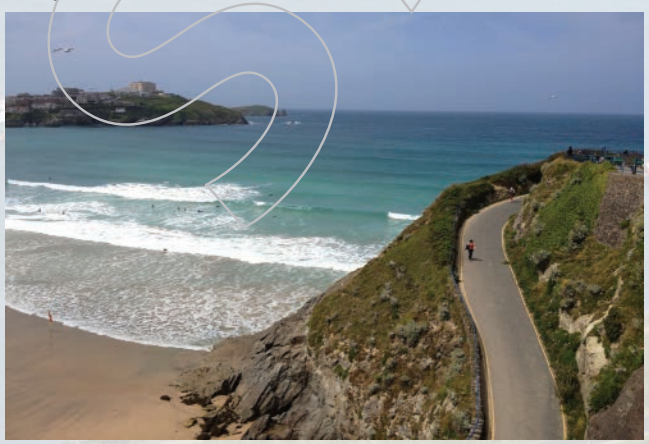
4 Coastal landscapes

Key idea: There are a range of landforms within the coastal landscape.

In this section you will study:

- the formation of coastal landforms – headland, bay, cave, arch, stack, beach and spit
- a case study of the North Norfolk coast, a coastal landscape, including: the geomorphic processes operating at different scales and how they are influenced by geology and climate; landforms and features in the North Norfolk Coast; how human activity, including management, works in combination with geomorphic processes to impact the landscape.

▲ **Figure 1** Wells-next-the-Sea, North Norfolk



▲ **Figure 2** Newquay, Cornwall

▲ **Figure 3** Groynes and surf, Tywyn, West Wales

Activity

1. Take a look at the images on these pages.
   a. What landscape features can you already recognise?
   b. What processes do you think are active in these areas?
   c. What other sources of information would be useful to add to your knowledge about these places?
   d. How will these areas change in the short or long term in terms of their physical geography?
   e. How do people use these areas, and what impact does this have on them?

'All too often, chasing far-away places, we forget just what beauty we have on our doorstep'.

Michael Palin, former president of the Royal Geographical Society

Wherever you are in Great Britain, you are never more than 75 miles from the coast. The coastline is part of our history as a country, is central to our culture, and is part of our childhood as the setting for shared family experiences. In this chapter we will look closely to see what processes created (and continue to shape) this dramatic and varied landscape, which runs for over 10,000 km around England alone.

Geographical skills

Interpreting photographs

- Look at a photograph and consider the features that are shown. Which are human and which natural? How do they relate to each other?
- Is the surface geology shown? Are there particular types of landscape features present?
- Look for evidence of human activity, including population, economic activity or farming. Are there any patterns to the activities shown in the photograph?
- Remember that one photo by itself can be misleading. When interpreting photographs in your exams, use them along with other resources and information, for example, an OS map extract.

Geographical skills

Surveys are an important way to gather data and are useful for fieldwork enquiries.

1. Carry out a survey within your class of the favourite coastal landscapes of students. Ask them to bring in or gather photographs.
2. Add the locations to a map of the UK and create a picture collage. Which places have been most visited? What types of coastal landscape are featured?
3. Do the same survey for staff at the school or parents. Are there differences between the results of the surveys?

How geomorphic processes shape coastal landscapes

Geomorphic processes are the processes that change the shape of the land, including: weathering, mass movement, erosion, transport and deposition. These processes cause changes that can be large or small, and that can happen very quickly or over hundreds of years.

Geomorphic processes influence and shape the land found at the coast in different ways, and across different timescales. These create coastal landforms that together make up the huge variety of coastal landscapes we can see along the coast of the UK. The daily rise and fall of the tides changes the shape of beaches by moving beach sediment around, but it is the longer-term action of waves, wind and storms that results in some of the more visible changes in coastal landforms, combined with weathering and other processes acting on the material that makes up the coast.

Much of the coastline is not wholly natural and is managed by people to reduce its susceptibility to these processes, to reduce the damage to property or the risk of loss of life. The sea is often seen as an 'enemy' to be combatted, although some recent projects have allowed the sea to reclaim areas of land in a managed realignment of the coastline.

Waves are the main source of energy at the coast and marine erosion refers to the removal of material by waves, some of which are described as destructive. Waves also weaken the base of the cliff, leading to mass movement such as slides and slumps depending on the type of rock making up the cliffs.

Weathering

Weathering is the impact of mechanical (physical), chemical and biological processes, which act to break down the surface of the Earth *in situ* (without any movement). If transportation is involved, such as by waves, wind or moving water, this process is then called erosion. Weathering may create loose rock fragments, which may then be picked up by waves and used in the process of erosion called abrasion.

▲ **Figure 4** Waves causing erosion on the coast

Mechanical weathering

Cliffs along the coastlines, in places such as South Devon and Pembrokeshire, are subject to mechanical weathering (also known as sub-aerial processes) which are the physical actions of rain, frost and wind. Freeze-thaw weathering (also known as frost shattering) happens when water enters cracks in the rocks and expands as it freezes, putting pressure on the surrounding rock and enlarging the cracks. Repetition of this process causes rock to break off and accumulate at the bottom of the cliff. Salt spray can also get into cracks in the rocks, and the salt crystals that grow can also put pressure on the rock.

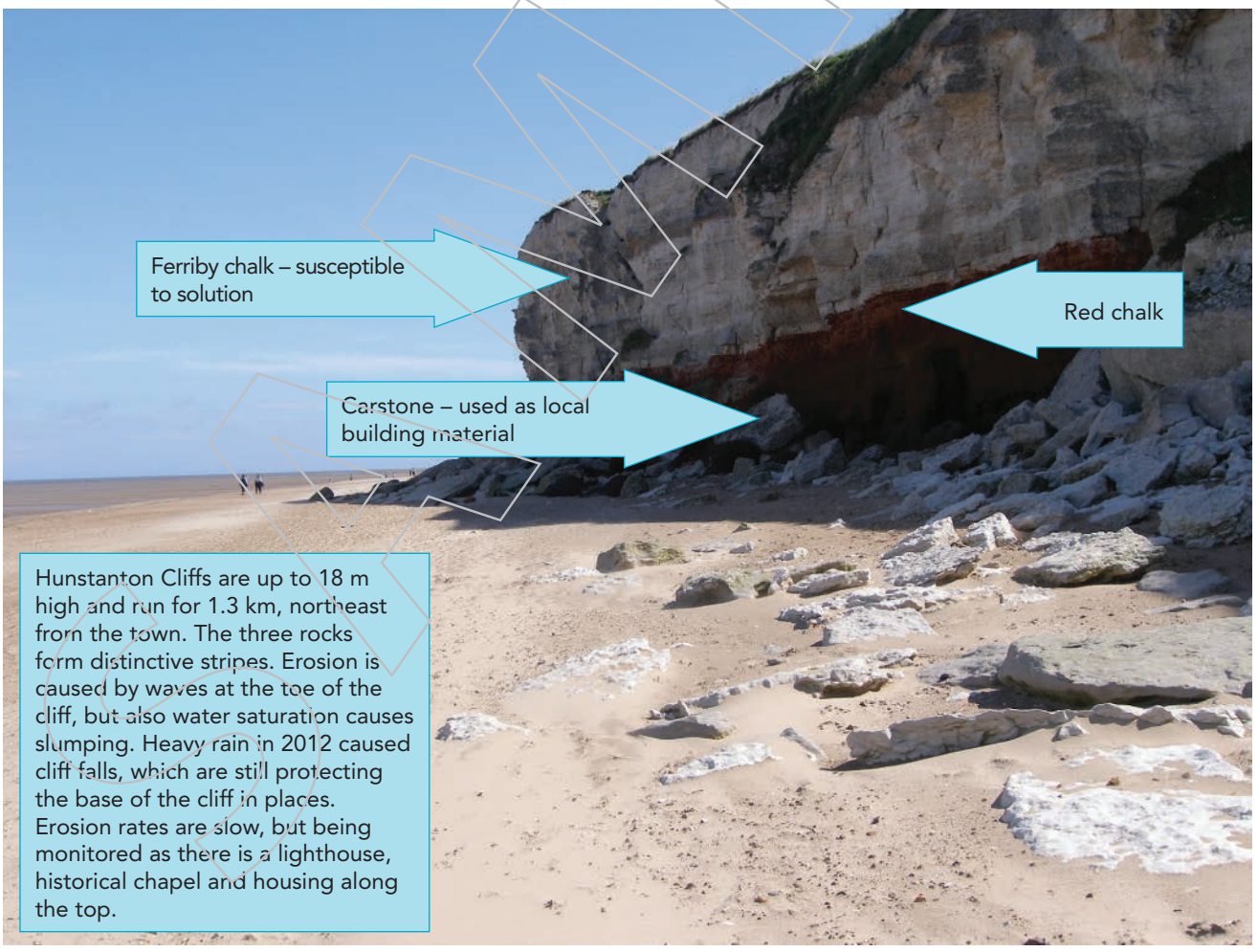
Chemical weathering

Cliffs along the coast of Kent or the Holderness coast around Flamborough Head are composed of chalk and limestone, and are susceptible to chemical weathering.

- Rainwater leads to carbonation, when weak acid reacts with limestone (calcium carbonate) to form calcium bicarbonate which is soluble. The limestone is slowly removed by a process called **solution**.
- Minerals are also weakened when they are exposed to the air in a process called **oxidation**.
- Some minerals are affected by water in a process called **hydrolysis**, which involves acidic rainfall reacting with minerals to produce material that is soluble and easily washed away.

Biological weathering

The rocks and land on the coast are broken down by the actions of living organisms, including plants and animals. Tree roots act to loosen rocks and provide crevices into which water can penetrate. Molluscs use their feet to cling to the rocks, but can also weaken the rock surface over time.



▲ **Figure 5** Hunstanton Cliffs, Norfolk

▲ **Figure 6** Slumped cliffs near Southwold, Suffolk

Mass movement

Mass movement refers to the sudden movement of material down a slope due to the pull of gravity. Heavy rain soaking into permeable rocks can add weight to them and the water can also lubricate the boundaries where materials meet, so that flow is more likely as the cliff 'fails'. Rotational slumping occurs on the soft cliffs, where the base of the cliff moves; other material then slumps down the face as the bottom moves outwards and across the beach (see Figure 6). These can happen suddenly and have caused several fatalities in recent years, for example at Birling Gap in August 2018, where the cliff is retreating rapidly. There may be crops planted at the top of the cliff which end up on the beach before they can be harvested. In some cases, livestock have even been carried down the cliff. Cliffs made of softer materials, including those along the east coast of the UK, are particularly susceptible to slumping.

On other cliffs, rock slides occur, where the failure occurs along a particular geological boundary within the cliff. A section falls down due to gravity and may dislodge other material on its way down. This can be caused by prolonged wet weather, or alternatively dry weather, which causes rocks such as clay to shrink. Cracks near the top of a cliff are a sign that it is an active area which may fail at any time.

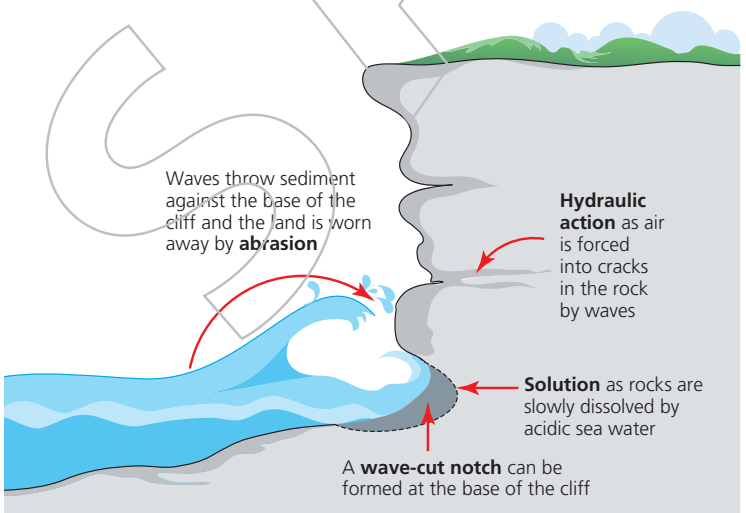
▲ **Figure 7** Budleigh Salterton, Devon: a landscape of headlands and bays

Erosion

Erosion is the wearing away of the coast by a moving force. The main energy causing this erosive force at the coast is provided by waves (see Figure 8).

- Waves arrive every few seconds and, along with the water, they also move sand or pebbles. When this sediment is thrown or rubbed against the base of the cliff as the wave breaks, the land is worn away by abrasion. This can sometimes result in a wave-cut notch at the base of the cliff where there is a greater rate of erosion than higher up the cliff.
- Water hitting a rock will compress air into any cracks within it. In the pause between waves, the air in the crack expands explosively outwards as the pressure is released by the receding water. This process, called hydraulic action, removes fine material and enlarges cracks, speeding up the process.
- Seawater is slightly acidic and can slowly dissolve certain rock types such as limestone by solution. Over time, large sediment removed by the earlier processes is broken down into smaller, more rounded sediment through attrition as particles hit each other. These smaller particles may then form the ammunition for the next wave to hit the cliff in the process of abrasion. As can be seen in Figure 5 on page 25, material that has fallen from a cliff can protect the base of it for some time before it is eventually removed. These smaller particles may then form the ammunition for the next wave to hit the cliffs, which leads to the process of abrasion as they are combined with the water in the wave.

Where hard rock occurs at the coast, you will tend to see cliffed coastlines. Softer rock is more likely to result in lower coastlines, with sand dunes or salt marshes. Where the two are found in close proximity, the result is often a more 'interesting' combination of headlands and bays, with the headlands being made of the more resistant rock (see Figure 7).



▲ **Figure 8** Key marine erosion processes lead to the retreat of cliffs and the creation of new landforms

Transportation

Sediment is transported along the coast in several ways. The processes are the result of wave action and may occur at different rates depending on location.

Traction refers to the movement of larger sediment. Circular wave action rolls pebbles along the sea bed, or shifts the sediment on a beach during a storm. Smaller pieces of shingle or large grains of sand may be picked up temporarily in a process called saltation before being dropped back to the sea bed. Finer clays and smaller particles may be suspended in the water, giving it a brownish colour when seen from the air, especially after storms or along easily eroded stretches of coastline. A milky colour close to chalk or limestone cliffs may also be a sign that solution has been happening: when minerals dissolve into the seawater.

Similar processes occur in a river, see page 15.

Longshore drift

Beach sediment is moved (transported) up and down the beach profile by waves in different ways:

- The swash is the forward movement of water up the beach as the wave breaks.
- The backwash is the movement of water down the beach due to gravity after a wave breaks.

The direction of the waves hitting the coastline is dependent on the wind. If the wind is blowing at an angle to the coastline, the wave swash will be at a similar angle, transporting loose sediment along the beach with it.

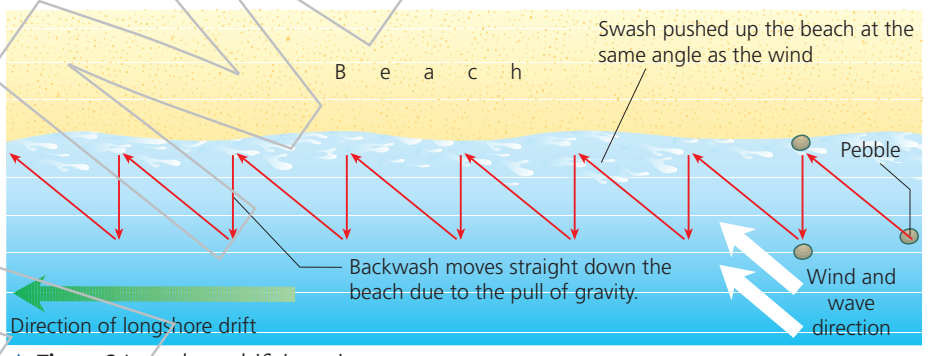
As the backwash is being pulled by gravity, it always returns to the sea at 90° to the coast, which is the shortest route down the beach. This means that the sediment will be moved along the beach in a zigzag manner (see Figure 9).

Although the wind may change direction from day to day on any stretch of coastline, there will be a prevailing wind direction. This will result in a net movement of sediment in one particular direction along the beach. This process of sediment being moved along the coastline is called longshore (littoral) drift.

Groynes are sometimes built to slow down this movement of sediment across the beach. This might be because too much sediment would be moved from vulnerable sections of coastline. They could also be built to ensure that a sandy beach remains in place for tourist or sea defence purposes.

Deposition

When waves move material along the coast, and more sediment stays on the beach than is taken away by the backwash, this is deposition. This creates landforms such as beaches and spits (see page 30).



▲ **Figure 9** Longshore drift in action

Activities

1. Carry out an internet search for the term 'cliff collapse' and click the 'News' option to see where they have been happening. Read through a few of the reports and fill in an incident report containing the following information:
   - where the incident happened
   - type of rock involved
   - how much material was lost
   - any damage or casualties
   - what was done to reduce the impact.
2. Explain the processes which cause cliffs to retreat through erosion.
3. Explain the process of longshore drift, using a series of diagrams.

➜ Take it further

4. Identify some measures which could be taken to reduce the impact of erosion along the coastline. Research the relative advantages of each of these options. Which of these methods is likely to be the most cost-effective?
5. Design the wording for a sign to be placed at the top of a cliff, offering some warning but also an explanation of why cliffs retreat over time.

The formation of coastal landforms

Features of erosion: headlands, bays, caves, arches and stacks

A headland is a narrow piece of land that projects outwards from the coast and is surrounded by the sea on three sides. Wave energy is concentrated on these locations because the waves curve towards them as they enter shallow water. The rocks making up a headland are more resistant than the rest of that stretch of coastline. A bay is an indentation in the coastline found between two headlands. Bays are made up of a less-resistant rock type which is eroded more easily than the harder rocks of the headlands. The sea erodes the land back into a crescent shape (see Figure 10).

Weak points in headlands are exploited since the rock is not all made up of the same type. Cracks such as vertical joints or horizontal bedding planes in sedimentary rocks allow water to enter the rock. These cracks are also widened as a result of hydraulic action and abrasion. As these processes take place where waves impact the base of the cliff, there may be the creation of a wave-cut notch, resulting in a slight overhang.

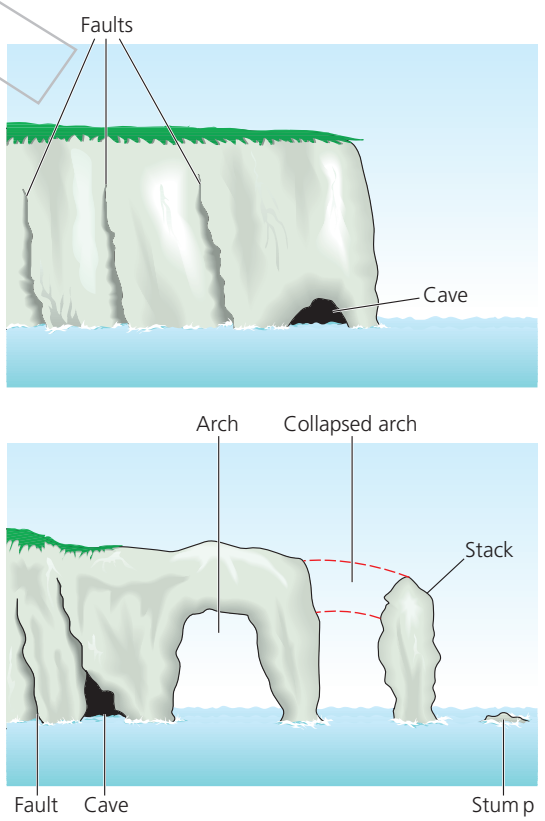
Over time, small caves are formed at weak points as cracks are enlarged. These often form along the tide line. Caves extend into the headland, and may join up with another cave being formed at the opposite side, or may follow a line of weakness and extend across from one side, to create a natural arch that started out as a tunnel.

▲ **Figure 10** The Old Man of Hoy

These arches start small and form close to the tide line. Water surging into these openings widens them and salt spray speeds up the process of erosion, through hydraulic action and abrasion. Rock falling from the cave walls or ceiling may form a temporary barrier that encourages water to move up and over it, increasing the height further. In time, as arches grow, the weight of the 'ceiling' may become too much, and collapse. The outer part of the arch will then become separated from the headland and form a tower called a stack (see Figure 11).

Stacks vary in height and stability. The Old Man of Hoy (see Figure 10), a 137 m sandstone stack in Orkney, has stood for over 200 years, but the so called Twelve Apostles along the Great Ocean Road in Victoria, Australia, are now down to just eight after the most recent collapse in 2008.

Stacks will be worn down to form a stump, which may eventually be covered over at high tide. The wearing down of the cliff to the level of the waves produces a wave-cut platform, which grows in size as the cliffs retreat ever further inland. Over time, the headland will erode back towards the rest of the coastline, where the process of headland formation will start again.



▲ **Figure 11** Formation of a headland

Beachgoers warned after huge Birling Gap cliff fall

The UK Coastguard has issued a warning after a cliff fall at Birling Gap this afternoon prompted a search operation to check no one was hurt.

Jason Edwards, 30, from Eastbourne said he was walking on the beach at around 1 p.m. when he heard 'a massive crack' and the sound of stones and rocks falling and turned to see the cliff falling away.

He said, 'This huge cliff face just missed me and my girlfriend, we literally ran for our lives.' The whole fall happened quickly. 'Approximately 30 seconds of pure noise,' he added.

The beach has since been closed for public safety.

HM Coastguard said it coordinated an 'intensive' search in the area after the 'significant' fall.

A spokesman said, 'No one has been injured and there are no reports of anyone missing following an intensive search of the area, involving Coastguard rescue teams, a Coastguard rescue helicopter and Newhaven RNLI lifeboat as well as involvement from Sussex Police and Essex Fire and Rescue.

'However, Birling Gap Coastguard Rescue officers on scene today are very concerned about public safety and the possibility of more falls and are warning people to give the cliff edges a very wide berth and not to get too close to the top of cliff edges or approach the base of cliffs either.

'As seen in other parts of the country this weekend, the period of dry weather, followed by rain and then a return to warm dry conditions again is increasing the risk of cliff instability and it makes cliff falls more likely.'

▲ **Figure 12** Article from *Eastbourne Herald*, 4 August 2018

Activities

1. Read the article above.
   a. What reasons are given for the cliff collapse at Birling Gap?
   b. What options do the police have for managing the risk in an area that is popular with holidaymakers?
   c. How is the cliff collapse described?

➜ Take it further

2. What are the options for people whose clifftop houses are threatened by coastal erosion? How can cliffs be protected?
3. People still take risks by going close to the tops of cliffs, even taking selfies on the edge. Provide some text which could be added to this article to explain why people should steer clear of cliff edges.
4. Find out about the 'Easternmost House' at Easton Bavents near Southwold in Suffolk, and its owner Juliet Blaxland, who has written a book about living there.

Geographical skills

1. Draw a sketch map of Figure 15. Annotate your sketch map with the likely processes that led to its creation, including the winds that were involved and the source of sediment that helped build it.
2. Explore a stretch of coastline of around 100 km in length by looking at the area on an Ordnance Survey map. Use the map to explore the different types of landform that can be found and the way that people use your chosen stretch of the coast. If your classmates are allocated consecutive stretches of the same coastline, this could result in an interesting large-scale survey.

Features of deposition: beaches and spits

Beaches

Beaches are often found along the UK coastline. They are areas of land that lie between the storm-tide level and the low-tide level. They can be made up of sand, pebbles or a mixture of both. Some beaches are made up of mud and silt.

The charactesistics of sandy beaches are:

- Gently sloping land; very low angle to the sea
- Stretches far inland
- Tourist resorts often have groynes to keep the beach in place
- Can be found in bays or along straight stretches of coastland

Spits

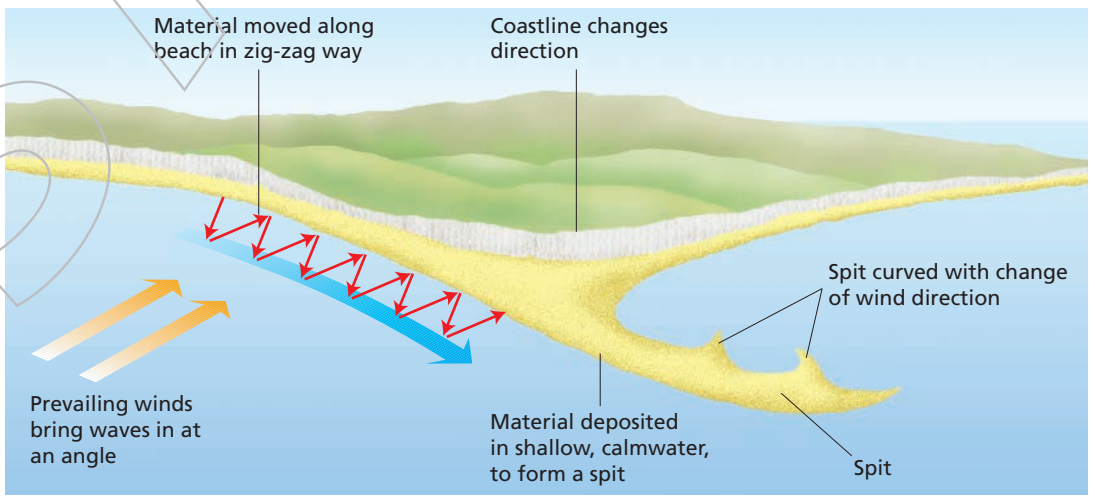
A spit is a sand or shingle beach which is joined to the land at one end, but extends out in the downdrift direction. Spits are created when the coastline ends and the process of longshore drift continues, so sediment is deposited off the coast. If the conditions are right, this sediment will build up to form new land which will extend out along the existing coastline. The end of the feature will be curved by wave action and the impact of winds. Spurn Point is a spit at the mouth of the Humber.

▲ **Figure 13** Blakeney Point spit

Conditions that help the formation of spits are:

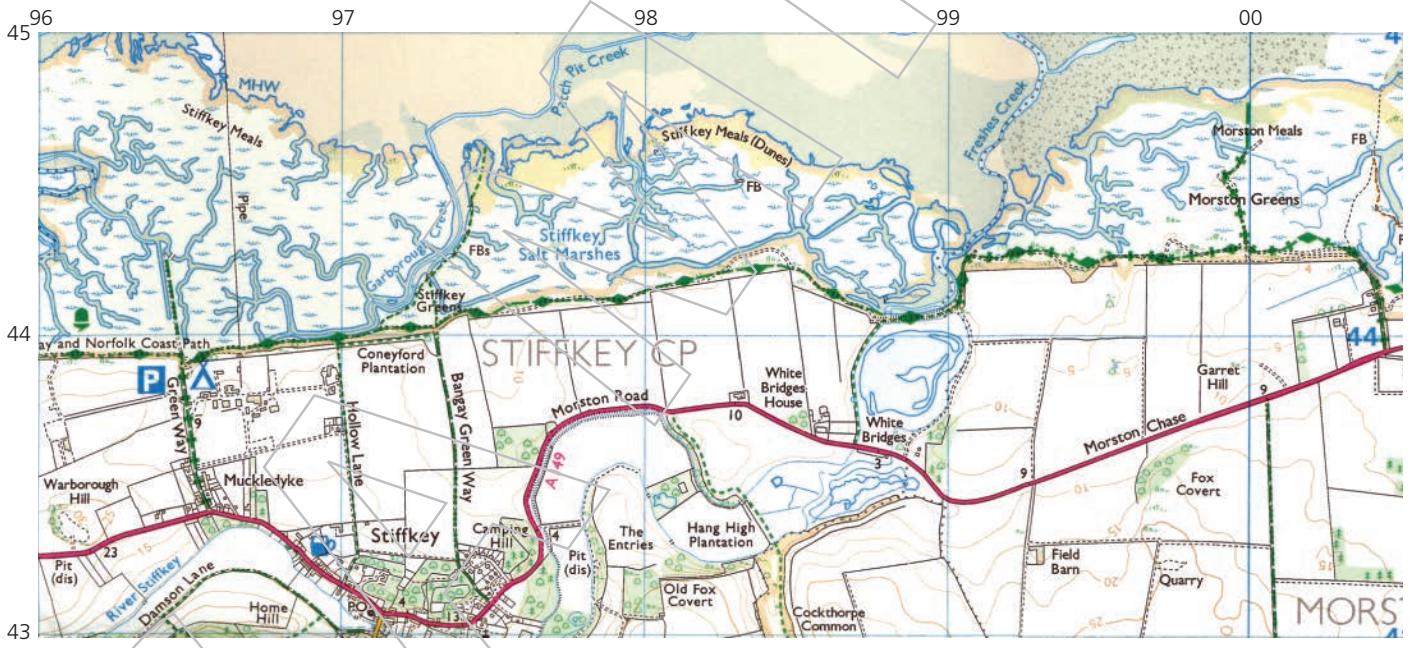
- large volumes of sediment of different sizes available
- rapid rate of movement of sediment along the coast
- shallow offshore gradient, which means that sediment is being deposited in shallow areas and can build up faster so that it comes above the surface
- sheltered from strong winds, or low wave energy
- opportunity for sediment to be vegetated which helps it become established as a permanent feature.

Spits are unstable landforms and can be destroyed partially or wholly several times before they become established. Material needs to be added more quickly than it is removed. Human activity can therefore impact on the formation on spits. Spits also help salt marshes form behind them as they reduce the wave energy. For example, Morston on the Norfolk coast is protected by Blakeney Point spit. Spits are also habitats for animals such as seals and nesting birds like terns.



▲ **Figure 14** Formation of a spit, for example Blakeney Point spit

▲ **Figure 15** Ordnance Survey map of Sheringham, scale 1:25,000 © Crown copyright and/or database right. All rights reserved. Licence number 100036470



▲ **Figure 16** Ordnance Survey map of Blakeney National Nature Reserve, scale 1:25,000 © Crown copyright and/or database right. All rights reserved. Licence number 100036470

Activities

1. Compare the coastal environments shown in the two map extracts in Figures 15 and 16.
2. Comment on the reasons for the location of the main road shown in Figure 16.
3. Identify the features in Figure 15 or Figure 16 shown at the following grid references:
   - **a.** 157432
   - **b.** 174432
   - **c.** 969433
   - **d.** 159428
   - **e.** 178423
   - **f.** 977444

   Which of these is the odd one out?
4. What types of sea defence are shown on the beach to the north of Sheringham town centre? Explain how these work with the aid of a labelled diagram.

➜ Take it further

5. Stretches of the Norfolk Coast are managed by the National Trust. Read their Shifting Coastlines report to find out more. https://nt.global.ssl.fastly.net/documents/shifting-shores-report-2015.pdf

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