Chapter 3 – Physical landscapes in the UK

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3.01 The UK's relief covers a range of diverse landscapes

The UK is an incredibly **diverse place** for **natural landscapes** given its small size. We have over 12,000km of coastline, magnificent mountain ranges and some great rivers. Our land has been shaped by volcanoes, the wind, ice sheets and glaciers, the vast seas and oceans that surround the UK and the work of rivers over millions of years. As can be seen on the map below the bulk of ur upland areas above 250m are found in the North and West of the UK in areas of old volcanic and metamorphic rocks. Lowlands are found along coastal fringes and further south, in areas of more sedimentary geology.

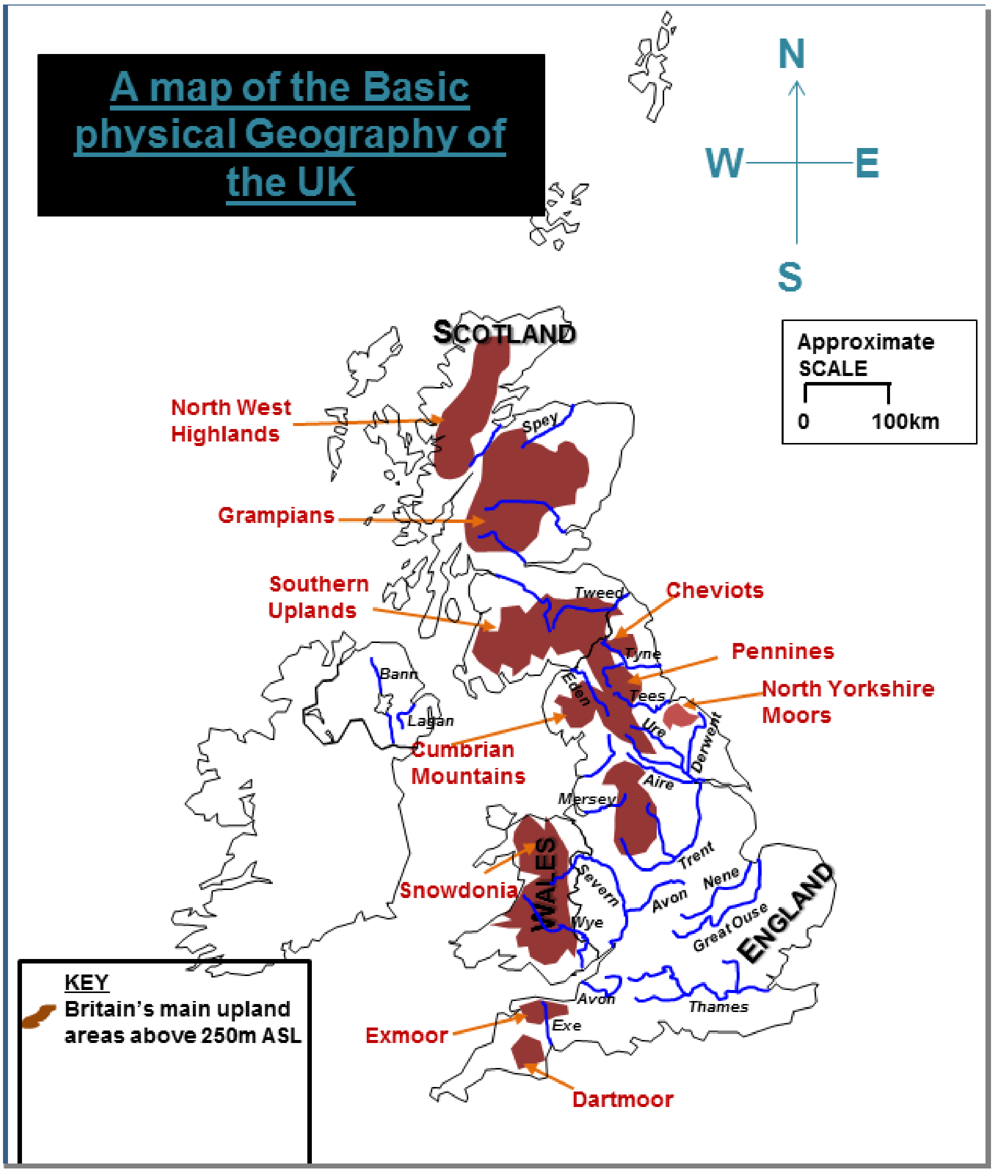
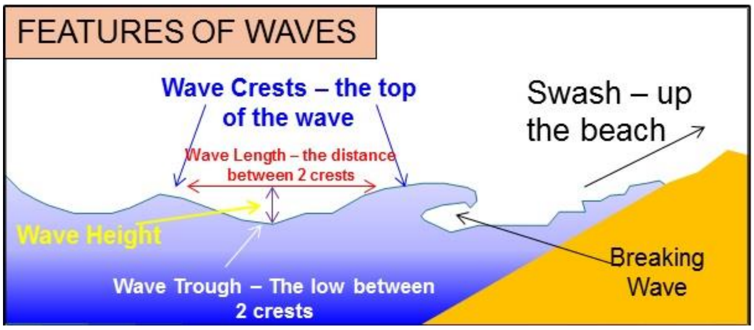


Figure 1 Map of UK physical features

3.02 Waves



Waves are essentially the movement of water molecules within the ocean, and are restricted to the surface layers of our oceans and seas.

They involve the **circular orbit** of water molecules and are the agents of coastal change. Waves vary enormously in size and character, from ocean to ocean.

What causes waves?

Waves are created by the action of the wind blowing over the sea or ocean. The **friction** from the wind causes the surface water to move in ripples which eventually form full waves. The stretch of ocean water over which the wind blows is called the **FETCH**.

Generally, the longer the fetch the larger the wave, and the faster the wind speed the larger the wave (this is why we generally get the largest waves during and just after storms). The South West of Britain is affected by waves that have an incredibly long fetch, as the South Westerly winds which blow the sea there travel uninterrupted for thousands of miles across the Atlantic Ocean. It is for this reason that the waves are large in Cornwall and generally great for surfing!

As the water approaches the coastline it encounters **increasing contact with the shelving sea bed**, which exerts a frictional force on the base of the wave. This changes the normal **circular orbit** of the wave into an **elliptical orbit**. As the waves get closer and closer to the coast the impact of friction grows, with the top of the wave moving faster than the base of the wave. Eventually a critical point is reached where the top of the wave (**the CREST**) curves over and creates a breaking wave. This breaking wave can be further disrupted by water returning down the coastline back out to sea.

Key words

- **Erosion** - The wearing away and removal of material by a moving force, such as a breaking wave.
- **Mass movement** - The downhill movement of weathered material under the force of gravity. The speed can vary considerably.
- **Sliding** - Occurs after periods of heavy rain when loose surface material becomes saturated and the extra weight causes the material to become unstable and move rapidly downhill, sometimes in an almost fluid state.
- **Slumping** - Rapid mass movement which involves a whole segment of the cliff moving down-slope along a saturated shear-plane or line of weakness.
- **Waves** - Ripples in the sea caused by the transfer of energy from the wind blowing over the surface of the sea. The largest waves are formed when winds are very strong, blow for lengthy periods and cross large expanses of water.

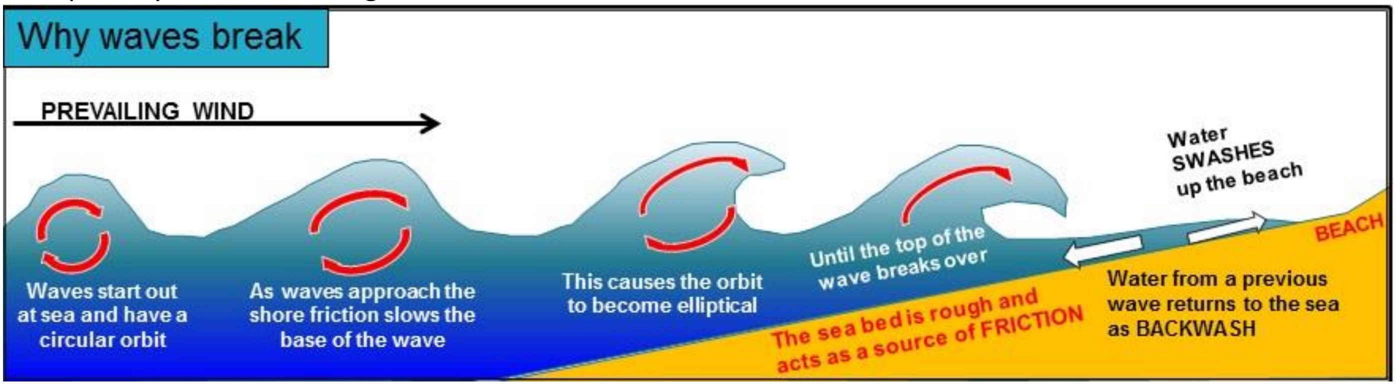
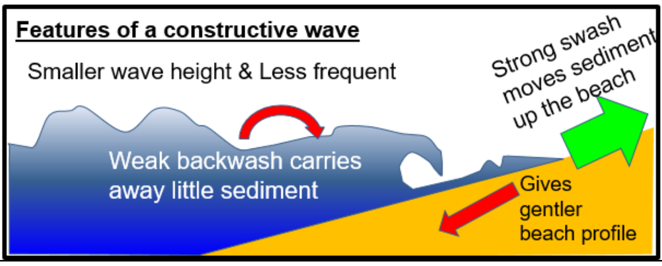
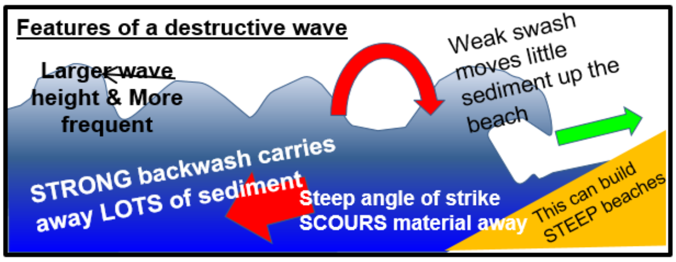


Figure 2 Why waves break

Waves and interaction at the coastline

The movement of water and sediment **up a beach is known as the swash**, and is the direction of swash is largely determined by the prevailing wind. Whereas the **movement of water back down the beach is known as backwash**, and its direction is determined by the slope of the beach, and the water will move back at right angles to this slope. These 2 wave actions interact to give us **LONGSHORE DRIFT, which moves sediment in one general direction along the coastline in a zig-zag fashion**, governed by the prevailing wind. This action is important, as it moves or erodes sediment from an up current area and moves it down current, changing the shape and sizes of beaches.

Constructive and Destructive Waves

Constructive waves	Destructive waves
	
When the swash is bigger than backwash material gets pushed up to the back of beaches rather than removed. These waves are called CONSTRUCTIVE waves, and these waves tend to have low wave heights, lower wave frequencies (they break less often) and the waves are less steep. These waves are created by storms far out to sea which create a large swell which eventually reaches the coast.	Where backwash is larger than swash more material is being eroded from the beach profile than is being accumulated. This carries material out to sea and makes for a gentler beach profile. These waves are called DESTRUCTIVE WAVES which have steeper wave profiles, larger and higher wave crests and come more frequently. These waves are generated during large storms, such as the depressions which affect the British Isles.

ACTIVITIES 3.02

1. Explain why waves break
2. Label the photograph with the key features of a wave – mention wave height, length, crest, trough breakers

3. Explain why waves vary from place to place and time to time

3.03 Coastal processes

The British Isles are surrounded by coastline and we are an island nation. The processes operating at the coast therefore have a very big impact upon our Island.

Coasts are dynamic environments that have inputs of sediment and losses of sediment. Indeed, they can be viewed as an open system as they receive sediment from outside of their locality. Coasts are in constant change, and numerous factors can affect our coast such as:

1) **The type of wave hitting the coastline** (destructive or constructive). Constructive waves have strong swash (the movement of the wave up the beach) and weaker backwash (the movement of a wave and sediment down the beach towards the sea). This builds material up at the landward side of the beach. Destructive waves have weak swash and stronger backwash, this carries material away from the beach and can lead to gentle beach profiles or shapes.

2) **The rock type and structure of the coastline** - some rocks are stronger than others at resisting wave attack. Igneous rocks such as Granite are much tougher than weak clays which are easily eroded. Jointed rocks such as Limestone and sandstone are susceptible to erosion as waves can attack the joints and bedding planes in the rock.

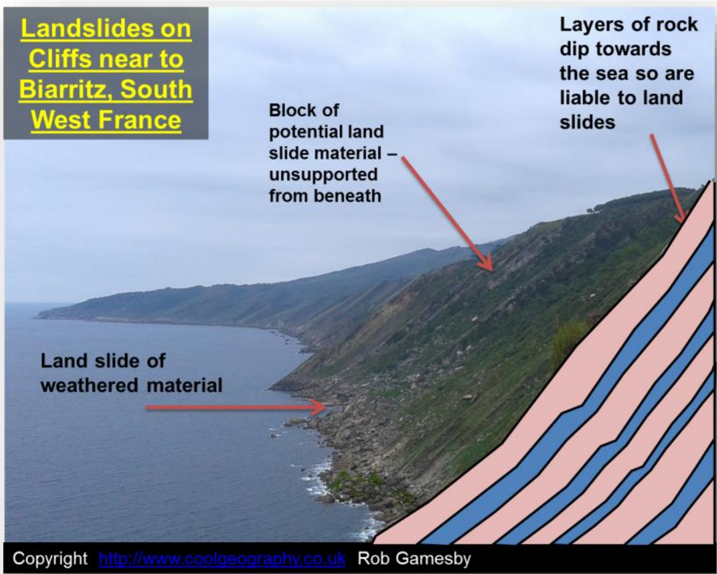
3) **The fetch and prevailing wind** operating upon the wave. The fetch is the distance over which the wave has travelled, the longer the fetch the bigger the waves and the more destruction caused. The prevailing wind is the dominant or main wind direction, and determines where the wave strikes on the coastline.

4) **The geomorphology or shape of the coast in front of the beach or cliff** - if a coastline shelves steeply in front of a cliff or beach waves can break directly on that beach causing more damage. A gently sloping beach profile can result in waves breaking sooner and protection of the coastline.

5) **The climate of the area** - temperature and rainfall can affect which weathering processes occur.

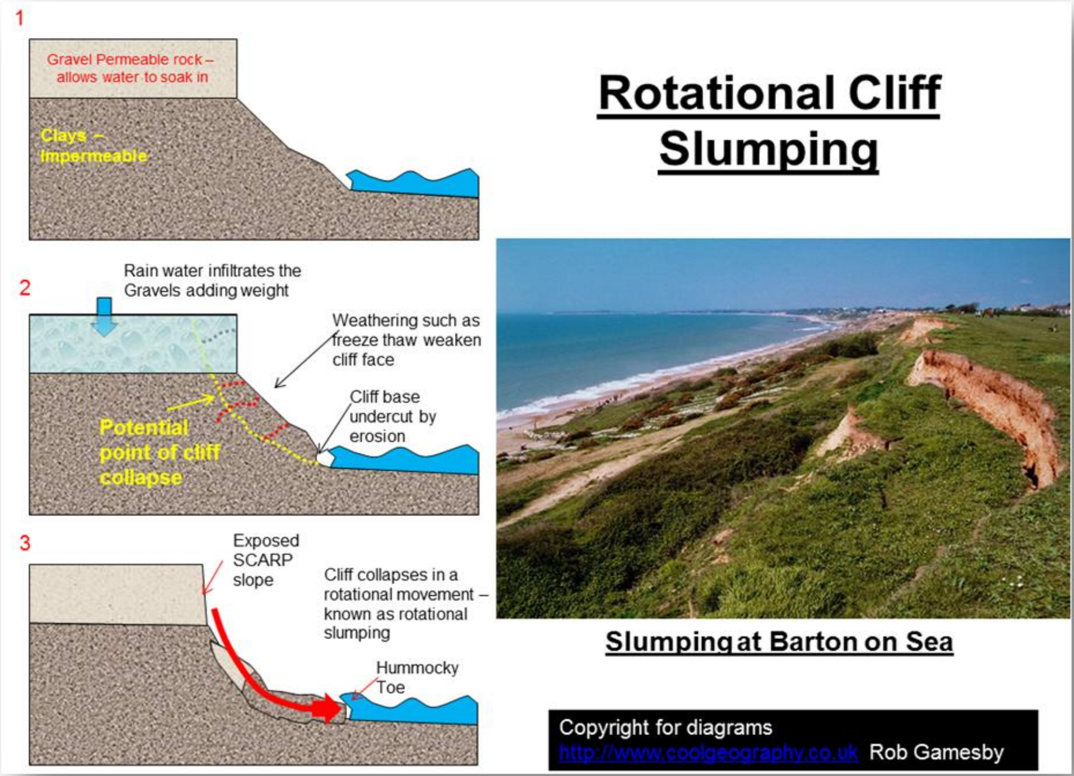
The major processes operating at the coastline are;

Coastal DEPOSITION - Deposition occurs when wave velocities slow, or when ocean currents slow due to encountering frictional forces such as the sea bed, other counter currents and vegetation. Deposition is simply the laying down of preciously eroded and weathered material. We encounter deposition in slow wave environments such as in bays, where contrasting sea currents or river currents slow water down, and why there are low winds (and hence low wave velocities).



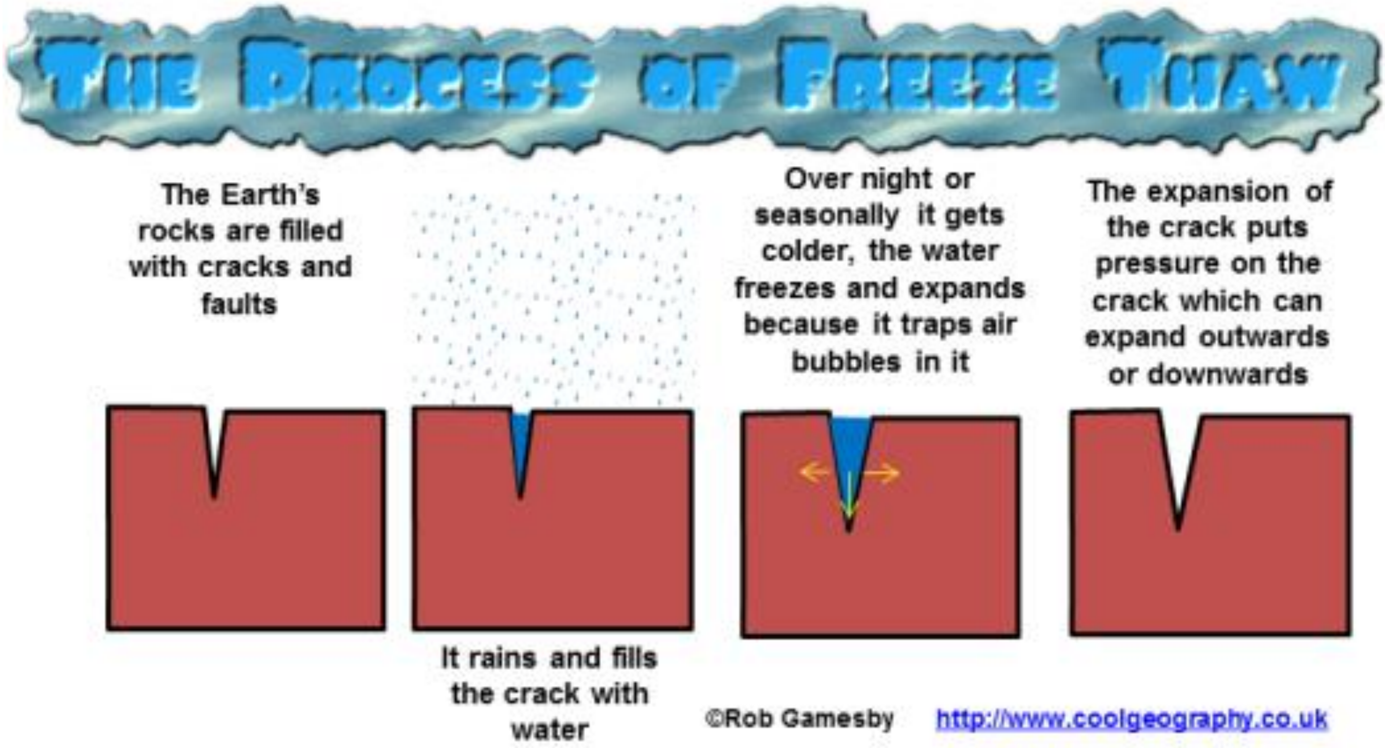
Mass movement - Once weakened by weathering mass movement can then deliver this material to beaches and the sea to be eroded. Some mass movement processes occur slowly, such as soil creep and solifluction, but some are very rapid such as rock falls.

Landslides occur where layers of rock dip towards the sea, and whole blocks of land slips down towards the sea. Slumping occurs in areas with alternating layers of permeable and impermeable rock.



Erosion	Weathering	Coastal TRANSPORT
This is the wearing away of the land by moving agents such as the sea. There are several types operating at the coast including:	This is the breakdown of rocks INSITU. This means that the rock structure is weakened by elements of the weather but the rocks remain where they are. There are 2 basic types:	This is the movement of material along a coastline. Sediment can be moved by 4 basic processes:
<u>Hydraulic Power</u> - this is where water from a wave enters cracks in the cliff face, compresses air within the cracks and causes pressure to be exerted on the surrounding rock, which weakens and breaks off. **Corrosion** - weak acids within the sea can react with certain rocks types at the coast and cause them to dissolve slowly, this is particularly important for Limestone and chalk coastlines. **Abrasion** - This is where rocks picked up and carried within waves are thrown onto the beach and cliffs **Attrition** - This is where rocks and pebbles carried within the sea hit against one	**<u>Chemical</u>** - this involve the chemical alteration of the structure of rocks, processes include carbonation (were weak carbonic acids attack rocks) and hydration (where water swells the structure of rock) **<u>Mechanical</u>** - Weathering processes that cause physical disintegration or break up of exposed rock without any change in the chemical composition of the rock, for instance freeze thaw. This is one process where water enters cracks, freezes (often overnight), expands by 9.05% and exerts pressure on the rock, weakening it.	**<u>Traction</u>** - where large stones are rolled along the sea bed **<u>Saltation</u>** - where stones are bounced along the sea bed in a hopping motion **<u>Suspension</u>** - where fine material is held within the water mass **<u>Solution</u>** - where rocks and minerals are dissolved within the water.

another and break down into smaller particles.		



ACTIVITIES 3.03

Odd One Out

1. Hydraulic Power	*2. Land slide*	*3. Abrasion*	*4. Rock Type*	*5. Long shore Drift*
6. Backwash	*7. Freeze Thaw*	*8. Attrition*	*9. Solution*	*10. Chemical Weathering*
11. Acids	*12. Biological Weathering*	*13. Constructive Waves*	*14. Cracks in Rocks*	*15. Limestone*
16. Mass Movement	*17. Destructive Waves*	*18. Roots*	*19. Swash*	*20. Burrowing Animals*
21. Soil Creep	*22. Mechanical Weathering*	*23. Rotational Slipping*	*24. Slumping*	*25. Water*
26. Low energy	*27. Deposition*			

Instructions

For each set

1. Write down the word that corresponds to the number.
2. State which word is the *odd one out*.
3. Give a reason why.
4. Now that you have started to see a pattern, add another word from the table, but keep the ***same*** *odd one out*.

	Write down the word that corresponds to the number			Reason	Extra word to keep the odd one out the odd one out!
Set A	16	20	21		
Set B	11	3	9		
Set C	23	25	22		
Set D	13	18	20		
Set E	16	1	8		
Set F	22	7	10		
Set G	14	4	17		
Set H	6	17	19		
Set I	15	27	26		

Extension

1. Try to put together your own group of words with an odd one out. You must have a good and obvious reason. Swap your group of words with a partner and see if they can work yours out and vice versa.

2. Now try and sort out all of the words in the table into 4 to 6 groups. Write a justification of your groupings.

3.04 Distinctive coastal landforms are the result of rock type, structure and physical processes.

Erosion Landforms: Headlands and bays, cliffs and wave cut platforms, caves, arches and stacks

Coastlines are littered with the evidence of erosion and the power of the sea. Erosion makes the coastline varied and interesting, and often give the coastline its "wow" factor.

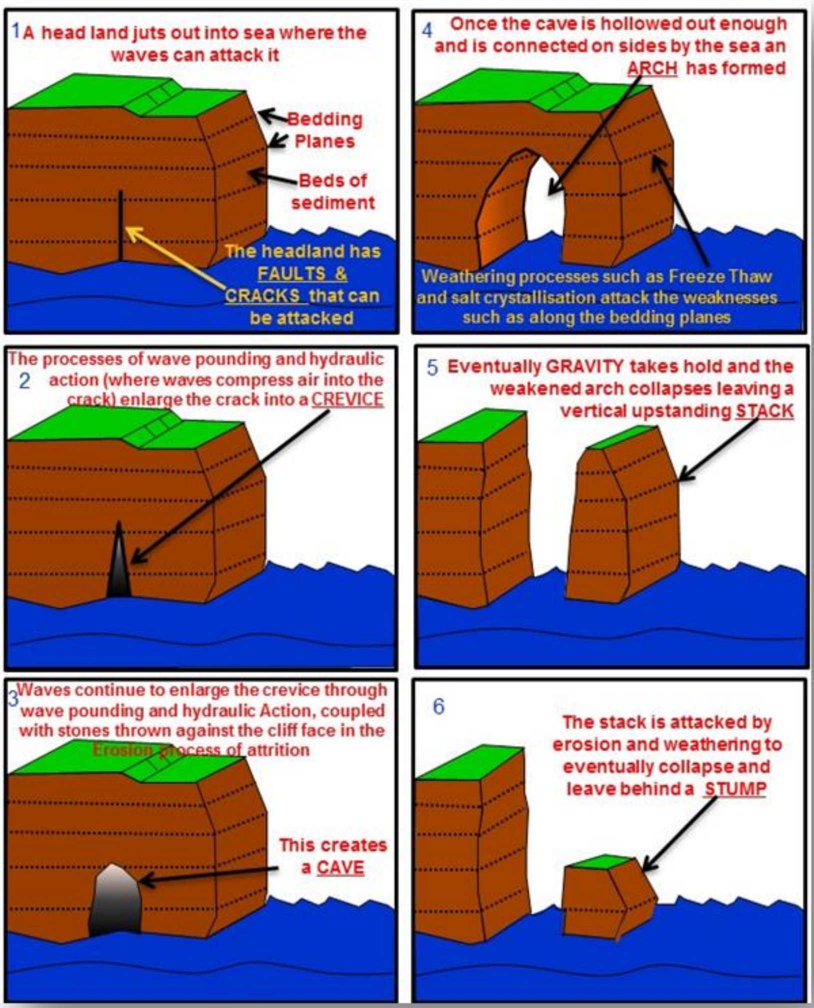
For each landform you need to understand how processes of weathering **(freeze thaw, hydration, biological, salt crystallisation**), mass movement (slumping, slides, rock falls) and erosion (**Hydraulic Power, Corrasion, Corrosion**) contributes to the formation.

Key words

- **Arch** - A wave-eroded passage through a small headland. This begins as a cave formed in the headland, which is gradually widened and deepened until it cuts through.
- **Cave** - A large hole in the cliff caused by waves forcing their way into cracks in the cliff face.
- **Cliff** - A steep high rock face formed by weathering and erosion along the coastline.
- **Headlands and bays** - A rocky coastal promontory made of rock that is resistant to erosion; headlands lie between bays of less resistant rock where the land has been eroded back by the sea.
- **Stack** - An isolated pillar of rock left when the top of an arch has collapsed; over time further erosion reduces the stack to a smaller, lower stump.
- **Wave cut platform** - A rocky, level shelf at or around sea level representing the base of old, retreated cliffs.

Caves, arches stacks and stumps

These features are **formed on cliffs or headlands**. Waves attack vertical lines of weakness in the rock known as **Faults**. Processes such as hydraulic action and abrasion widen these faults into cracks and eventually the waves will penetrate deeply enough to create **caves**.

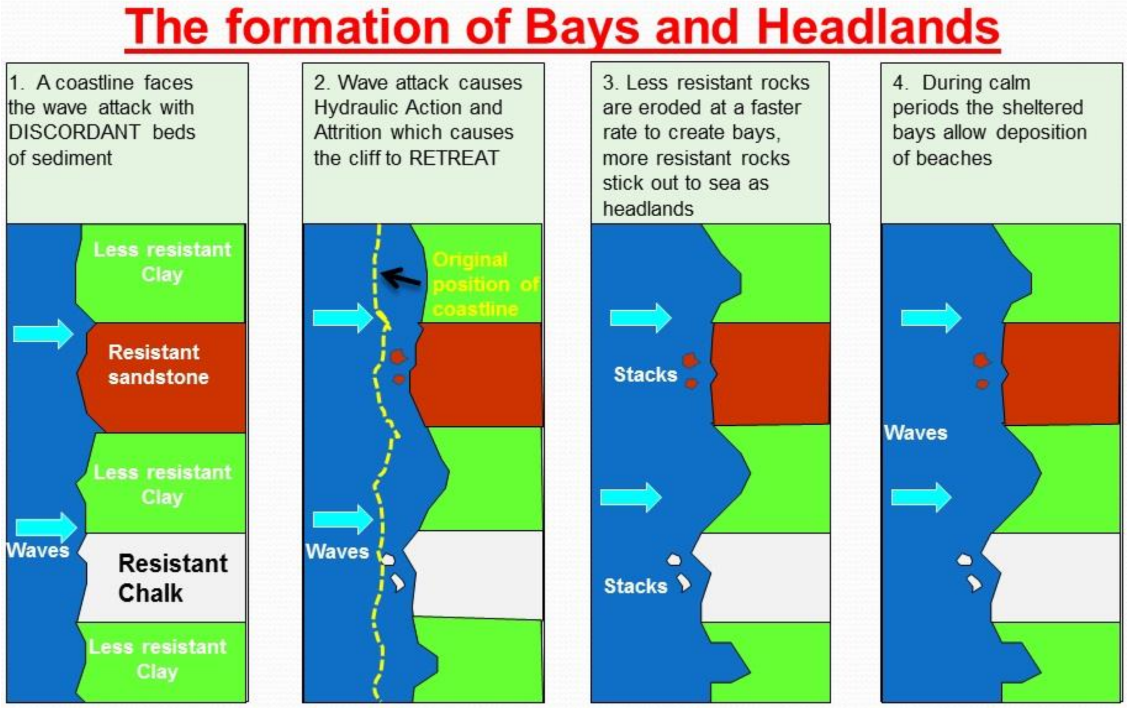


Over time, the cave will be eroded into an **arch**, accessible to the sea on both sides. Weathering will also play a role, with physical weathering processes such as freeze thaw and salt crystallisation and chemical processes such as carbonation weakening the rock surrounding the cave or arch making it more susceptible to mass movement and collapse.

Finally, the erosion and weathering continues and the arch collapses leaving behind a **stack** (a vertical column of rock). These stacks can be attacked further, and eventually the stack may collapse to leave a low lying **stump**.

Bays and headlands

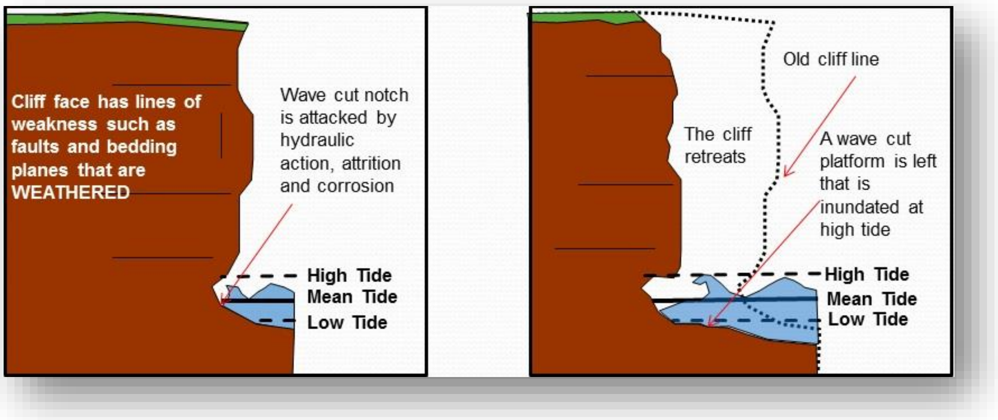
In areas where the geology or rock type runs at **right angles** to the coastline, bays and headlands can be created. If there are alternating bands of harder and softer rock running at right angles to the sea, the sea will erode these bands at different rates (called differential erosion). Hydraulic action, abrasion and corrosion are more effective at eroding the softer rock, particularly during storms, and this will erode further inland than the harder rock. During calmer weather and no stormy periods, the hard rock will absorb a lot of the wave energy and **refract or bend** the waves into the area with the softer rock, allowing sediment to be deposited and accumulate as beaches. The net result of this over long periods of time is that the hard rock is left jutting out to sea as a headland, and the softer rock is eroded into curved sand filled bays.



Cliffs and cliff retreat

A cliff is a **vertical, near vertical or sloping wall of rock** or sediment that borders the sea. They generally differ in their angle of slope because of their rock structure and geology, but the processes involved in their formation are the same.

Marine erosion processes attack the foot of the cliff and cause the erosion at a **wave cut notch**. Waves can pound this area causing fragments to break off, and the water can also trap air in pore spaces, faults and crevices, compressing the air which in turn exerts pressure on the rock causing it to break off. This process is known as hydraulic action. Another process that occurs is corrasion, where sediment and rocks in the sea water are hurled against the cliff face. All three of these processes erode the wave cut notch at the base of the cliff **undermining** the whole structure of the cliff. These processes are variable and depend upon the fetch of the wave (the distance it travels over open water), wind speed and how many storms there a year, but they are more or less continuous over long periods of time.



At the same time that the base of the cliff is being eroded, the cliff face and its structure are being weakened by weathering processes. Oxidation and carbonation are some of the chemical processes that can weaken the structure of the rock, and depending upon the climate physical processes such as freeze thaw and water layer weathering can take effect. Over time this weakens the structure of the cliff face, and coupled with the erosion of the wave cut notch at a critical point this cliff face will succumb to the influence of gravity and collapse in a process of mass movement. This material will then be carried away by the sea in the process of long shore drift by the transportation process of solution, suspension, saltation and traction (depending upon the particle sizes). The **cliff retreats**, leaving behind a **flat wave cut platform**.

3.05 Coastal Deposition Landforms

Characteristics and formation of beaches, sand dunes, spits and bars.

If rocks and cliffs are being continually weathered, eroded and moved then it stands to reason that this will generate a lot of material that will need to be **deposited (or laid down)** somewhere else along the coastline. The **major deposition landforms** are **beaches, sand dunes, spits and bars**. Deposition occurs when wave velocities slow, or when ocean currents slow due to encountering frictional forces such as the sea bed, other counter currents and vegetation.

Beaches are areas of sand, pebbles and shingle that are formed by deposition produced by wave processes. Beaches are by no means uniform and contain a huge variety of sediment types and sizes, and have many different shapes.

Key words

- **Bar** - Where a spit grows across a bay, a bay bar can eventually enclose the bay to create a lagoon. Bars can also form offshore due to the action of breaking waves.
- **Beach** - The zone of deposited material that extends from the low water line to the limit of storm waves. The beach or shore can be divided in the foreshore and the backshore.
- **Deposition** - Occurs when material being transported by the sea is dropped due to the sea losing energy.
- **Longshore drift** - The zigzag movement of sediment along a shore caused by waves going up the beach at an oblique angle (wash) and returning at right angles (backwash). This results in the gradual movement of beach materials along the coast
- **Sand dune** - Coastal sand hill above the high tide mark, shaped by wind action, covered with grasses and shrubs.
- **Spit** - A depositional landform formed when a finger of sediment extends from the shore out to sea, often at a river mouth. It usually has a curved end because of opposing winds and currents.

The formation of a beach:

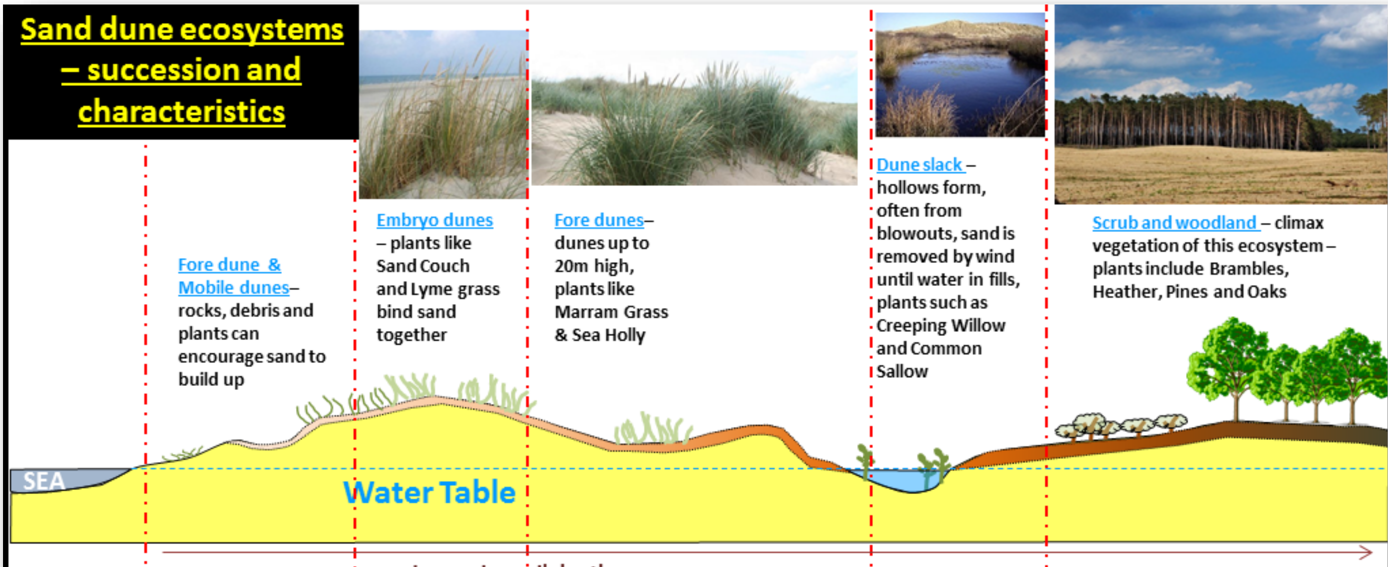
- **Stage 1** — Deposition is the main process that creates a beach.
- **Stage 2** — This occurs where waves have limited energy and so beaches often form in sheltered areas such as bays where wave energy is less than on exposed headlands.
- **Stage 3** — Here, waves are likely to be constructive where the swash is dominant and the backwash weaker so that material is left on the beach rather than being taken away by the waves.
- **Stage 4** — Over time this beach material will accumulate in the sheltered bay, and may be composed of different sediments from pebbles to fine sands
- **Stage 5** — Beaches are under constant change, from processes like longshore drift. Beaches can also grow over time when constructive waves dominate, or even shrink in size during winter periods in the UK when we are more likely to get storms and destructive waves

Gently sloping beaches are formed by strong destructive waves that backwash more material away from the beach that they swash up the beach.

Steeply sloping beaches occur by constructive waves that swash more material up the beach than they backwash away, building up a steep beach gradient.

SAND DUNES

Sand dunes are **accumulations of sand** and other sized sediments that gather on a beach. Sand dunes are **created around obstacles** on the beach, these could be natural such as a rock or human things such as some waste drift wood or a fence.
The sea brings sediment to the beach and then the wind redistributes that sediment. When the **wind** encounters the beach obstacles velocity falls and sediment is **DEPOSITED**. This makes amount of sand or sediment at the front of the sand dune system, known as an **EMBRYO dune**.
Over time, tough plants known as **PIONEERS** such as Marram grass take root on the dune, their root systems helping to stabilise the sand and fix it in place.
As these plants die off they add nutrients and humus to the sand dune improving the soil, so more complex plants can move in, such as brambles.
Eventually, the **climatic climax vegetation** is reached, which in the UK would be forest.



Location/type of dune	Strand line	Embryo dunes	Fore dunes	Fixed dunes	Dune slack	Dune scrub	Woodland
Approximate distance from sea (m)	0-20	20-80	80-150	150-300	300-500	Variable	Variable
pH at surface of soil	8.5	8.0	7.5	7.0	6.5	6.0	6.0
Soil colour	Yellow			Yellow and grey		Grey	Brown
% Humus	< 1	2.5	5		20	>40	
% Calcium Carbonate	10	8	8	5	1	<0.1	
Age (years)	-	0-50	50-100	100-150	150-250	250+	250+

Figure 3. Sand dune systems

SPITS and BARS

Spits are created by the **process of Longshore drift**. Some eroded material ends up caught up within the waves and is carried by the sea along the coastline in cells known as littoral cells. Material is carried along the shore in a **zigzag fashion** by waves as they **swash material up** the beach at an angle and **backwash material down the beach at a right angle**. The angle of swash is determined by the prevailing wind (the dominant or main direction in which the wind blows).

Wherever there is a break in the coastline (e.g. across a river or a change in coastline direction) then material is deposited closest to the shore. This is because there are often counter currents and a loss in velocity, so material is dropped or deposited.

Eventually this material builds up out into sea to form a spit. As seen in the picture opposite of Spurn Head. The spit often curves inwards towards the land as a result of the prevailing wind directing the waves which push the sediment in towards the shore.

Spits often have salt marshes build up behind them because the spit offers protection from the stronger waves and the wind, allowing salt tolerant plants to grow.

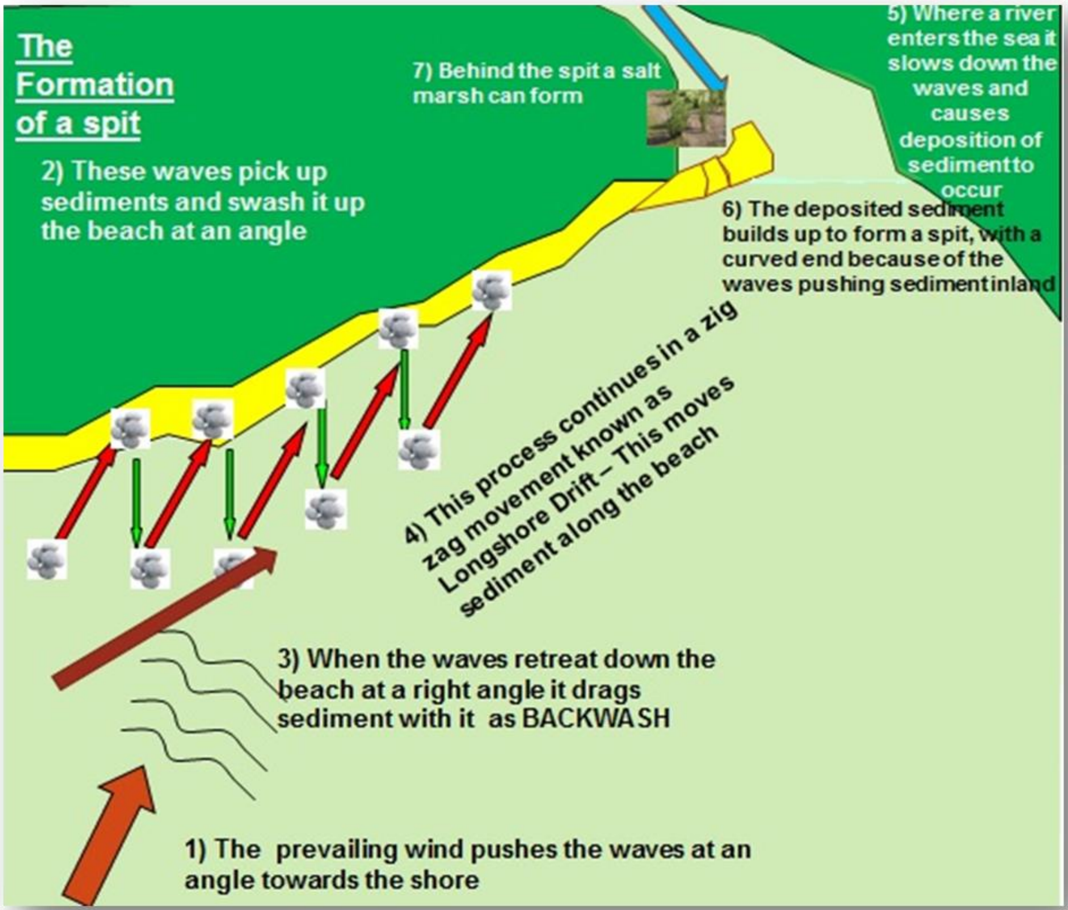
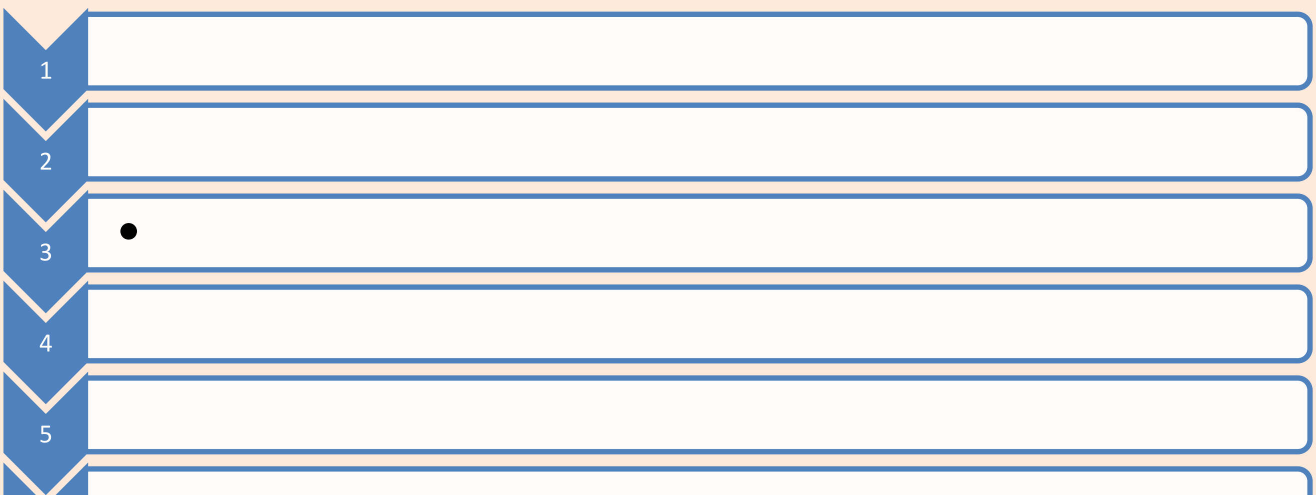


Figure 4. How spits are created

If a spit extends from headland to headland then a **bar** will be created.

ACTIVITIES 3.05

1. Draw then complete the flow chart below to explain FULLY how a SPIT is created. Mention Longshore drift in your answer.



3.06 Managing coastlines

The coastline is a used environment. Human beings, plants and animals all use the coastline for different things. In the case of humans, we use the coastline for agriculture, for fishing, for industry and power generation, for transport routes and for land upon which to live. However, a lot of these land uses are incompatible with the fact that the coastline is constantly changing.

Erosion processes remove land from some parts of the coastline, whereas deposition processes create new land in other places. In addition, the fact that the sea level is rising locally and globally could add to these erosion and deposition problems whilst also removing land from use at the coastline. It is for these reasons that human beings have long sought to control and MANAGE the coastline. However, there is a huge debate as to how to do this - either by using **HARD ENGINEERING or SOFT engineering.**

Hard engineering – sea walls, groynes, rock armour

Hard engineering involves the building of entirely ARTIFICIAL structures using various materials such as rock, concrete and steel to reduce or stop the impact of coastal processes.

Sea walls are walls of concrete, supported by Iron pilings dug into the underlying rock that are designed to prevent coastal erosion. They are generally placed at the foot of vulnerable cliffs or at the top of a beach. They can be up to 5m high and can be flat faced or curved. The curved walls are more expensive but dissipate the energy from incoming waves better. These defences can be up to £6 million per kilometre to construct. Their good points are that they are very effective, have a reasonably long lifespan and often have walkways along the top for people to walk along. However, they are very expensive and are accused of being ugly (not aesthetically pleasing!). Also, sea walls have been known to cause down current scarring, where waves cause more damage to unprotected areas.

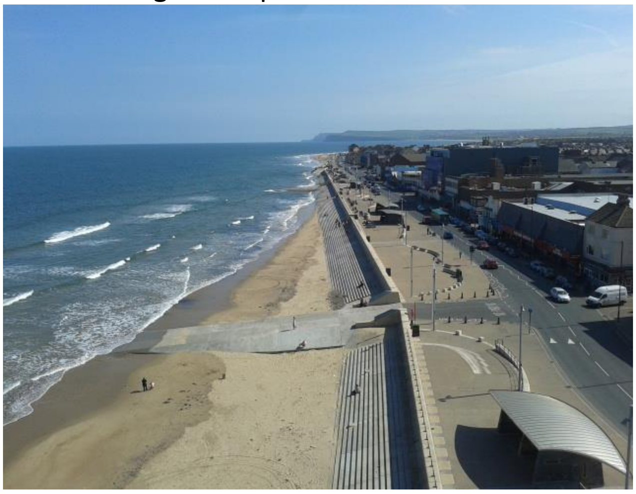


Figure 5. Sea walls at Redcar, NE England

Groynes (as seen at Seaton Sluice!) are basically wooded fences that run at right angles to the beach. These fences run out into the sea, and are designed to interrupt longshore drift and catch sediment as it moves along the coastline, thus widening a beach. This larger beach can then act as a buffer against waves, as there is more beach to absorb wave energy. These features can cost as much as £10,000 each, and need to be spaced at 200m intervals. They are good because they result in a larger beach, which not only protects the coastline but can also be good for tourism. In addition, they are not that expensive. However, they starve down current (or drift) beaches, which makes them more vulnerable to erosion, and again they are not that attractive.

Key words

- **Beach nourishment** - The addition of new material to a beach artificially, through the dumping of large amounts of sand or shingle.
- **Beach reprofiling** - Changing the profile or shape of the beach. It usually refers to the direct transfer of material from the lower to the upper beach.
- **Dune regeneration** - Action taken to build up dunes and increase vegetation to strengthen the dunes and prevent excessive coastal retreat. This includes the re-planting of marram grass to stabilise the dunes, as well as planting trees and providing boardwalks.
- **Gabion** - Steel wire mesh filled with boulders used in coastal defences.
- **Groyne** - A wooden barrier built out into the sea to stop the longshore drift of sand and shingle, and so cause the beach to grow.
- **Hard engineering** - The use of concrete and large artificial structures by civil engineers to defend land against natural erosion processes.
- **Managed retreat** - Allowing cliff erosion to occur as nature taking its course: erosion in some areas, deposition in others. It may involve setting back or realigning the shoreline and allowing the sea to flood areas that were previously protected by embankments and seawalls.
- **Rock armour** - Large boulders dumped on the beach as part as part of the coastal defences.
- **Sea wall** - A concrete wall which aims to prevent erosion of the coast by providing a barrier which reflects wave energy.
- **Soft engineering** - Managing erosion by working with natural processes to help restore beaches and coastal ecosystems

Figure 6. Groynes at Blyth

Rock armour - This is a simple strategy that involves the dumping of huge boulders of rock at the base of a cliff. These rocks help the wave to break and in so doing they absorb the wave energy. They cost between £1,000 and £4,000 per metre, depending upon the material used, and are relatively cheap and easy to maintain. They are however unnatural and do not fit with the geology of the cliff line, and can be expensive to transport. Another type of rock armour is **Gabions** - which are cages of smaller rocks that work in much the same way.

Hard engineering schemes are effective but expensive, and recent attempts to manage coastal processes have focussed on softer engineering techniques. These techniques seek to mimic nature's own ways of managing coastal processes and to use natural materials and strategies to prevent erosion. In effect, these measures can be better for the environment, cost less money to implement and maintain, but not totally control the erosion problem. They are a more sustainable way of managing the coastline.

Soft engineering – beach nourishment, dune regeneration and marsh creation.

Beach nourishment is a measure whereby additional sand and shingle is added to a beach to make it higher and wider. This material is brought onshore by barge, and moved about by large trucks and diggers. It costs around £3000 per km and is a cheap method. This material is the **REPROFILED** by huge diggers to change the shape and gradient of the beach so that it is more effective at absorbing the waves energy.

It will blend in with the beach if the sediment is locally sourced (such as the new sand dune at Seaton Sluice, which was created from dredged sediment for the River Blyth) and will have benefits for tourists. However, this method needs constant maintenance or else this new sediment will also eventually be eroded by the sea!

Figure 7. Beach replenished with sand at Newbiggin

Dune regeneration is any action taken to **build up dunes and increase vegetation** to strengthen the dunes and prevent coastal retreat. This includes artificially creating new sand dunes along the coastline to act as a buffer between the land and the sea, the re-planting of marram grass to stabilise the dunes, as well as planting trees and providing boardwalks to prevent people walking on plants.

Sand dunes occur naturally but are under threat because they are fragile and people walk all over them, ride horses and motorbikes on them and destroy the dune ecosystem. Using fencing to help trap sand, planting Marram grass into coconut matting (as was done at Seaton Sluice) and encouraging dune formation helps to protect these systems which protect our coastline and absorb storm and wave energy. This can cost £2,000 per 100m and helps to maintain the ecosystem of the area whilst offering protection. However, it is time consuming to plant the **Marram grass and fence off areas**, and is less effective than hard engineering schemes.

Figure 8. Dune regeneration in Tynemouth

Managed retreat is a method whereby we humans concede defeat to the power of the sea and allow it to erode and create salt marshes for example. We can allow cliffs to retreat in some areas and deposition to occur in others. We can **realign the coast** and allow the sea to do its work, whilst moving valuable land uses away from the coast. We then **monitor the coastline** to check that nothing valuable is at risk of being lost. We can also allow cliff erosion to occur in areas of low value farmland and just compensate farmers for their losses, rather than construct more expensive coastal defences. This can only work where the coasts of compensation are significantly less than the coasts of building coastal defences, and can be a cheap option. It can also be beneficial to plants and animals by providing new habitat. This method is highly controversial however, as land is lost and the human cost can be greater than just financial. Imagine a farmer told to quit land and a family home that could have been in the family for generations because the council do not want to build a sea defence - the trauma of this is huge.

Figure 9. Tollesbury Managed Realignment site in June 2007

ACTIVITIES 3.06

Which do you prefer – hard engineering or soft engineering? Justify your answer giving evidence for both sides and providing full reasons for your conclusions.

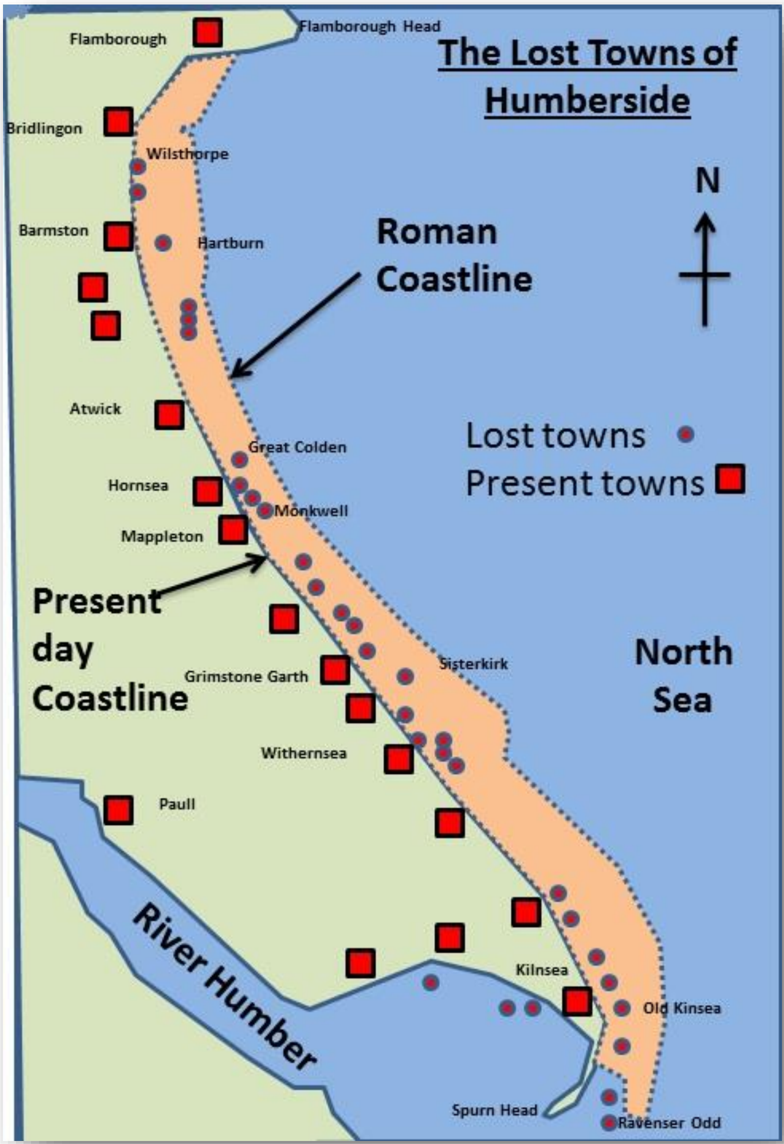
3.07 Holderness Coastline, a case study of coastal management in the UK

The Holderness Coastline is in the North of England and runs between the **Humber Estuary** in the south and a headland at **Flamborough Head**.

It has a fantastic array of coastal features including;

1. A **headland with caves, stacks and stumps** at Flamborough Head
2. **Beaches** accumulated along the whole coastline
3. The deposition of sediment along the **spit** at Spurn Head
4. **Cliffs** from Flambrough Head southwards towards the spit

It has the unenviable reputation as the number one place in Europe for coastal erosion, and in a stormy year waves from the **North Sea** can remove between **7 and 10m** of coastline. It is one of the fastest eroding coastlines in Europe as a result of its geology. The coastline starts with blowholes, stacks and stumps at Flamborough, and culminates with Spurn Head, a very large spit that runs across part of Humber Estuary.



Geology

The geology runs in bands, with a chalk layer at Flamborough in the North, Boulder clay or till (lain down in the last ice age) south of that and finally river deposits in the Humber Estuary. Because the clay is an **unconsolidated WEAK mass** of clay particles and boulders it erodes more rapidly than the more **resistant rock of chalk** in the north. The processes of erosion and weathering occurring are numerous but include hydraulic action, freeze thaw, abrasion, solution and carbonation (on the clay)

This has left a bay where the clay is and a headland jutting out to sea at Flamborough head. Although wave refraction focuses the wave's energy on the layered and faulted rocks of Flamborough head, eroding the calk, the incredibly weak nature of the clay still means that it erodes faster than the chalk. The chalk headland has stumps and blowholes.

The coastline today is around **4km inland from where it was in Roman times**, and there are many LOST villages of the Holderness coastline that have long disappeared into the sea. Indeed, today, farmland, tourist sites such as caravan parks and villages remain under threat. The weak clay, stormy nature of the North Sea, and rising sea levels of 4mm per year mean that the future is bleak for parts of this coastline. In addition to the clay being vulnerable to erosion, it is also prone to slumping. This is because water enters cracks and pore spaces in the rock, adding weight and making it slump.

Defending the Holderness Coastline

There is a debate about whether or not human beings should attempt to defend coastlines. In the case of the Holderness coastline, its geology (weak clays) waves (destructive during North Sea storms) and Geomorphology (the shape of the coastline allows the waves to break at the base of the cliffs) make erosion almost inevitable. However some defences have been attempted.

Figure 10. The beach and rock groynes at Mappleton, by Helen Wilkinson via Wikimedia Commons

Mappleton is a small village that could become village number 30 lost to the sea. The road running through it, the B1242 links towns along the coastline and would have been lost to coastal erosion if protection measures were not put into place. It was decided that the cost of coastal defence for a village of only 100 people was less than the cost of building a new road. So, blocks of granite were brought in and placed along the cliff base and 2 rock groynes were put into place to trap sediment moving because of longshore drift.

This has caused **CONFLICT**, this is because the farms south of the village of Mappleton have been starved of sediment as it is being retained up current. This has led to the loss of a defensive beach and a loss of people's farmland. Should the farmers suffer at the expense of protecting a village and its road?

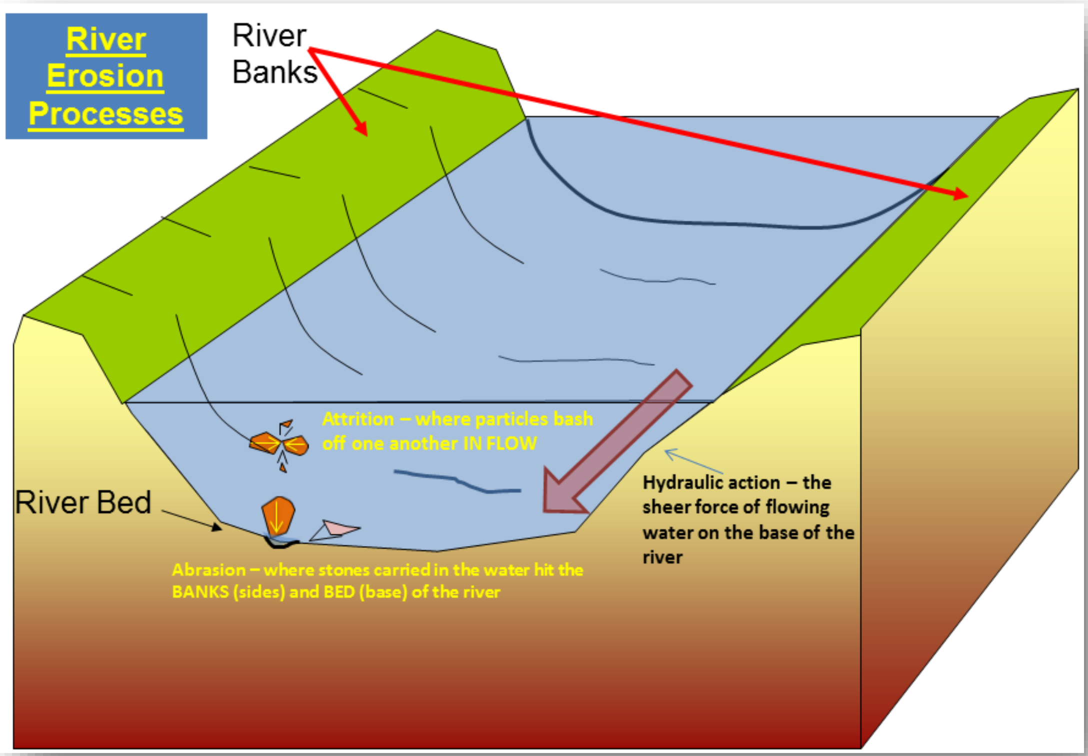
ACTIVITIES 3.07

Draw then complete the case study table below

Background to Holderness (where, when, why)		
Causes of cliff collapse		
Effects	Environment	
	People and economy	
Responses and	Individuals	
	Agencies	

3.08 River Processes

Rivers are dynamic systems and they have shaped the UK in many ways over thousands of years. There are many processes operating in different parts of rivers. These processes are known as **Fluvial processes** which relate to erosion, transport and deposition by a river.



Erosion is the wearing away of the land by moving forces - in this case the river.

Processes include;

Hydraulic action - where the sheer force of the water erodes the stones, bed and banks of the river

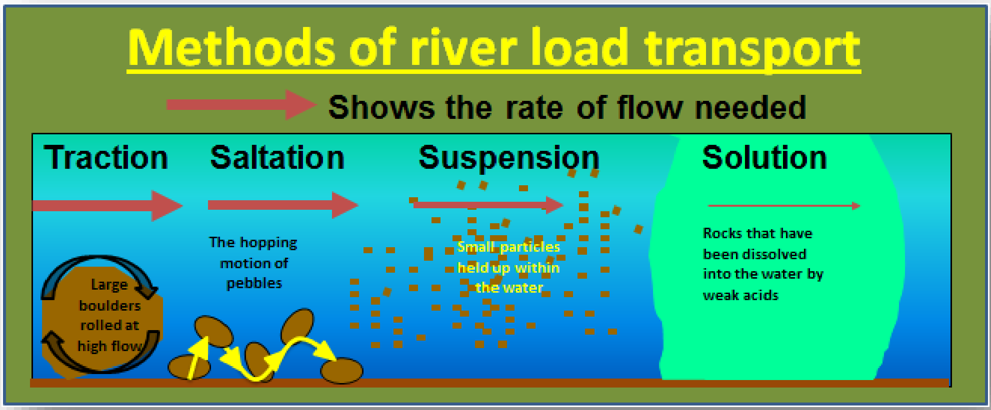
Abrasion- where stones in transport are thrown into the bed and the banks eroding them

Corrosion - where weak acids within the water react with the rocks and bed and bank of the river

Attrition - where stones in transport are thrown into one another.

In the upper parts of rivers the water tend to **erode vertically** downwards into the river bed, whereas as we progress downstream this changes to **lateral erosion**, or a side to side erosion of the river valley.

Transport is the movement of material, in this case by river water. Processes include;



- **Solution** - where material is dissolved within the water
- **Suspension** - where small particles are held up or suspended in the water
- **Saltation** - the bouncing motion of larger particles along the river bed
- **Traction -** the rolling motion of sediment along the bed - normally much larger sediment.

Obviously the larger sediments will only be moved during periods of high river flow.

Deposition - this is the laying down of sediment in the river channel or on floodplains. This occurs when river velocities slow within the channel, or when velocities slow over floodplains or when the river enters a sea or lake. Velocities slow because the river might widen and become shallower, increasing the friction between the water and the river bed, or variations in channel shape leave some parts shallower and therefore slower than others. When rivers enter the sea they tend to spread out and counter currents from the tidal motion of the sea slow river water and encourage sediment to be dropped.

ACTIVITIES 3.08

A) What is the difference between abrasion and attrition?

A) Sediments in Northumberland

B) Silt found in Idaho, USA

B) Compare the sediment (stones) in photographs A and B in terms of its size and shape

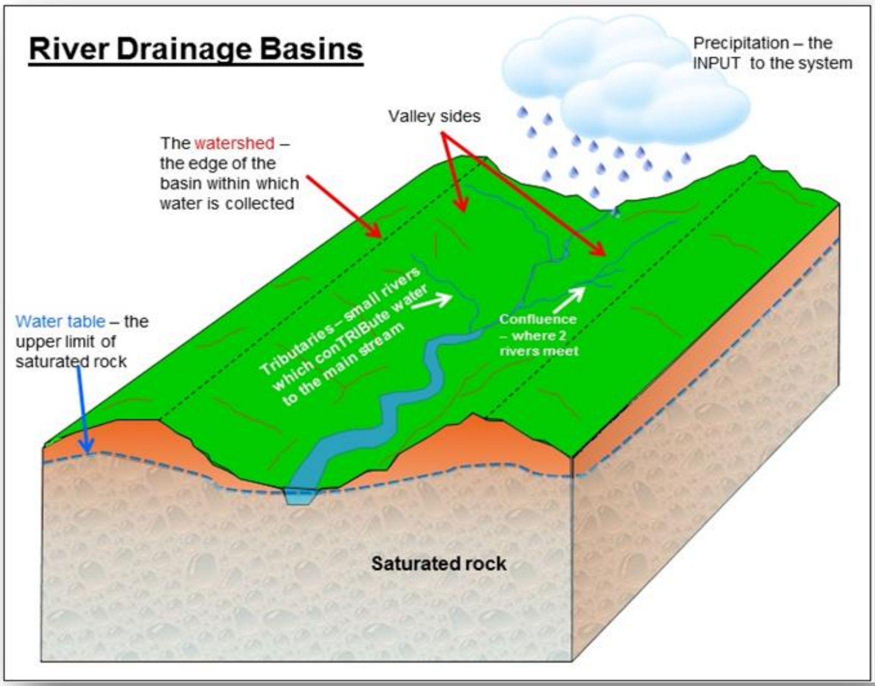
C) Explain the differences mentioning the PROCESSES from the previous page

D) Complete the odd one out in the sets below in your book and give a reason why:

Set 1 - Hydraulic action **Traction** **Abrasion**

REASON:

3.09 The shape of river valleys changes as rivers flow downstream – River long and cross profiles

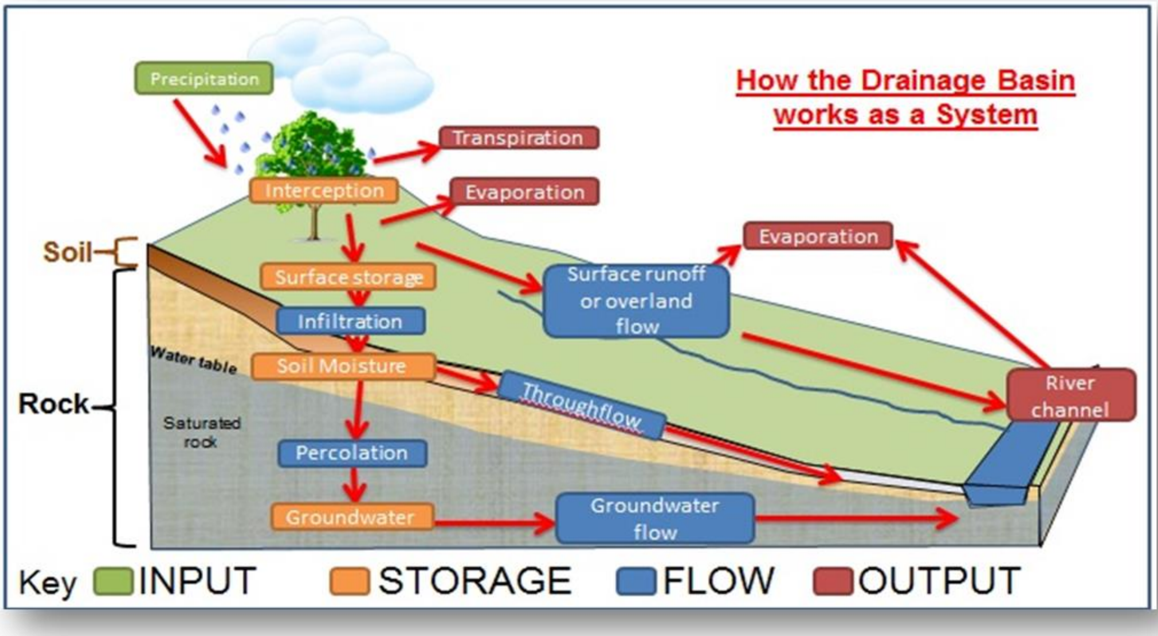


Key words

- **Cross profile** - The side to side cross section of a river channel and/or valley.
- **Lateral erosion** - Sideways erosion by a river on the outside of a meander channel. It eventually leads to the widening of the valley and contributes to the formation of the flood plain.
- **Long profile** - The gradient of a river, from its source to its mouth.
- **Vertical erosion** - Downward erosion of a river bed.

Figure 11. The river drainage basin

Rivers change immensely on their journey from **Source areas** (where they start) to their finishing point at their **mouths**. The **drainage basin, as shown above,** is the area of land drained by a river system (a river and its tributaries). It includes the surface run-off in the water cycle, as well as the water table. Drainage basins are separated by watersheds. A drainage basin is an example of an open system because it is open to inputs from outside, such as precipitation, and is responsible for outputs out of the system, such as output of water into the sea and evaporation of water into the atmosphere. The **water cycle** is a series of processes by which water is evaporated from the sea and eventually condenses and precipitates over the land. You can see how water travels through the drainage basin system on the diagram opposite.



The **long profile** of a river is a way of displaying the channel slope of a river along its entire course. Therefore, it shows how a river loses height with increasing distance towards the sea.

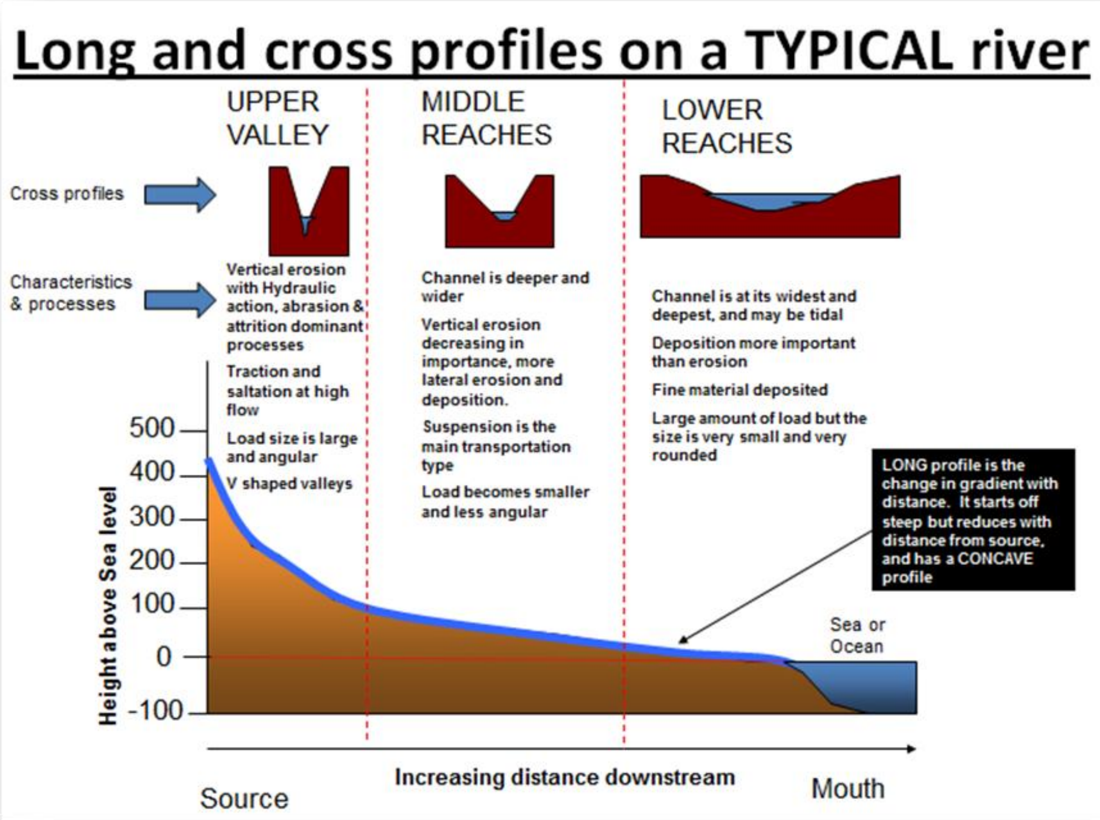


Figure 12. The long profile of a river

The diagram shows how the long profile changes downstream. In the upper reaches (also known as the **source**) the gradient is at its steepest because of **vertical erosion**. This changes further downstream as **lateral erosion** (side to side) from the river and deposition start to replace vertical erosion as the dominant process. Finally, the river really flattens out as it approaches the mouth as deposition become dominant. In addition, along the upper part of the long profile or Thalweg there is more turbulence, lots of bed load in comparison to discharge and lots of roughness and fiction. As more streams and tributaries join the river, roughness decreases, discharge and velocity increases and the erosive power of bed load will decrease. As a result the gradient of the river will generally decrease creating a concave long profile with distance downstream, and deposition serves to enhance this phenomenon further. The **cross profile** diagrams show that in the source area the drainage basin (an area of land drained by a river and its tributaries) contains V shaped valleys and waterfalls, and the dominant processes are erosion. Erosion tends to be vertical (straight down into the land).

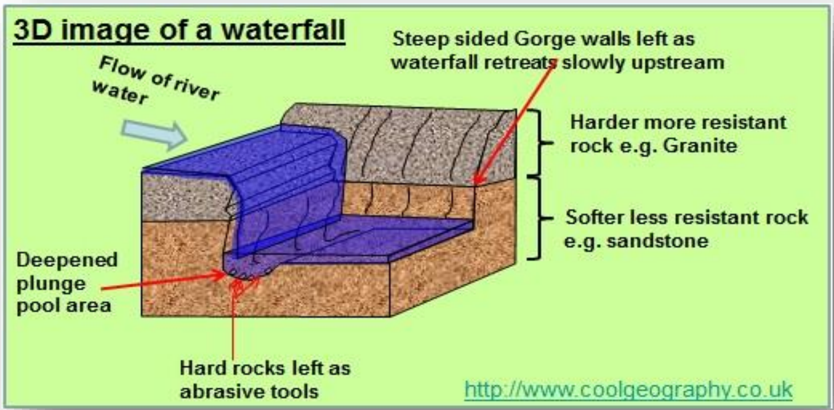
In the middle section of the drainage basin the river starts to erode laterally. This section contains meanders and Ox bow lakes, and the river creates a flood plain often with Levees. Here, Material is deposited and erosion can also occur.

In the lower drainage basin deposition dominates as a river enters a sea or lake, the valley is at its widest and deltas and estuaries are major landforms and habitat.

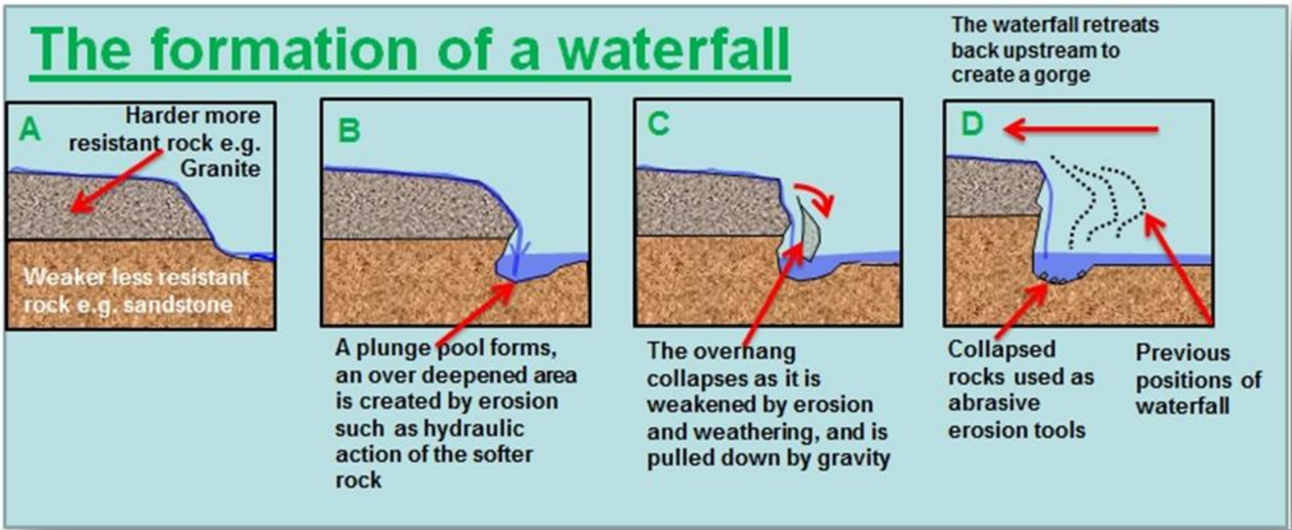
ACTIVITIES 3.8

1. Draw a copy of the drainage basin systems diagram and define all of the key terms around it

3.10 River landforms of erosion – waterfalls



Landforms in upland regions are dominantly created by erosion processes, where land is worn away. Generally, the volume and discharge of rivers in upland regions tends to be low, and the river uses much of its energy in overcoming friction. The erosion direction here is vertical, or straight down into the bed of the river. This has the effect of destabilising the slopes on either side of the river,



creating a steep landscape. **Waterfalls** are one of the most spectacular landforms found in the upper valley and are created by erosion processes.

Figure 13. High Force Waterfall on the River Tees, by Les Hull via Wikimedia Commons

They occur where a band of **hard rock** (e.g. granite) overlies a **softer rock** (e.g. sandstone).

Erosion processes such as Hydraulic Action (the force of the water) and Abrasion (where the river rubs stones that are being transported against the bed of a river thereby breaking it down) dominate. The softer rock is eroded quicker than the harder rock and gradually washes away downstream.

This creates a **plunge pool** where water is swilled around, potholing can occur here and any rocks and debris swept into the plunge pool by the river will be swirled around and rub against the bed and banks of the plunge pool (called ABRASION), deepening it further.

Over time, the softer rock is eroded further creating an **overhang** of hard rock. This overhang is unstable as its weight is unsupported.

Eventually, this hard rock collapses because it is unsupported and the waterfall moves back upstream. This creates **Gorges**, which are steep sided deep river valleys. This process will repeat continually, with the location of the waterfall moving back upstream.

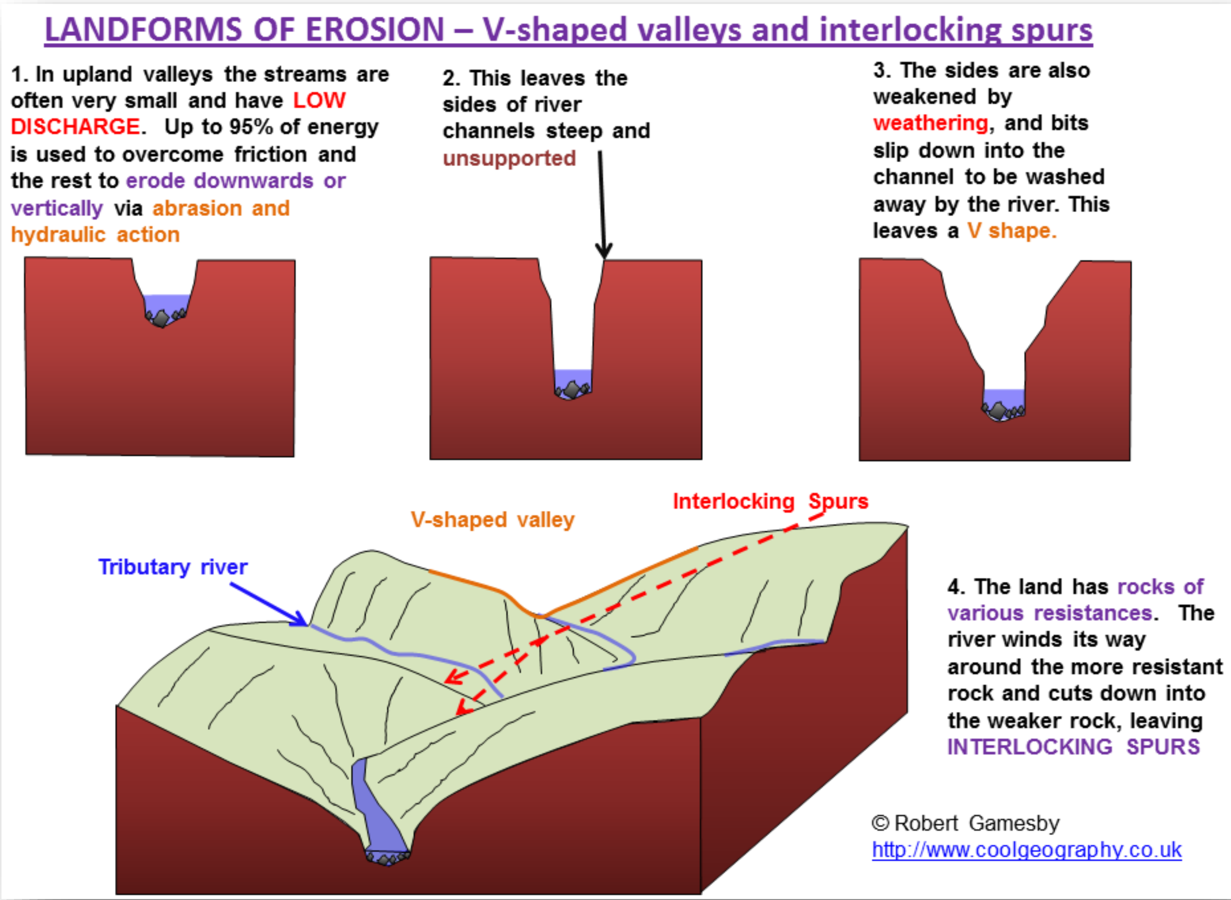
Key words

- **Estuary** - The tidal mouth of a river where it meets the sea; wide banks of deposited mud are exposed at low tide.
- **Flood plain** - The relatively flat area forming the valley floor on either side of a river channel, which is sometimes flooded.
- **Gorge** - A narrow, steep sided valley, often formed as a waterfall retreats upstream.
- **Interlocking spurs** - A series of ridges projecting out on alternate sides of a valley and around which a river winds its course.
- **Levees** - Embankment of sediment along the bank of a river. It may be formed naturally by regular flooding or be built up by people to protect the area against flooding.
- **Meander** - A pronounced bend in a river.
- **Oxbow lake** - An arc-shaped lake which has been cut off from a meandering river.
- **Waterfall** - Sudden descent of a river or stream over a vertical or very steep slope in its bed. It often forms where the river meets a band of softer rock after flowing over an area of more resistant material

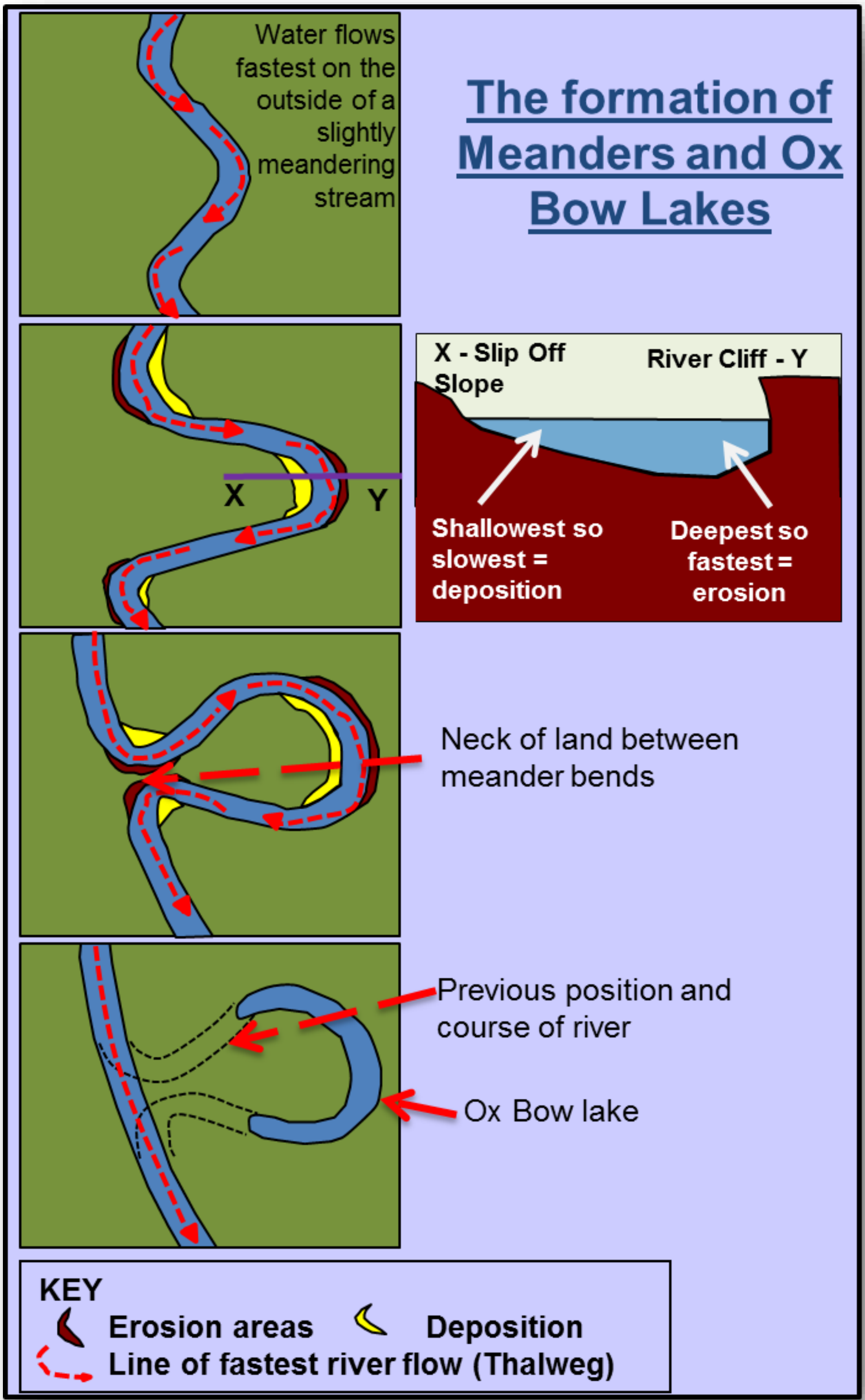
ACTIVITIES 3.10

Produce and complete the flow chart below to explain FULLY how a GORGE is created. Mention erosion processes, rock resistances, Plunge pools and rock types in your answer.

River landforms of erosion – V-shaped valleys and interlocking spurs



Vertical erosion also creates **V shaped valleys and interlocking spurs**. This is shown in the diagram above. In upland valleys the streams are often very small and have LOW DISCHARGE. Up to 95% of energy is used to overcome friction and the rest to erode downwards or vertically via abrasion and hydraulic action. This leaves the sides of river channels steep and unsupported. The sides are also weakened by weathering, and bits slip down into the channel to be washed away by the river. This leaves a V shape. The land has rocks of various resistances. The river winds its way around the more resistant rock and cuts down into the weaker rock, leaving **INTERLOCKING SPURS**



3.11 Landforms of Deposition and Erosion –

Meanders and Ox Bow Lakes

In contrast to the upper reaches of a drainage basin where the rivers start, the middle reaches are characterised by more gentle relief, erosion and deposition processes and wider valley floors (due to **lateral erosion**)

Meanders occur in the middle valley and are the result of **erosion AND deposition** processes on a river.

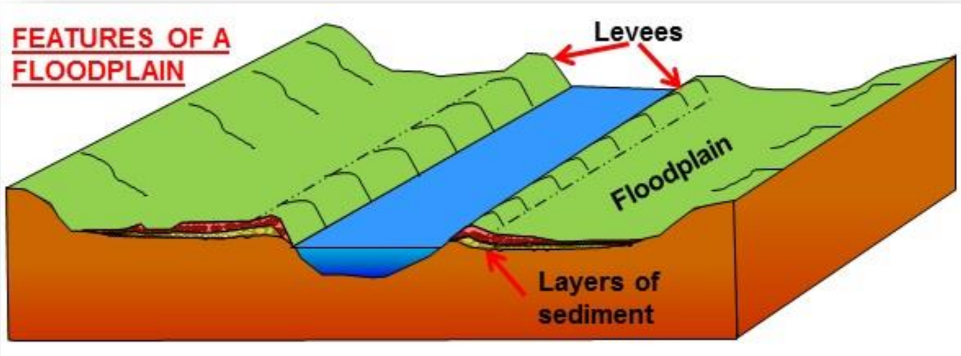
In this section of the valley the **river erodes laterally** and migrates across the valley floor over time, widening the valley. Within the river itself, the **fastest current is found on the outside of a bend** and the slowest current on the inside of the bend, this can be observed on the cross section diagram. This is because the depth of the water on the outside of the bend is deeper, so there is less friction and hence higher velocities.

Over time, this means that erosion occurs on the outside of meander bends and deposition occurs on the inside.

This process can lead to formation of one of Geography's classic landforms, **Ox bow lakes**. In the diagrams, erosion of the outside of the meander means that the neck of land becomes narrower and narrower over time.

On the inside of the bend the slow flow encourages the deposition of beaches. After a long time the neck of land gets totally cut through by erosion processes such as hydraulic action and abrasion .This cuts off the meander bend which is totally isolated by deposition leaving an Ox bow lake, which is a crescent shaped lake that will eventually fill with reeds and sediment over time.

Landforms of Deposition - Flood plains and Levees



Rivers flood on a regular basis. The flat area over which they flood is known as the floodplain and this often coincides with regions where meanders form.

When they flood velocity is slowed and deposition of any rocks being transported is encouraged. This **deposition** leaves a **layer of sediment** across the whole floodplain.

After several floods there are **several layers** of sediment (rocks) deep on the flood plain. In addition, the largest rocks and most deposition occurs next to the river channel. This leaves a ridge of higher material next to the river channel on both banks of the river known as a **levée**. Meandering rivers can contribute greatly to floodplain development by eroding laterally and helping to flatten valley floors.

Levées can be reinforced as a flood prevention measure, and there are many examples of concrete and earth being used to artificially build the height of Levées.

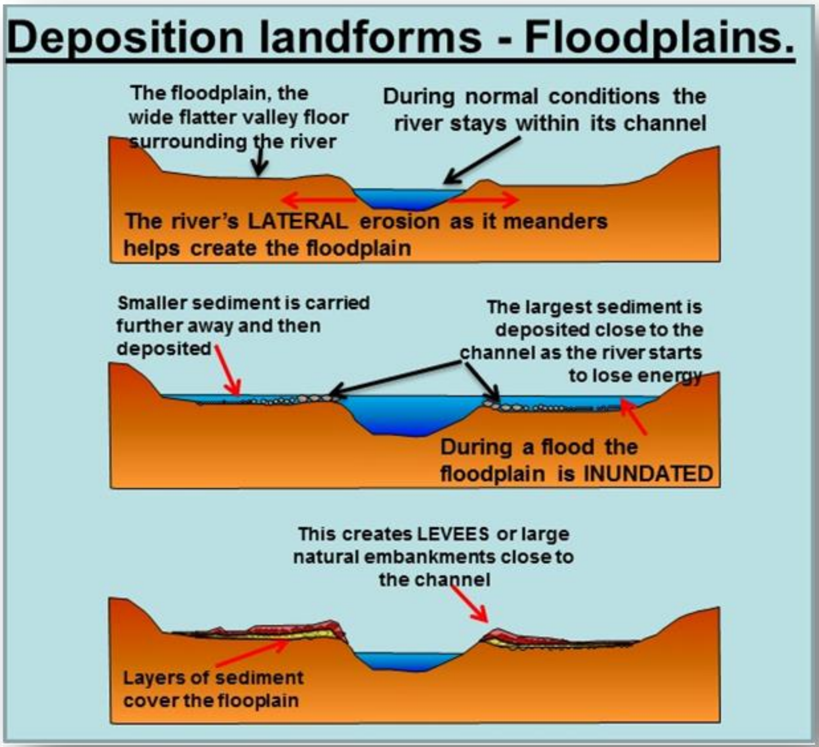
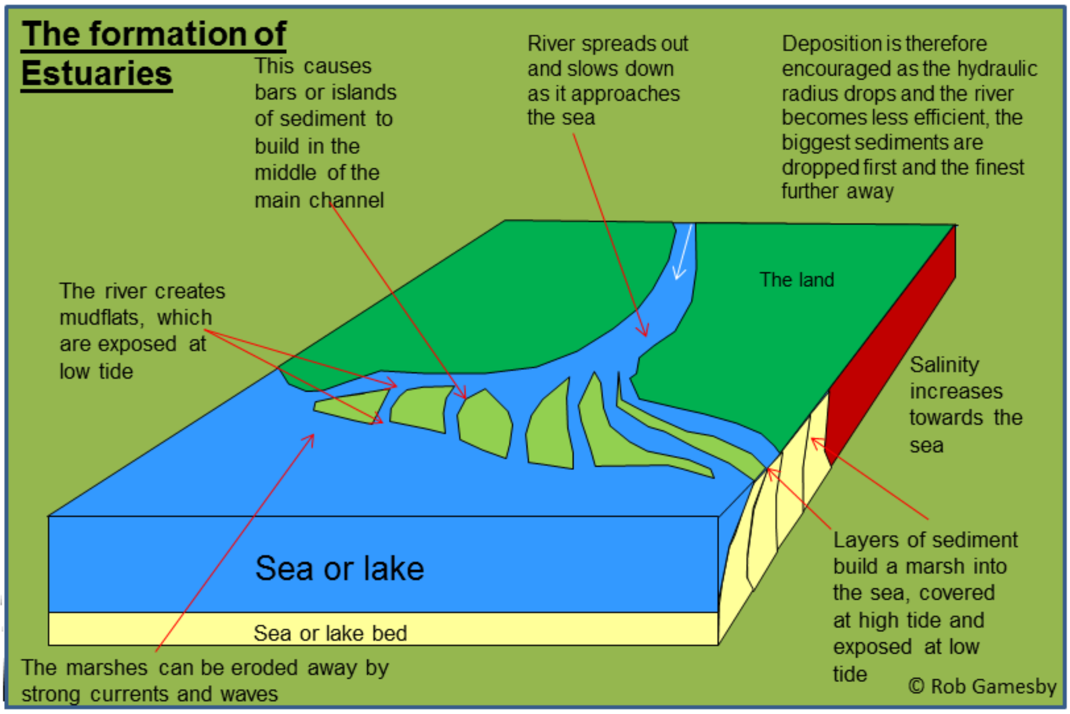


Figure 14. The formation of floodplains and levees

3.13 Landforms of Deposition – ESTUARIES

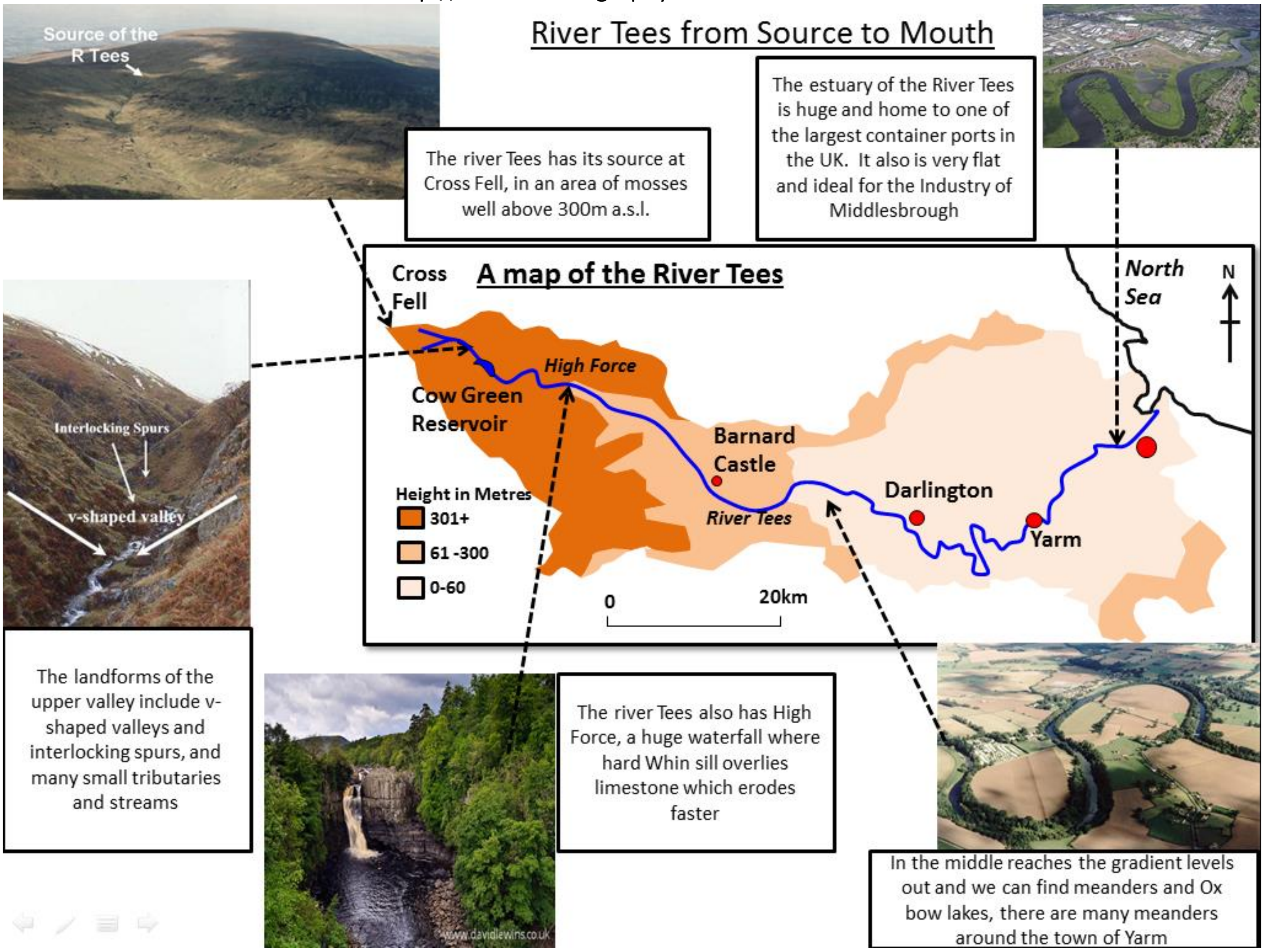


ACTIVITIES 3.13

1. Explain the development of Ox bow lakes mention processes of erosion and deposition
2. Annotate fully the photograph below to DESCRIBE the key river features

3.14 An example of a river valley in the UK to identify its major landforms of erosion and deposition – The River Tees

The River Tees is a fantastic river to study as it contains nearly all of the classic river landforms; V shaped valleys and interlocking spurs, waterfalls, floodplains and levees, meanders and ox bow lakes and an estuary at Tees mouth.



3.15 HYDROGRAPHS

A storm hydrograph is a way of displaying how the discharge of a river can change over time in response to a rainfall event. They show the **RELATIONSHIP** between precipitation events and the volume of water in a river. The discharge of a river is just the amount of water passing a certain point every second, and is calculated by multiplying the cross sectional area of the river by the velocity. Because the cross section is measured in metres^2 and the velocity is measured in metres per second the discharge is measured in metres [3] per second. These units are known as **CUMECs** (CUbicMetres per sECond). The key features of a hydrograph are shown below;

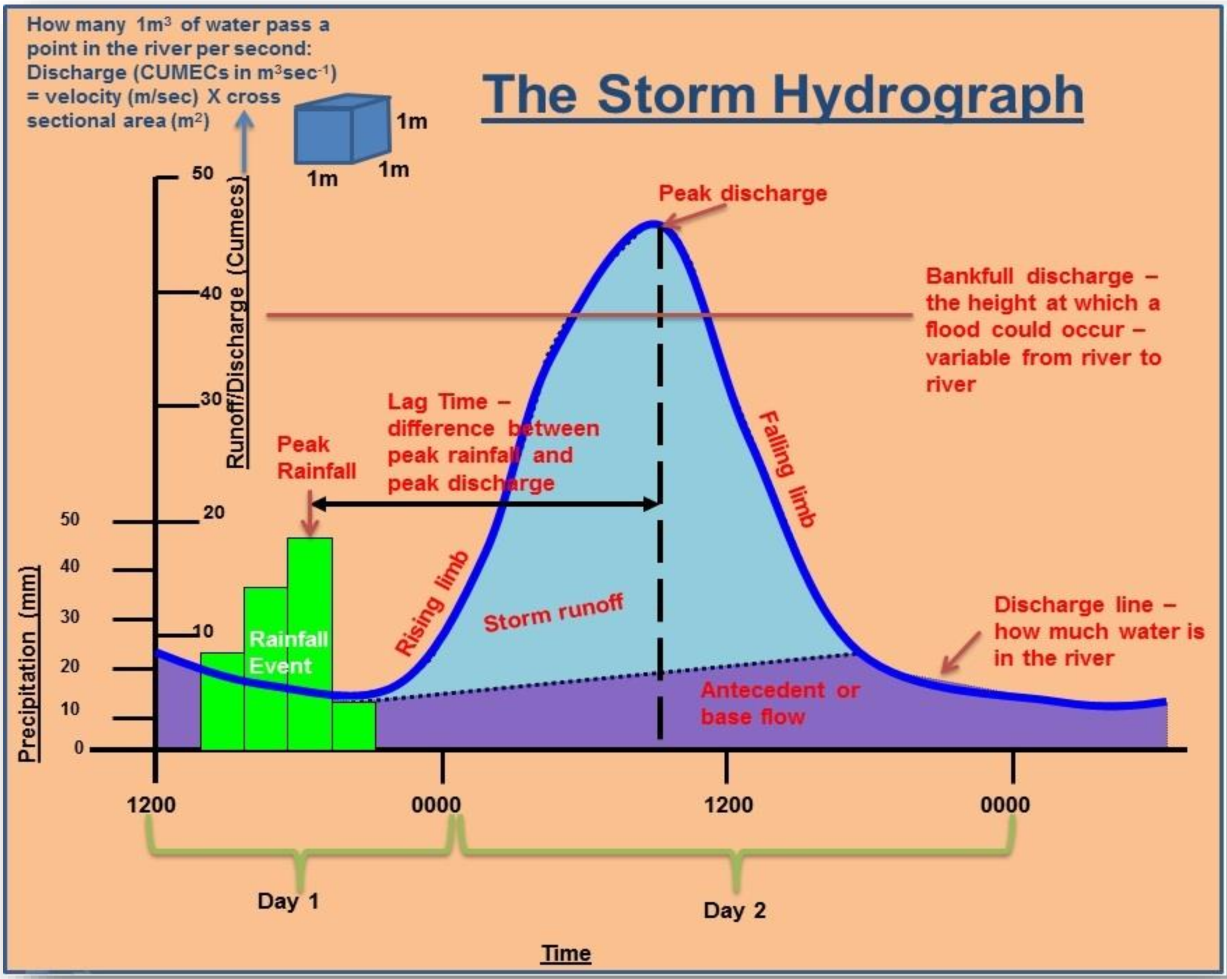


Figure 15 the storm hydrograph

The graph shows base flow which are the contributions made to the river via soil and ground water flows. These will be ever present on the graph unless there is a long extended period without any rainfall. The **runoff or storm flow** is the water that arrives in the river via surface runoff or rapid **throughflow** through the rock. The **rising limb** gives an indication of how fast water is reaching the channel and represents the level of water rising in the channel. The steeper the rising limb the more likely a flood is to occur; this is vital knowledge for flood forecasters. The **falling limb** shows the river as its level falls. Peak discharge is the maximum amount of water in a river after a rainfall event, if this level surpasses **the bankfull discharge** then a flood will occur where the river overtops its banks. The last item indicated on the hydrograph is the **lag time**, this is the amount of time between the peak amount of rainfall and the peak

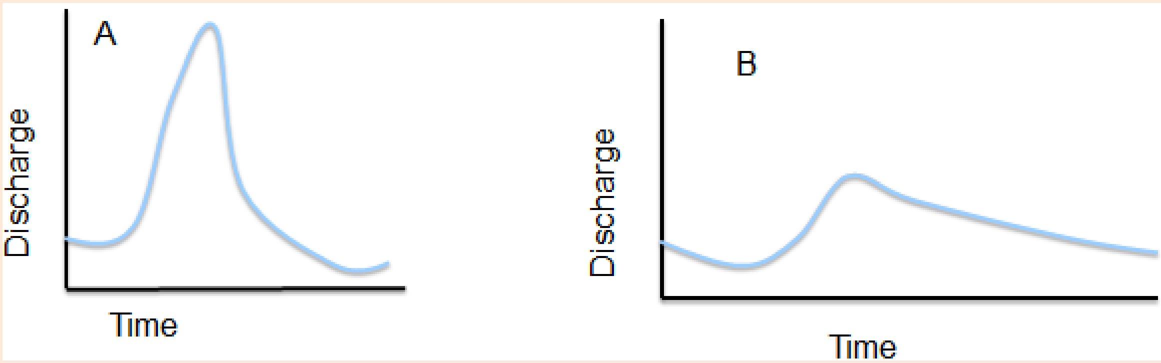
Key words

- **Discharge** - The quantity of water that passes a given point on a stream or river-bank within a given period of time.
- **Flood** - Occurs when river discharge exceeds river channel capacity and water spills out of the channel onto the floodplain and other areas.
- **Hydrograph** - A graph which shows the discharge of a river, related to rainfall, over a period of time
- **Precipitation** - Moisture falling from the atmosphere – as rain, hail sleet or snow.

discharge in the river. Generally, the less the lag time the quicker the river rises, the more FLASHY the graph and the more likely a flood.

ACTIVITIES 3.15

1. Define the term discharge
2. Explain why discharge can vary over the course of a year in the UK. Look at the images below and draw/complete the table



Which of the 2 hydrographs is most likely to:	A	B	REASON
Flood			
Have thick deciduous vegetation			
Be in an Urban area			
Have flood defences along the river			
Have permeable soils			
Have had a prolonged period of rainfall prior to this event			
Have a LOW water table			

3. Draw a **simple annotated sketch hydrograph** for a river close to saturated fields. Assume that the valley is steep sided, the soils are permeable and that 24 hours of heavy rainfall have just fallen.

3.16 Factors affecting River Flooding

Rivers flood for a variety of different reasons, and very few rivers have the same background characteristics. The reasons why rivers flood can be divided into HUMAN and PHYSICAL (or Natural) characteristics.

The physical reasons for flooding

Figure 16 River flooding by By Rob and Stephanie Levy from Townsville, Australia (Queensland floods)via Wikimedia Commons

Precipitation type, amount and duration are the most obvious reasons for river flooding. Long steady prolonged rainfall will produce rivers which rise slowly but can flood, whilst heavy short showers can cause rivers to rise quickly and burst their banks. Snowfall is another factor to take into account, river levels fall in the UK as precipitation is often stored as snow during cold snaps. However, when temperature warms and that snow melts many days' worth of precipitation can end up in rivers and cause flooding.

The RELIEF of the land can also have an impact. Steep slopes tend to reduce the amount of infiltration of water into the ground, this water can then flow quickly down to rivers as overland flow. In addition, steep slopes also cause more through flow within the soil. Both can raise river levels. Gentle slopes or flat land allow water to penetrate into the soil and increase lag times.

Vegetation type and coverage plays a big role, with forests intercepting more rainfall than grasses. This interception increases lag time and reduces the risk of a flood. Indeed, deforestation (the removal of trees) can increase soil erosion, reduce interception and increase flood risk. Afforestation, where trees are planted, can have the opposite effect.

GEOLOGY - Soil and rock type can also influence what happens to precipitation when it reaches the ground. Impermeable soils and rocks such as clay or shale do not allow water to infiltrate, this forces water to run off reducing river lag times and increasing flood risk. Permeable rocks allow water to infiltrate into them. If permeable rocks allow water in through cracks, fissures and bedding planes but not through their pores they are said to be pervious (such as limestone). Porous rocks allow water to penetrate into their pores such as sandstone.

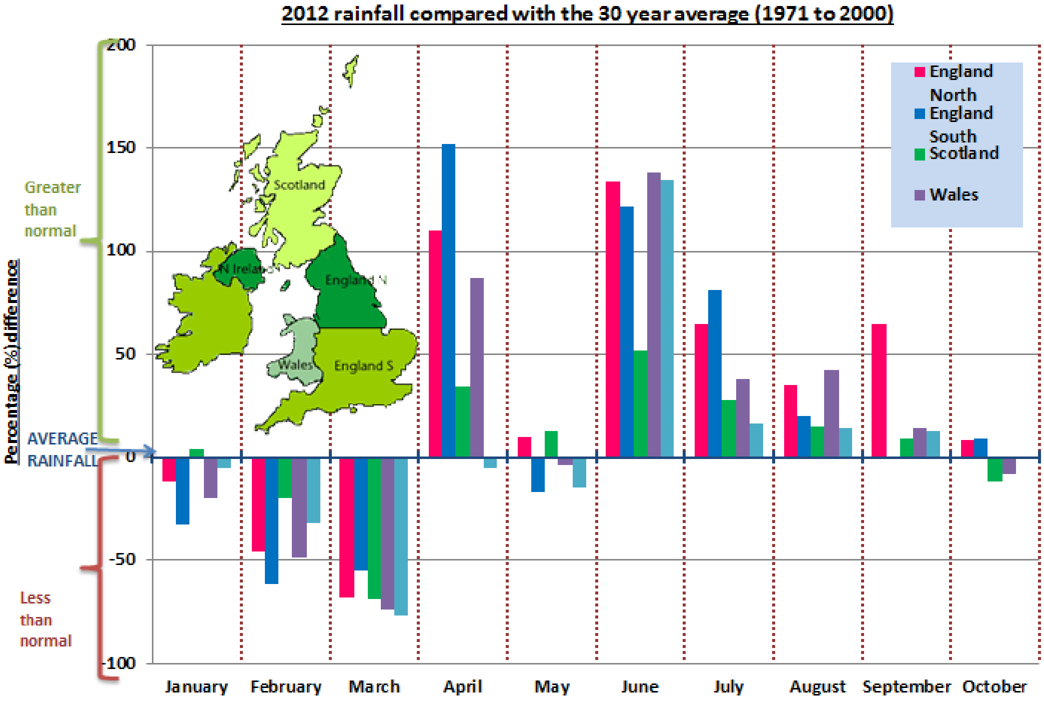
Human reasons for river flooding

Humans cause changes in **LAND USE** which can impact upon river flooding.

1. Urbanisation can cause flooding because many of the surfaces in towns and cities are Impermeable. The whole urban system is designed to move water from the surface into underground pipes and away from urban areas which have value. This can lead to floods in other regions.
2. Deforestation (the removal of trees) can increase soil erosion, reduce interception and increase flood risk.
3. Increases in population density can also have an impact as it places more people in flood risk areas. It is for this reason that we are building on floodplains and flood risk areas in the UK, this just increases the likelihood of a flood.

Patterns

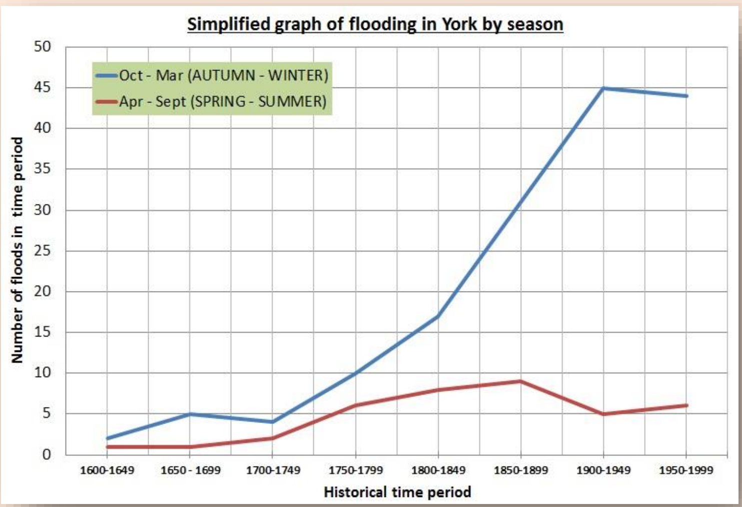
Historically floods were reasonably unusual events in the UK and mainly occurred during the winter season. This pattern is changing, with major floods becoming more frequent in the UK and many are now occurring in summer. Our case study of a flood in an MEDC, in Morpeth, occurred in early September. If these patterns continue it will cost a lot of money to protect the vulnerable people in flood risk zones. Winter rainfall is becoming more prolonged and heavier as well. This is shown wonderfully below, using statistics from the Met Office website for 2012;



This resulted in extensive flooding in the UK, even in Newcastle upon Tyne on "Thunder Thursday". It has been noticed across the UK that flooding is increasing in intensity (how large the floods are), frequency (how often they occur) and are becoming more common in ALL seasons of the year. This is nicely revealed by the graph from flooding over time in York in Northern England in the activities box.

ACTIVITIES 3.16

Describe the patterns on the graph below – be sure to QUOTE DATA in your response



Explain why we are getting more flooding in the UK in areas such as York

3.17 River management

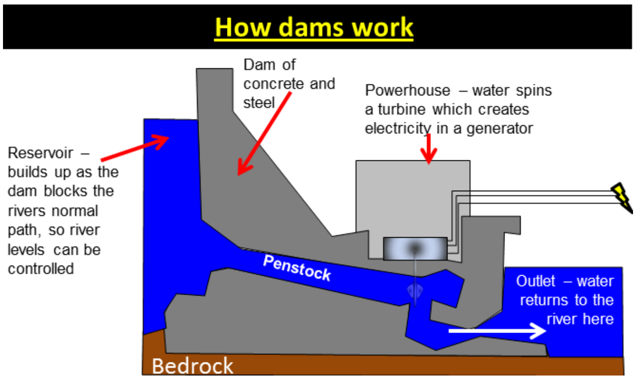
Rivers are managed in a huge variety ways and for a variety of different reasons. We use rivers for collecting water for drinking, industry and farming, and we manage then to prevent damage caused by deposition, erosion and flooding. Management can be split into 2 areas - **HARD and SOFT ENGINEERING.** These 2 methods have many **BENEFITS** for people and the ENVIRONMENT, but can also have associated **COSTS or negatives**.

Hard engineering involves the building of entirely **ARTIFICIAL structures** using various materials such as rock, concrete and steel to reduce or stop the impact of river processes.

DAMS & RESERVOIRS

Figure 17 - Three Gorges Dam in China - By Source file: Le Grand Portage Derivative work: Rehman via Wikimedia Commons

One way in which we manage rivers is to build huge concrete and steel structures called **dams**. These dams block rivers and cause the water carried by rivers to back up and flood the valley upstream of the dam creating a **RESERVOIR**. This water can then be used or released through the dam to produce Hydro Electric Power (HEP). By building a dam it allows engineers to control the flow of a river - this can therefore be used to prevent flooding during high rainfall periods. Newcastle is protected in part by the Kielder Water dam, and China has just completed construction of the World's largest dam at 3 Gorges. This dam has reduced the risk of flooding downstream of the dam from one in 10 years to one in a 100. Recent flooding prior to dam construction affected millions of people and ruined farmland because of clay that was deposited on the fields. The dam will protect over 25,000ha of farmland downstream. The dam has a huge series of locks running



Key words

- **Flood plain zoning** - This attempts to organise the flood defences in such a way that land that is near the river and often floods is not built on. This could be used for pastoral farming, playing fields etc. The areas that rarely get flooded therefore would be used for houses, transport and industry.
- **Flood relief channels** - Building new artificial channels that are used when a river is close to maximum discharge. They take the pressure off the main channels when floods are likely, therefore reducing flood risk.
- **Flood risk** - The predicted frequency of floods in an area.
- **Flood warning** - Providing reliable advance information about possible flooding. Flood warning systems give people time to remove possessions and evacuate areas.
- **Hard engineering** - Involves the building of entirely artificial structures using various materials such as rock, concrete and steel to reduce, disrupt or stop the impact of river processes.
- **Soft engineering** - Involves the use of the natural environment surrounding a river, using schemes that work with the river's natural processes. Soft engineering is usually much cheaper and offers a more sustainable option as it does not interfere directly with the river's flow.
- **Channel straightening** - Removing meanders from a river to make the river straighter. Straightening the river (also called channelising) allows it to carry more water quickly downstream, so it doesn't build up and is less likely to flood.
- **Dam and reservoir** - A barrier (made on earth, concrete or stone) built across a valley to interrupt river flow and create a man-made lake (reservoir) which stores water and controls the discharge of the river.

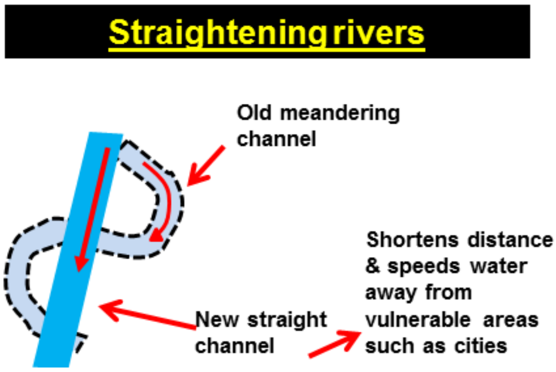
up one side to aid navigation, and will generate huge amounts of electricity. However, 1.4 million people had to be displaced (moved) to make way for the 600km lake that has formed behind the dam, there are expected to be problems with the huge amounts of sediment that will be deposited behind the dam and waste has been a problem. The city of Chongqing puts around 1 billion tonnes of untreated waste into the lake very year.

FLOOD RELIEF CHANNELS

Flood Relief Channels can also be used. Here, water is taken out of rivers and moved through artificial concrete channels away from vulnerable areas of valuable land use such as housing or industry.

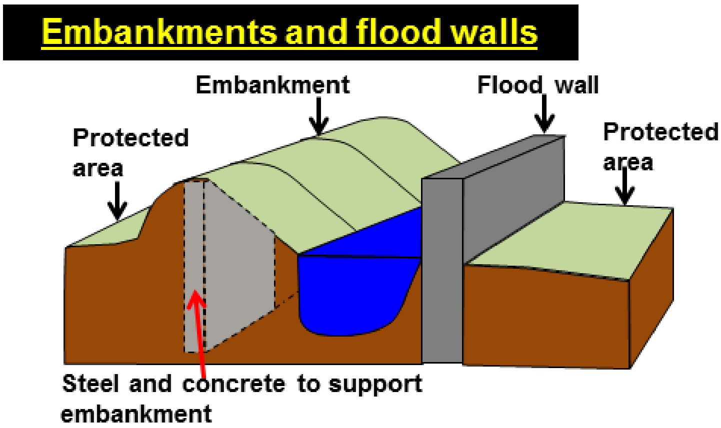
STRAIGHTENING RIVERS

Another way that rivers can be managed is to straighten meanders. This involves digging a straighter shorter channel in areas where rivers meander. The logic behind this is to speed up water flow in flood prone areas, and stop water from "hanging around". This has occurred on the Mississippi river and in York, but can cause flooding in downstream areas - a knock on consequence.



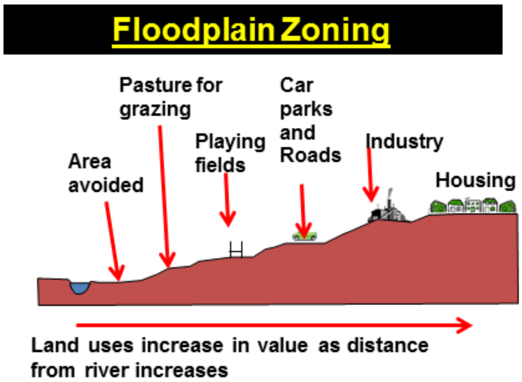
FLOOD WALLS AND EMBANKMENTS

A final hard engineering scheme is to build **flood walls or embankments** in flood risk areas. These strategies involve raising the banks of the river so that it can hold more water - thus reducing the risk of a flood. Morpeth has flood walls that will now be improved following flooding there, whilst it was the failure of floodwalls in New Orleans that caused so much damage during Hurricane Katrina.



Soft Engineering

SOFT ENGINEERING is a contrasting approach. It involves managing a river **using natural materials** and mimicking natural processes to protect more vulnerable areas. One technique used is to encourage the growth of reed beds which are allowed to flood and slow down river water. Another technique is known as **floodplain zoning**. Here, the areas closest to rivers are only used for low cost uses, such as playing fields and grazing. Higher cost land uses are kept away from the river on higher land..



A final approach is a **flood warning system**. In the UK if you live in a flood risk zone your details are kept on a database. In the event of a flood the Environment Agency will contact homeowners at risk via text message, phone call or a visit from a flood warden.

ACTIVITIES 3.17

JUDGE which strategies to manage river processes and flooding (hard or soft engineering) are most effective and why?

3.18 A case study of a flood management scheme in the UK - The Morpeth Floods

Morpeth is an ancient market town situated in a loop of the river Wansbeck in the northeast of England about 15 miles north of Newcastle upon Tyne and 12 miles west from the North Sea. Following **a flood in 1963**, a flood defence scheme was established. Flood walls were erected on the north bank to protect the main business district. Housing properties at Middle Greens on the south bank were also protected by flood walls. When the River Wansbeck swelled on the 6th and 7th September 2008 (see photo opposite by Tzdelski via Wikimedia Commons), the floodwater simply flowed over the top of the defences, which were not high enough to hold back the volume of water. This resulted in a new flood defence scheme being required.

Causes of the 2008 Floods

The flood of 2008 was estimated to have been a 1 in 115 year event. It was caused by;

1. Prolonged rainfall - The Environment Agency recorded a HUGE 150 millimetres of precipitation falling in the Wansbeck catchment between Friday 5 September and Saturday 6 September.
2. The River Wansbeck Valley is narrow and steep and as a consequence has exaggerated amounts of surface runoff.
3. The soil was already saturated as a result of the wet summer, the effect of surface runoff was greatly enhanced.
4. Increased urbanisation since the 1960s in Morpeth meant that most water falling on the town would have drained directly to the river channel.
5. Other tests investigating the catchment lag time (time lapse between the mid point of storm rainfall and peak river level) indicate that the Wansbeck has a LAG time of only 8 hours. This means that any water falling in the catchment area would have been rapidly converted into channel flow by surface runoff and to a lesser extent by throughflow.

This resulted in a peak water level of 3.99 metres recorded in the river channel, the biggest flow ever recorded in the Wansbeck.

Social Impacts

During 6 September 2008, more than 400 residents were evacuated. Shelter was provided in the Town Hall, King Edward VI High School and County Hall. An error made by the Environment Agency's warning system meant that 198 properties in the Middle Greens area of the town did not receive a flood warning. Fire fighters, ambulance crews, the RAF, the RNLI and the British Red Cross were among the emergency services involved in rescue and recovery operations over the weekend. Many residents had to be forced from their homes, and lived in caravans or with relatives as rebuilding took place.

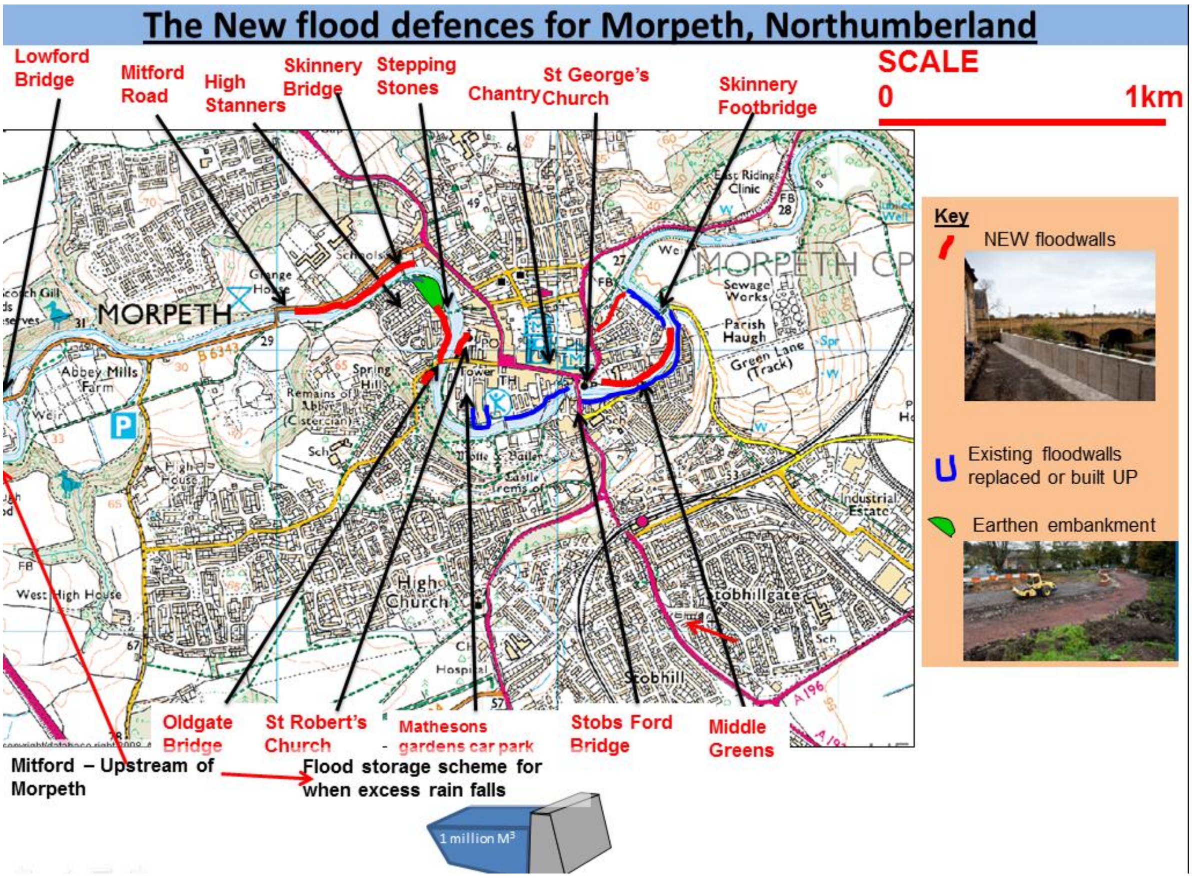
Economic

995 properties in Morpeth town centre were directly affected by the flood water. Early estimates suggested that damages could be over £10 million, but the Journal Newspaper later claimed it was £40 million. On Sunday 7 September, Morpeth Lions Club and the Red Cross launched the Morpeth Flood Disaster Fund and by Wednesday 10 September had raised over £20,000.

Environmental

At the peak of the flood, Morpeth High Street (Bridge Street) was under 60 centimetres (2.0 ft) of water. Not since 1963 had the main street been flooded. The library suffered severe structural damage due to the heavy debris transported by the river. Such was the extent of the damage that structural engineers were required to test its safety. Houses were full of mud and sewage.

THE NEW FLOOD MANAGEMENT SCHEME



Morpeth already had a system of flood defences (flood walls and low embankments) in place following the 1963 flood event, but these were overtopped by the high flood waters in 2008.

NEW plans were developed to;

1. Have a system of higher flood walls along weak spots in the town – walls were raised by 30cm in the most vulnerable areas
2. Poles were placed in the River Wansbeck to catch debris upstream, it is hoped that this will stop debris clogging up the bridges in the town which caused some of the flooding.
3. Clear out the culverts that drain water in Morpeth so that areas within Morpeth are well drained
4. Construct a huge upstream reservoir - which would hold over one million cubic metres of water- would only allow through a volume of water manageable by the town centre defences.
5. Build new flood walls in areas that had none
6. Add an earthen embankment to protect the housing estate of High Stanners

The social, economic and environmental issues involved with the flood management scheme.

This flood management scheme has many issues, which can be viewed as social, economic, and environmental. Overall, the scheme cost £ million pounds, a massive sum of money to protect residents in a small town in the North of England. The flood walls were also raised to a height of 1.8m, which obscures the view of the river for many residents and which intrudes in the natural landscape. The walls are also a barrier to some forms of wildlife. The culvert clearance is a good thing, as this provides areas with faster flowing drains for some fish and birds, and the reservoir will reduce the flood risk significantly.

ACTIVITIES 3.18

Draw the case study table and complete it to summarise the ESSENTIAL information about this flood;

Background (where, when, size)		
Causes		
Effects	Short term	
	Long term	
Responses	Individuals	
	Agencies	
	Governments	

