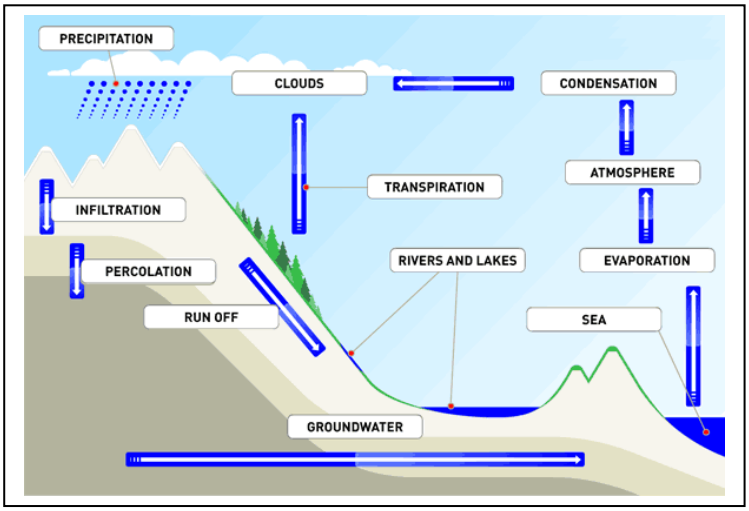
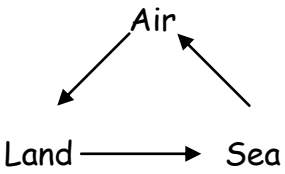
Water on the Land

The Hydrological Cycle



The hydrological cycle or water cycle is a CLOSE system. It is the continuous movement of water between land, sea and the air.

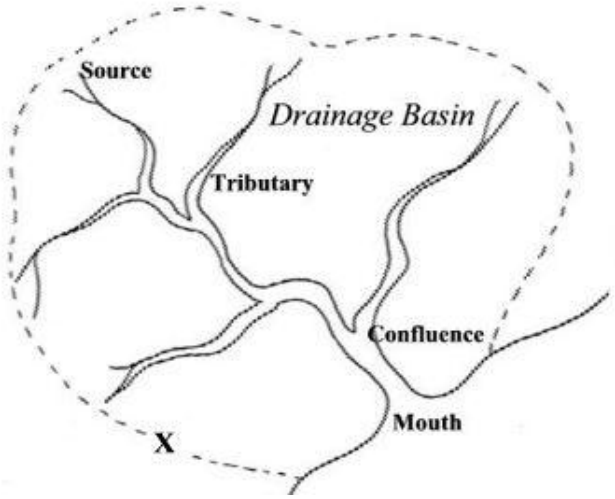


Key Terms

- Precipitation – any way that water reaches the ground from the air e.g. rainfall, sleet and snow
- Infiltration – the movement of water from the earths surface into the soil
- Surface run off – the transfer of water back to the sea over the surface of the land.
- Transpiration - Plants letting water out into the atmosphere as a vapour.
- Groundwater - The transfer of water through the ground back to the sea.
- Condensation - Water vapour in the air changing back as a liquid, creating clouds.

The Drainage Basin

The drainage basin in an open system – the amount of water in it is not fixed.



Key Words

- Drainage basin – the area of land drained by a river and its tributaries
- Source – where a river starts, usually in the highlands
- Mouth – where the river meets a lake or the sea
- Watershed – the imaginary line that divides two drainage basins
- Tributary – a smaller river that joins a main river
- Confluence – the joining point of two rivers

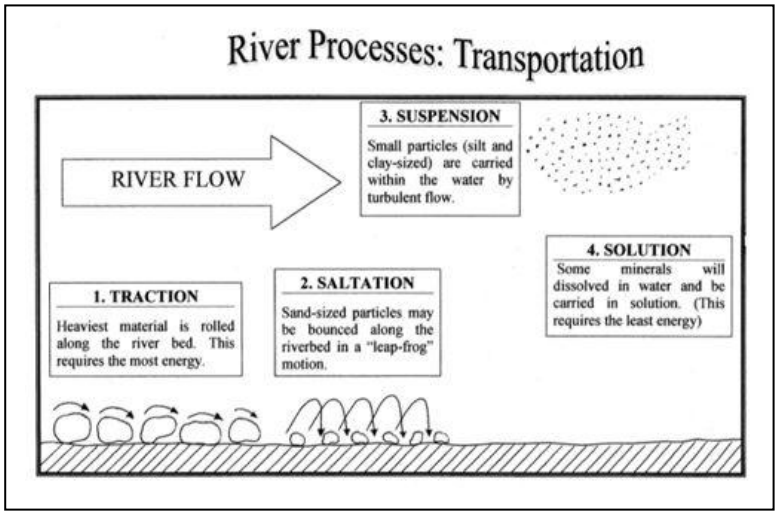
Processes of a river

Erosion

There are four ways that a river erodes; hydraulic action, corrosion, corrosion and attrition.

- Hydraulic action – the force of the water wearing away the bed and bank of the river
- Corrosion – the chemical reaction between the water and the bed and bank of the river, wearing it away.
- Corrasion/abrasion – where bedload in the river wears away its bed and bank.
- Attrition – where rocks in the water become smaller and rounder by hitting each other.

Transportation

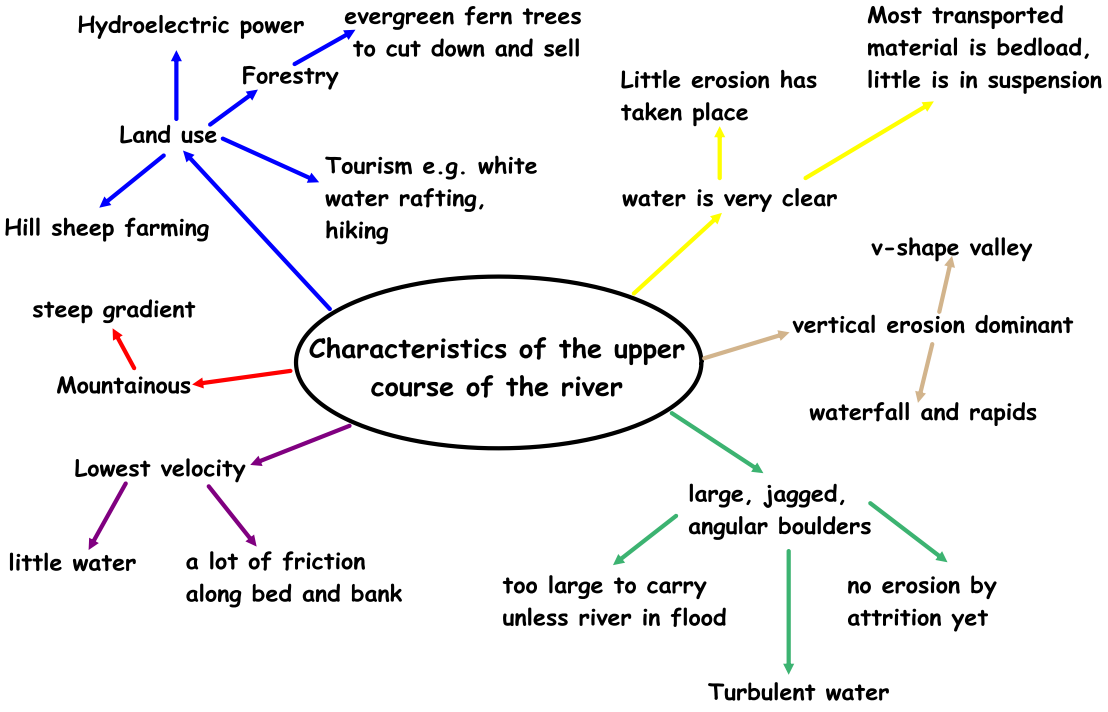


There are four ways in which a rivers moves its eroded material downstream; traction, saltation, suspension and solution.

Deposition

This is where the river drops its material. It occurs when the velocity of the river decreases, energy is reduced and the river can no longer hold all its material.

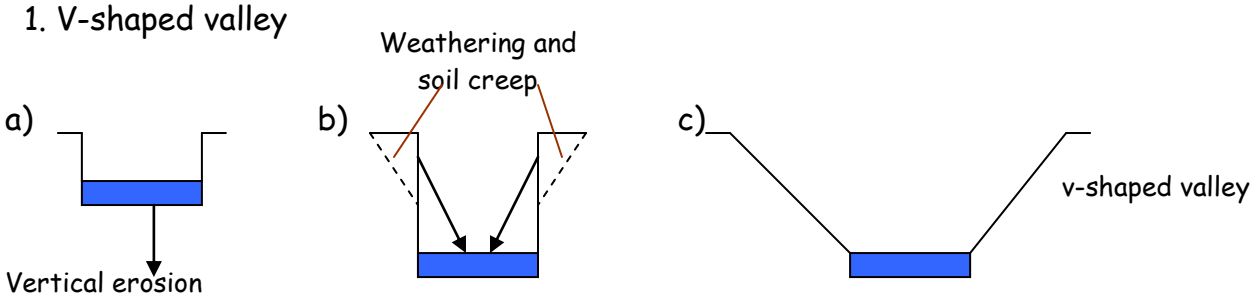
Characteristics of the upper course of the river



Features of the upper course

VERTICAL EROSION is the main process in the upper course of the river, as the river wants to get to sea level. This process creates five distinctive features; a v-shaped valley, interlocking spurs, waterfalls, gorges and rapids.

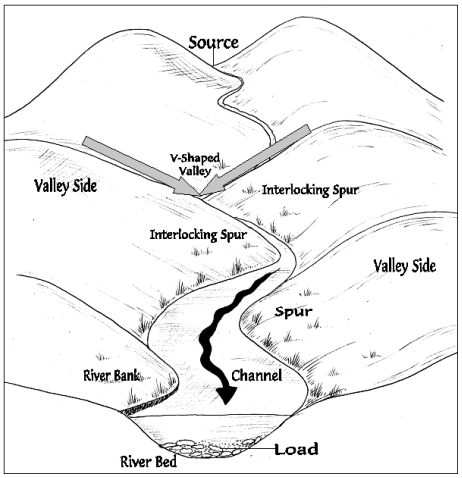
1. V-shaped valley



V-shaped valleys are created by vertical erosion (a). As the river erodes downwards freeze-thaw weathering loosens material, which is moved downhill by soil creep (gravity) (b). This creates the characteristic v-shaped valley only found in the upper course of the river. It is steep sided and narrow.

2. Interlocking spurs

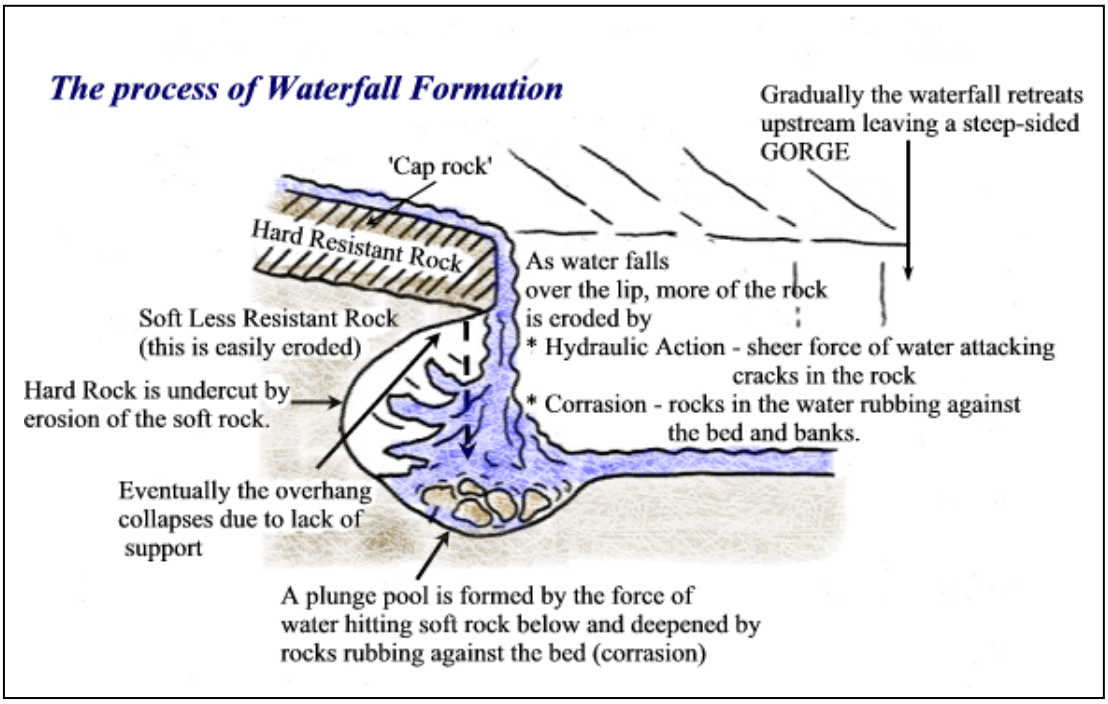
Interlocking Spurs are caused because the river wants to erode vertically. It therefore winds it way around areas of hard rock, avoiding them in favour of softer rock which is more easily eroded and leaves them as ridges of interlocking spurs.



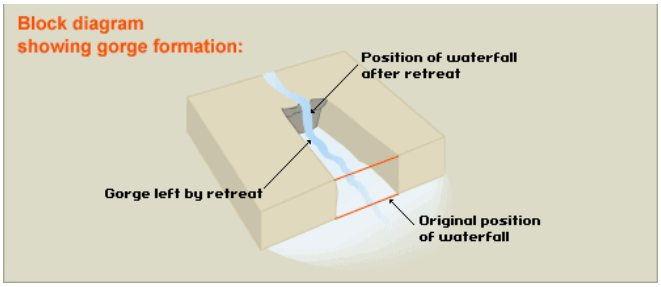
3. Waterfalls

These occur when there are horizontal bands of hard and soft rock.

An example is High Force on the River Tees

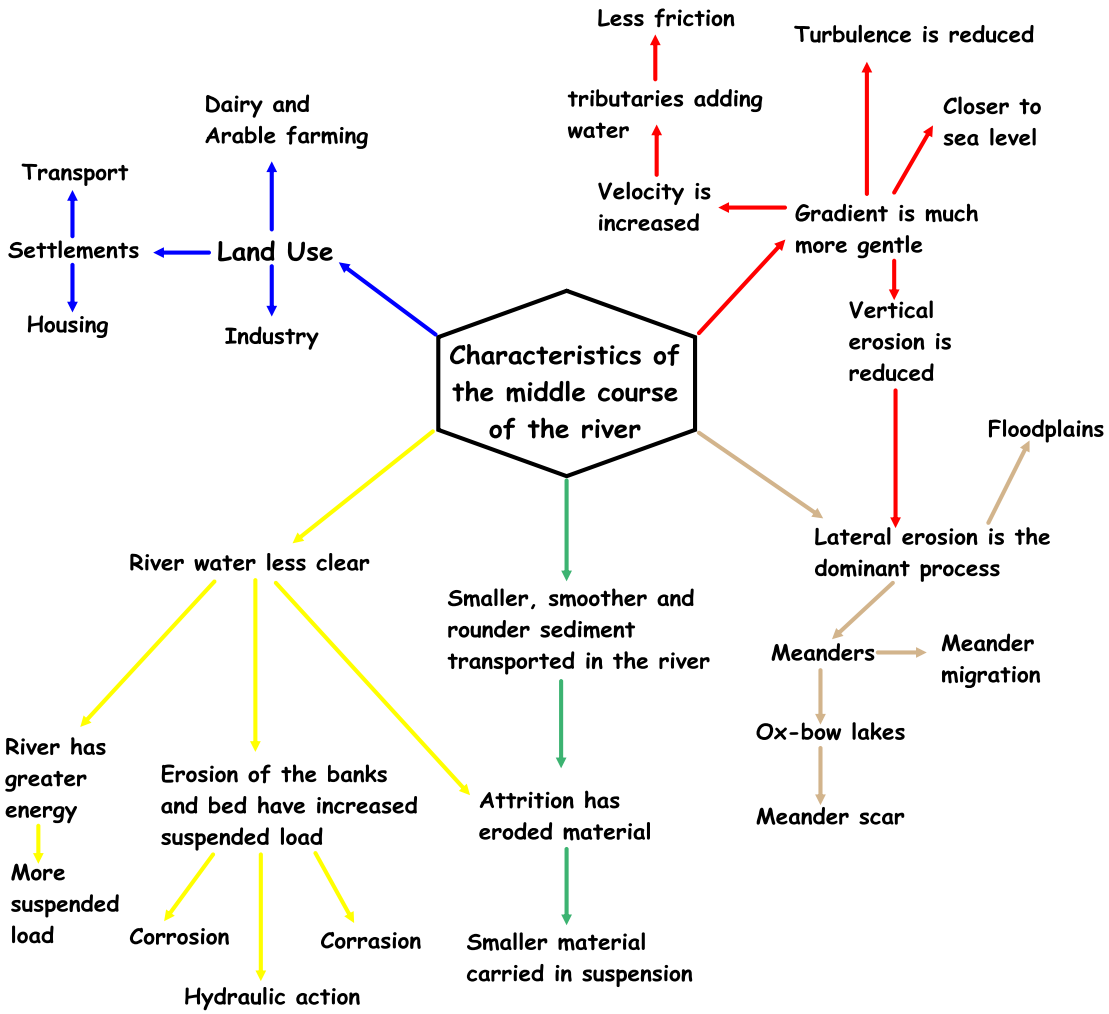


4. Gorges



Gorges are the results of the waterfalls retreating upstream. As the process of undercutting and collapse repeats, the waterfall moves back towards its source. This leaves a steep sided channel called a Gorge. An example of this is Katherine Gorge, Australia.

The Characteristics of the middle Course of the River



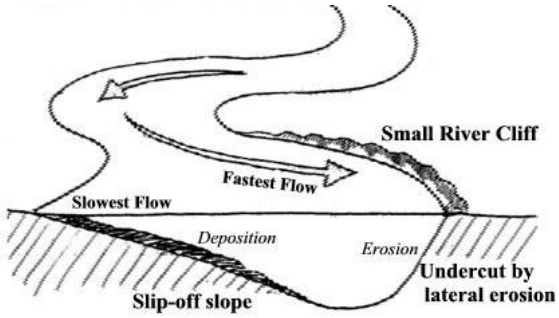
Features of the middle course

LATERAL EROSION is the dominant process in the middle course of the river, as it is getting closer to sea level, so doesn't want to erode downwards, but has more energy due to increased volume of water. Therefore the river erodes sideways. This process creates four distinctive features; meanders, oxbow lakes, floodplains and levees.

1. Meanders

A meander is a bend in a river. On the outside of the bend the river is fastest flowing and therefore erosion is greatest. This creates a deep area of water and a river cliff. On the inside of the bend water is forced to slow down, which reduces its energy, making it deposit its material. This creates a shallow slip of slope.

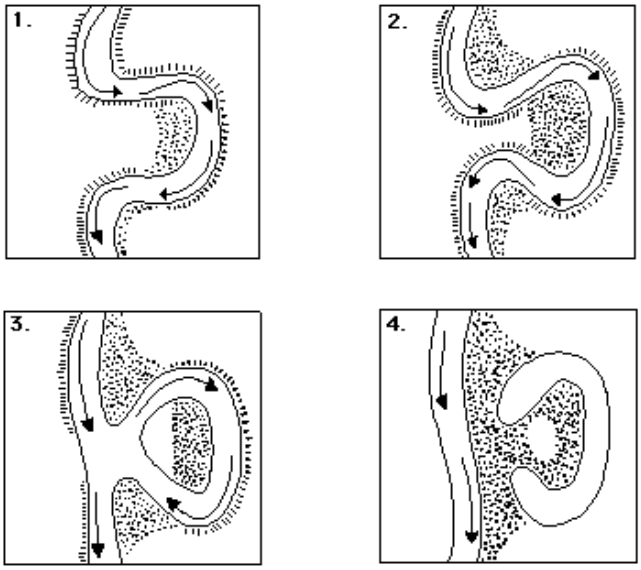
Cross section of a Meander



2. Ox-bow lakes

1. Erosion on the outside of the bend is caused by the fastest flowing water hitting it. This creates a river cliff. Deposition occurs on the inside of the bend due to the water being forced to slow down. This creates a slip off slope.

3. The meander neck gets so narrow that during a flood event the river cuts through, creating a new straight channel.



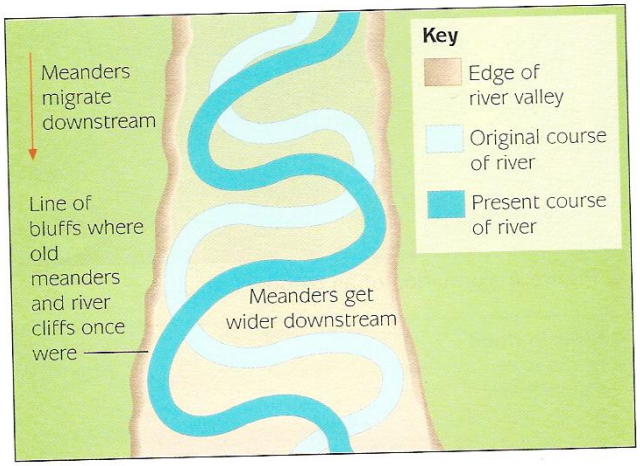
2. As erosion occurs on the outside of the bend, the meander neck narrows.

4. Deposition occurs on the outside of the channel, blocking up the former meander to create an ox-bow lake. Over time the ox-bow lake dries up to create a meander scar.

Key
//// = erosion
::::::: = deposition
→ = fastest flowing water

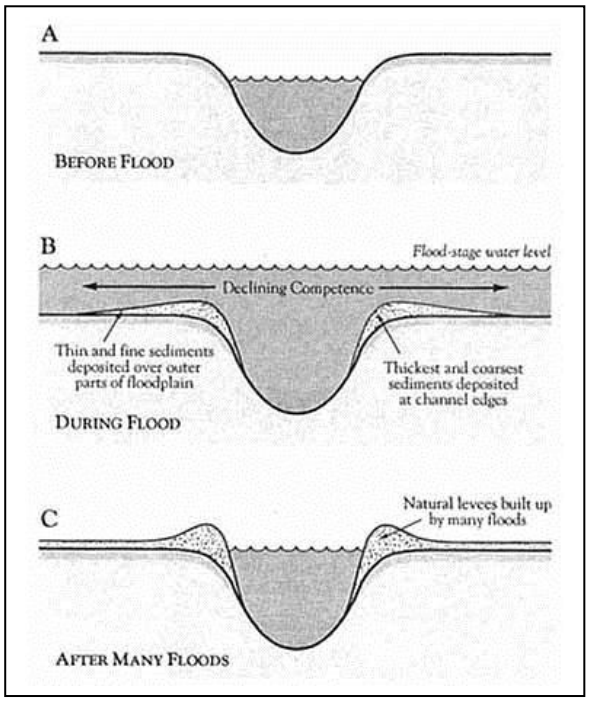
3. Floodplains

Diagram of Meander Migration



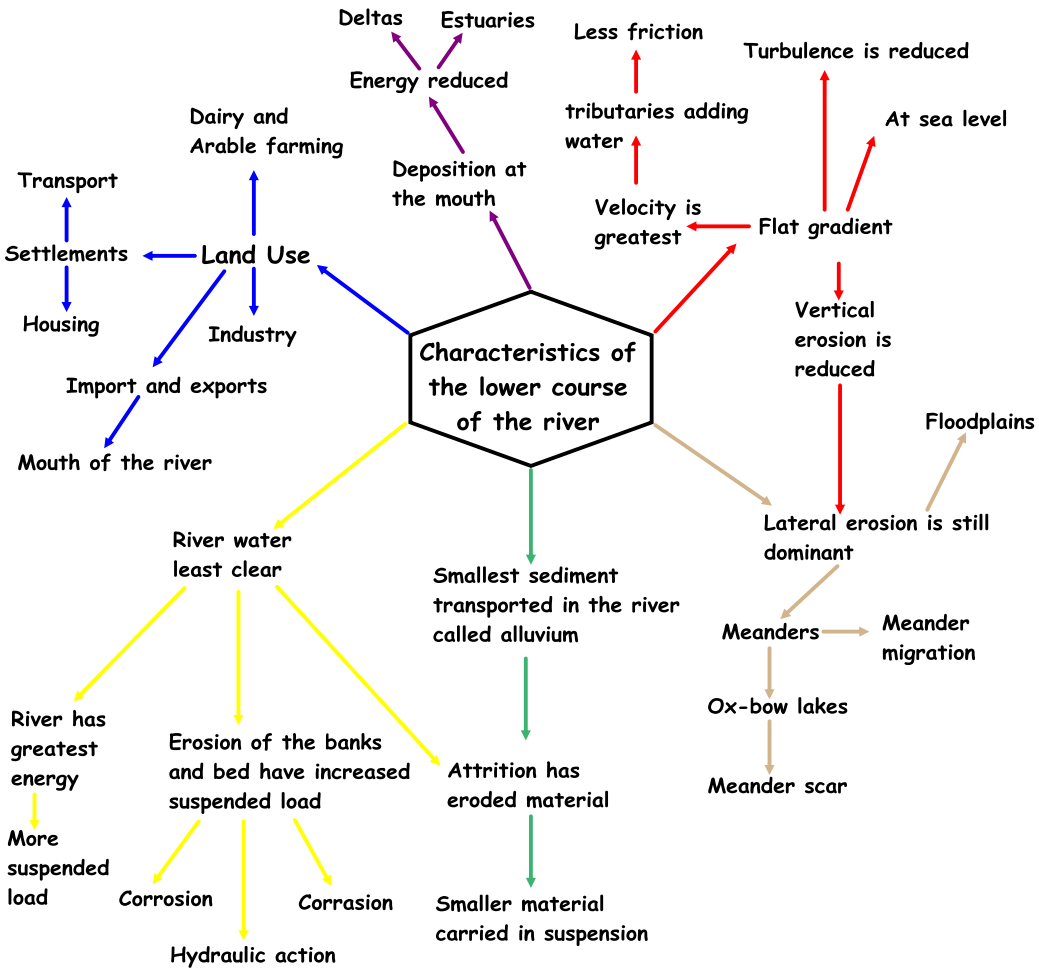
A floodplain is the wide, flat area of land either side of the river. It is formed by erosion and deposition. As meanders slowly move downstream, lateral erosion widens the floodplain, whilst deposition of the slip off slopes provides sediment to build up the floor. In addition, when the rivers floods sediment is deposited on the floodplain, making it very fertile. This makes it perfect for agriculture and is why many farmers are found on floodplains.

4. Levees



Levees are natural embankments that form by the banks of the river. They are created by deposition. When a river floods, the velocity of the river slows down as it travels over the floodplain. The river cannot hold all its sediment and is forced to deposit it. It deposits the largest material first and the smallest furthest from the river bank: this is called sorting. This process repeats over time creates a levee.

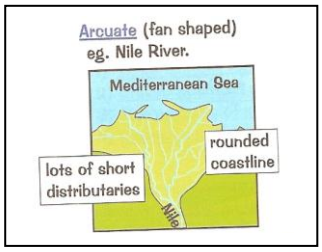
Characteristics of the lower course of the river

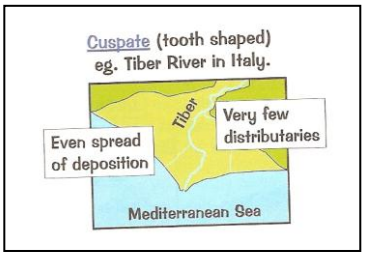


Features of the lower course

The river has greatest discharge and cross-sectional area. Many of the characteristics are similar to the middle course, including the floodplain, levees and meanders. However, due to reduced velocity at the mouth of the river it also has one additional feature; deltas.

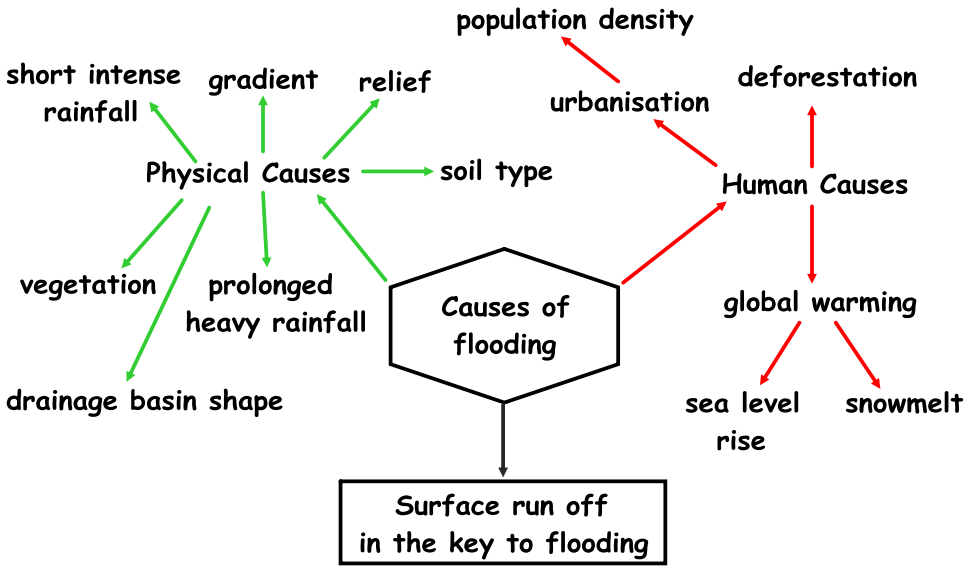
1. Deltas

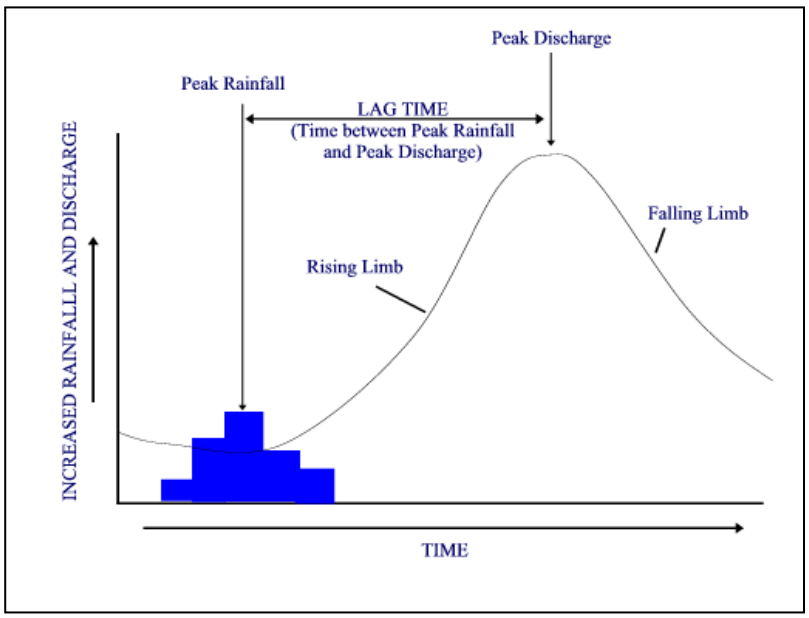




Deltas form at the mouth of river. The velocity of the river is reduced, so it deposits its material. This begins to choke the mouth of the river, and so it splits into smaller channels called distributaries. There are three types of delta; fan, tooth and bird's foot.

Causes of flooding



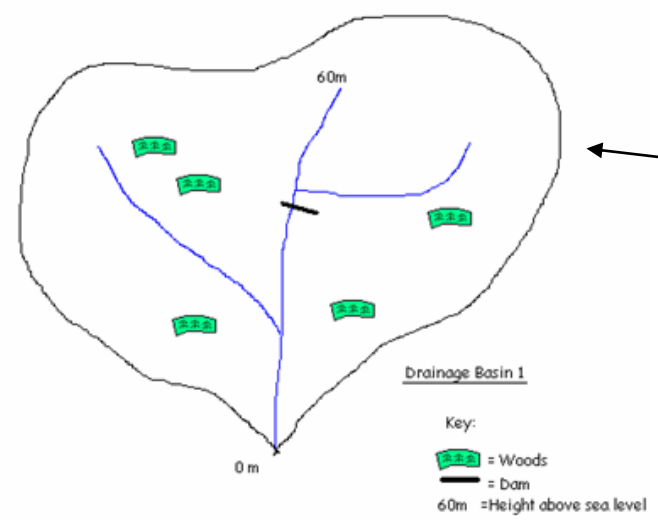


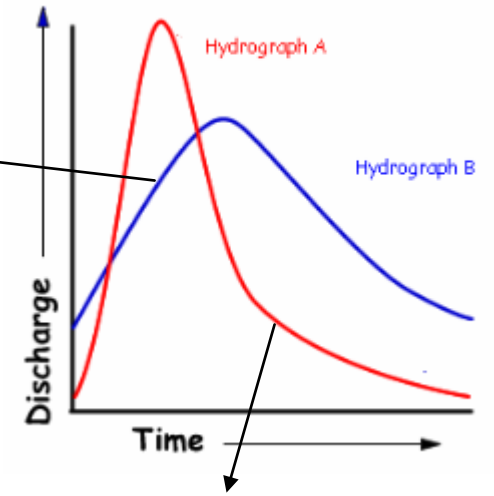
The Storm Hydrograph

A hydrograph is a graph which shows the discharge of a river over time, at a given point. A storm hydrograph shows the change in discharge during a storm event

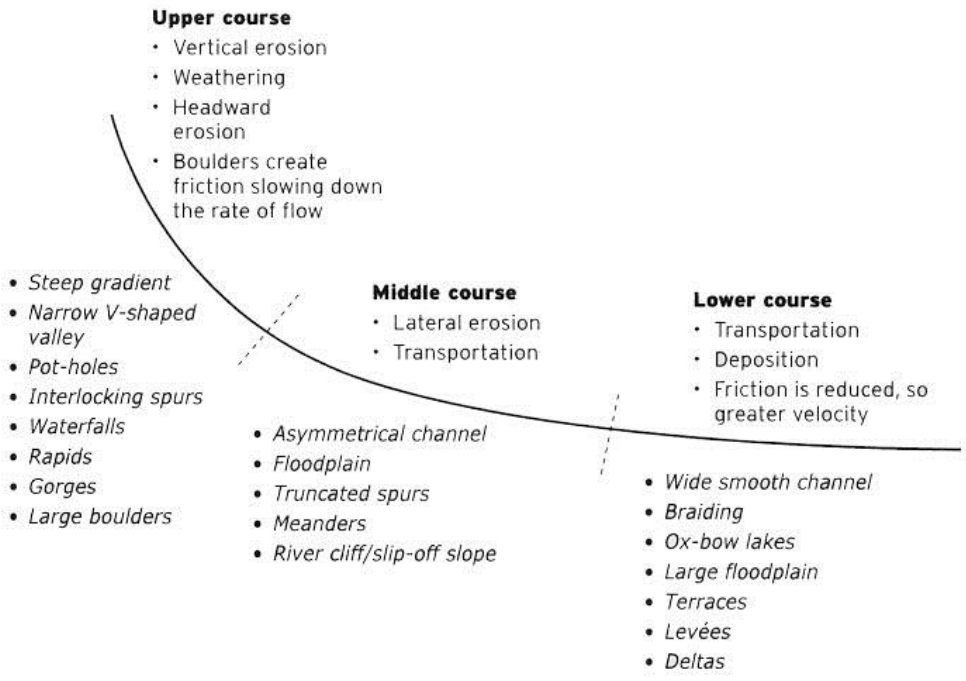
Key Words

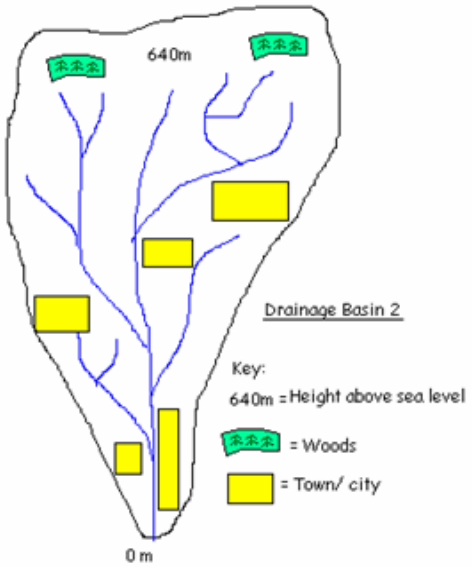
- Discharge – the amount of water in a river channel measured in cumecs (m/sec^3)
- Rising limb – this increase in river discharge, due to surface runoff
- Falling limb- the return to normal levels of river discharge after the storm event, slowed by through flow.
- Lag time – the time between the heaviest rainfall and the highest discharge. The shorter the lag time the greater the risk of flooding.
- Peak discharge – maximum volume of water in the river.

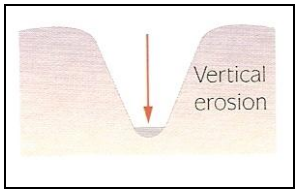
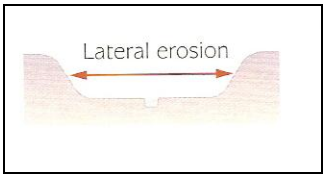
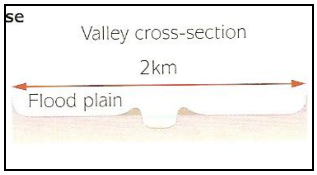
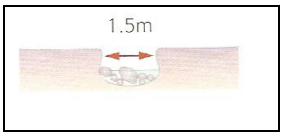
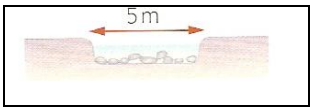
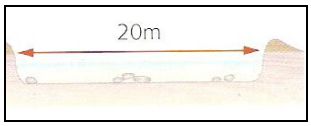




The long profile of the river



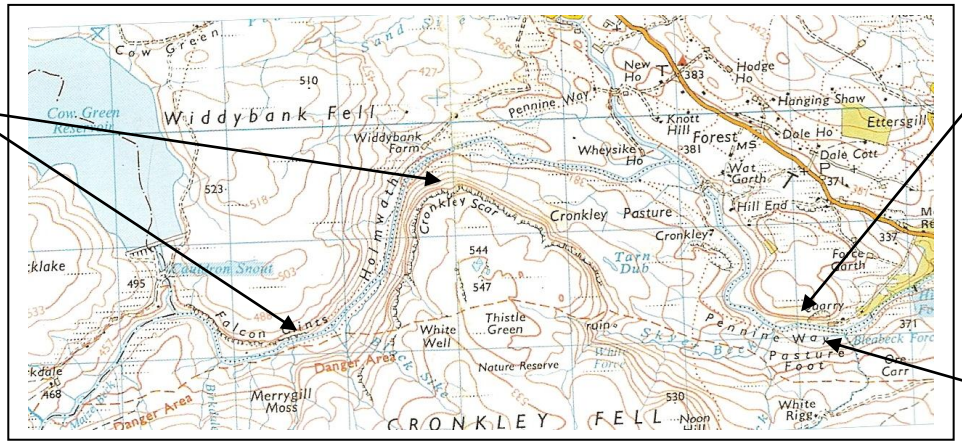


	Upper Course	Middle course	Lower course
Long Profile	Steep gradient	Gentle gradient	flat
Valley cross section			
Channel cross section			
Examples of features	V-shaped valley, waterfalls, rapids, gorges	Meanders, ox-bow lakes, floodplain, levee	Meanders, ox-bow lakes, levee, deltas

River Features on Maps

1. The upper course

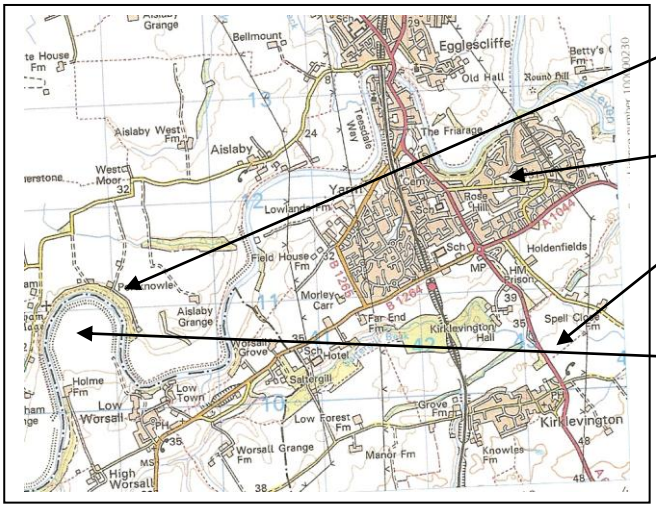
Contours slope down toward the river in a v-shape. This shows and interlocking spur.



Contours are close together, showing a steep sided valley.

The contours continue right to the river showing there is no floodplain (flat land next to the river).

2. The middle course



Meanders are evident in this part of the river.

Towns are often found in this section of the river

The contour lines are much further spaced out – showing a much flatter gradient.

The land close to the river has no contours – showing a flat floodplain.

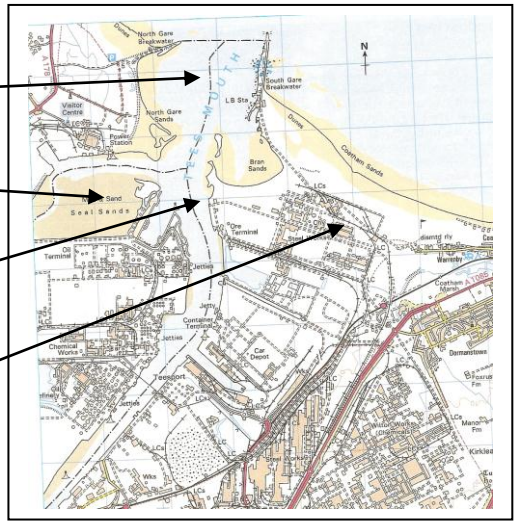
3. The lower course

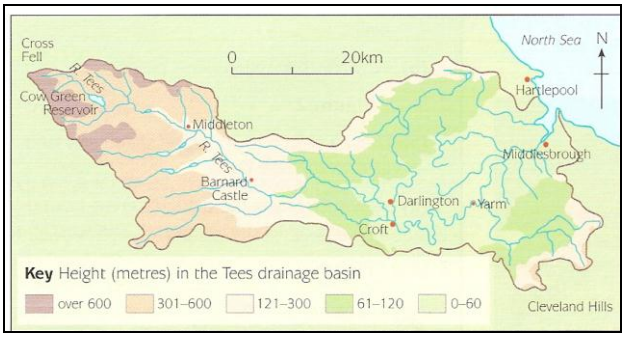
River is at its widest.

Deposition is evident, usually as mud flats or deltas.

The land has very few contours. It is very flat.

Heavy industry is often found at the lower course.





The River Tees

The drainage basin of the river Tees

Characteristics of the River Tees

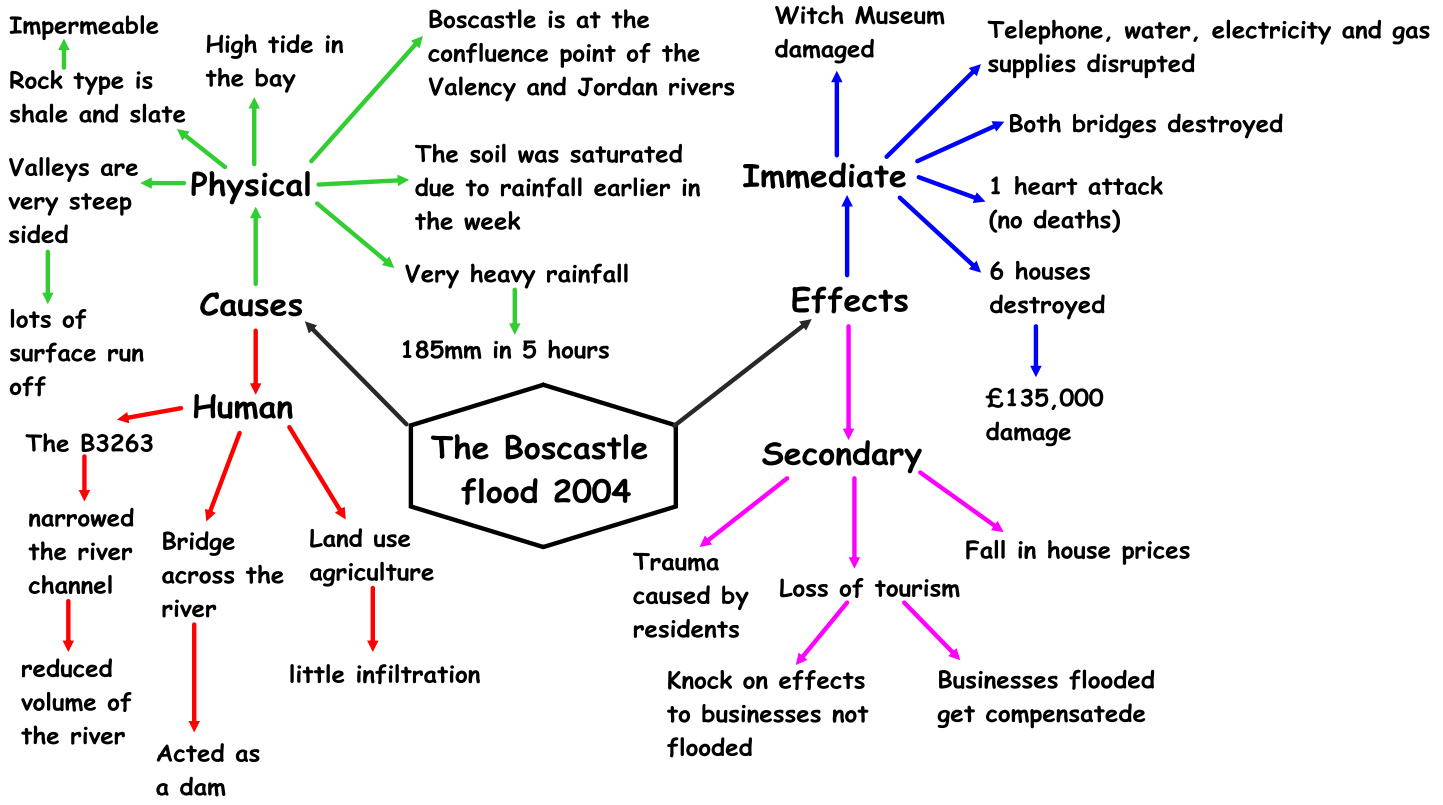
Location
- North-east England
- Middlesbrough
- Mouth in the North Sea
- River flows from west to east
- Source in the Pennines
  - Cross Fell
  - 893m above sea level
  - 2000mm rainfall per year

Upper Course
- High surface run off
- Large boulders
- Many rapids
- Steep v-shape valley
- Impermeable rock
- Steep gradient
- Hill sheep farming
- High Force waterfall
  - One of largest in England
  - Made up of Whinstone, with Sandstone below it
  - Gorge has formed
- Turbulent, clear water

Lower Course
- Widest channel
- Industry
  - Manufacturing
    - Imports
      - Coal
    - Exports
      - Shipping
- Large meander loops
- Teesmouth
  - Mud Flats
    - Alluvium
      - Smallest sediment
    - Wildlife
      - Seals
      - Migratory birds

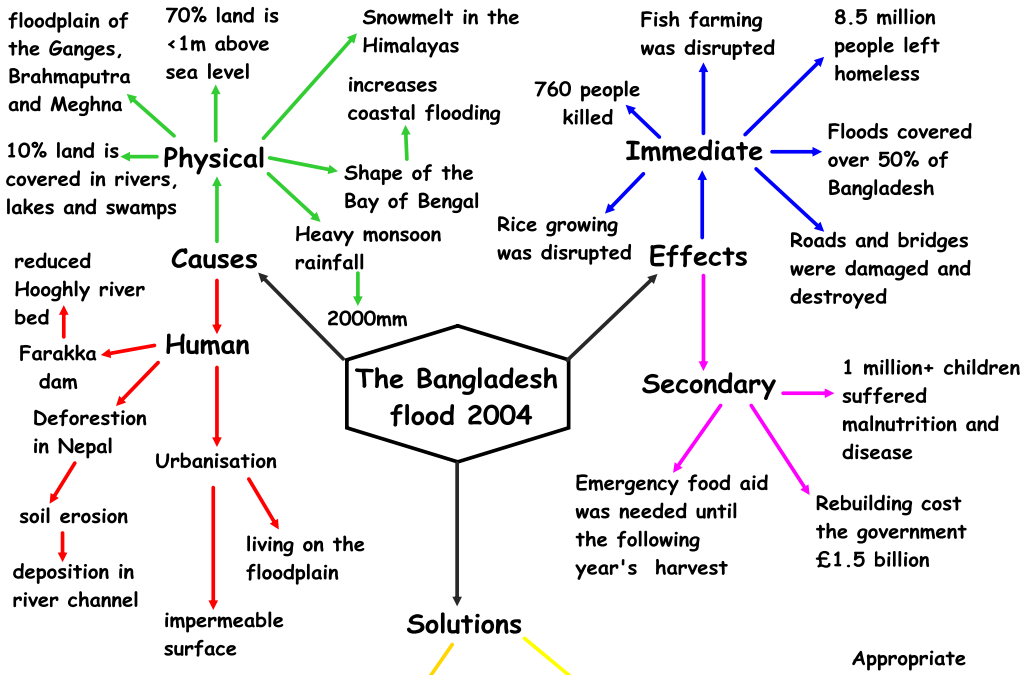
Middle Course
- Farming
- Bridging points
- Meanders
  - Smaller sediment
    - Smoother
    - Rounder
  - Stockton
  - Yarm
  - Meanders cut off in C19th for boats navigation

The Boscastle Flood, 16th August 2004

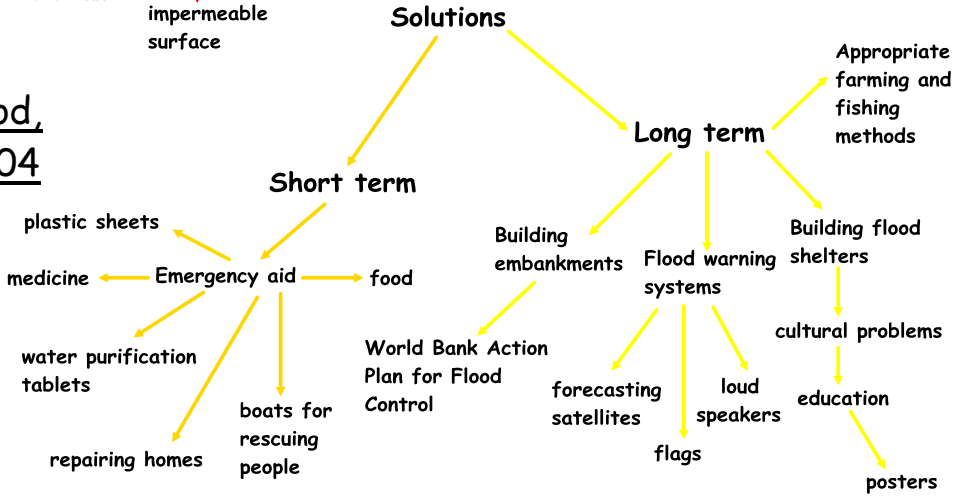


Responses:

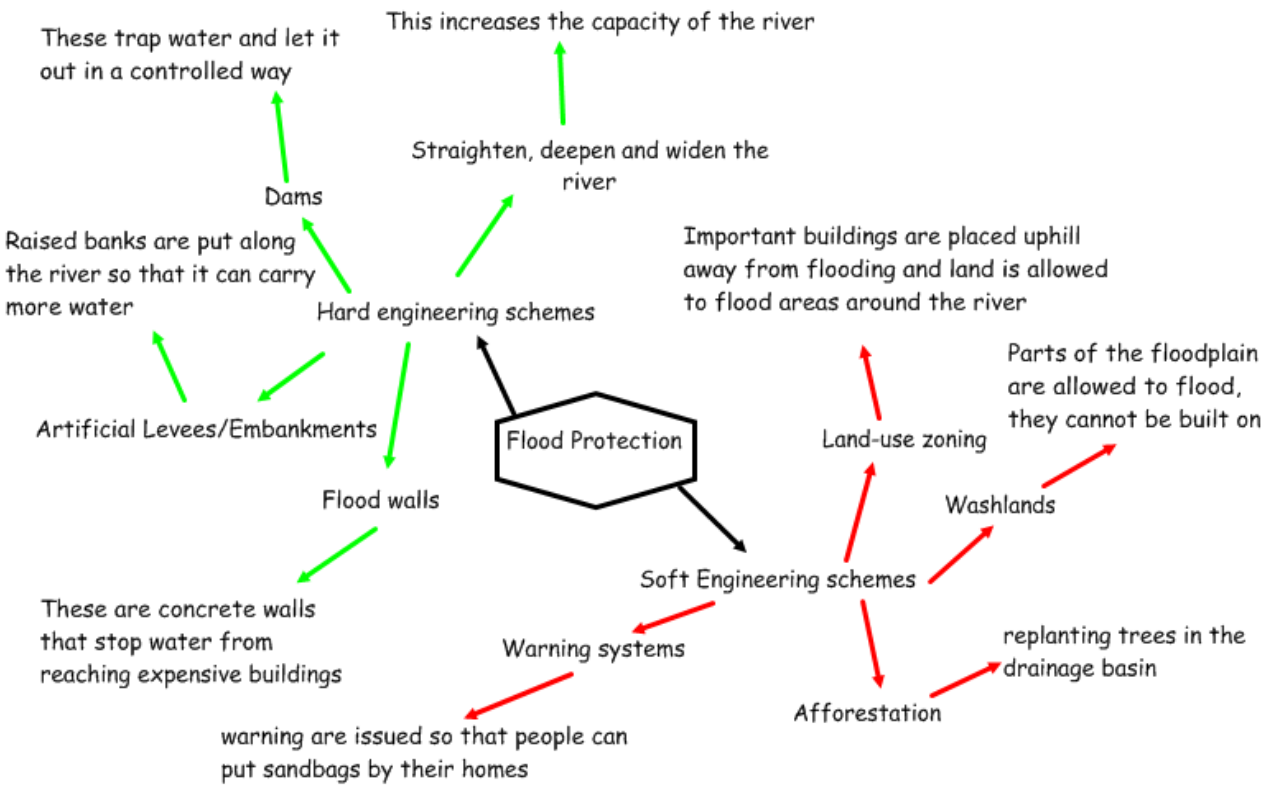
- New culvert was built
- Car park was raised and barriers put around it
- River was widened and deepened
- Bridges made taller
- Cost = £4.6 million



The Bangladesh Flood, July-September 2004



Managing Floods



MEDC Case Study: River Derwent

£7.5 million has been spent on protecting towns in the catchment area. They have used hard and soft methods to protect against future flooding.

Hard engineering:

- Embankments have been put along the river, these are now quite old and didn't protect against the floods in 1999
- Sluice gates upstream can hold back water and let it out in a controlled way.
- The area is quite rural so expensive schemes are not worth the money for the whole area.
- Flood gates have been put at Stamford Bridge to protect the road and homes
- Flood walls at Stamford Bridge have been built to protect homes and businesses.

Soft Engineering:

- Embankments have been built near settlements with washlands between the embankments and the river. Water can flood here without causing damage
- New building has been restricted on the floodplain
- Hedgerows and trees have been planted
- River banks have been reinforced with willow to stop bank erosion so that the river doesn't get silted up
- Early warning systems have been put in place

Hard Engineering scheme case study: Three Gorges Dam

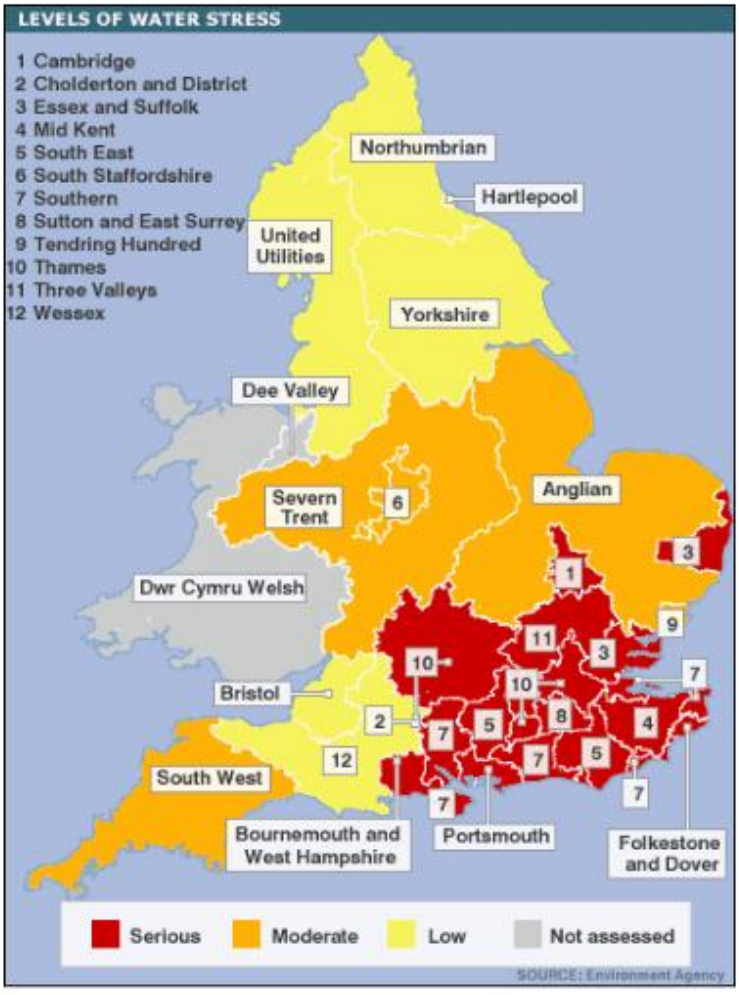
The Three Gorges Dam is built on the Yangtze River. The Dam is 181m high and 2.3km long. Construction started in 1994 and finished in 2006 and cost $25.5 billion. A reservoir has been created by the dam which is 632km^2.

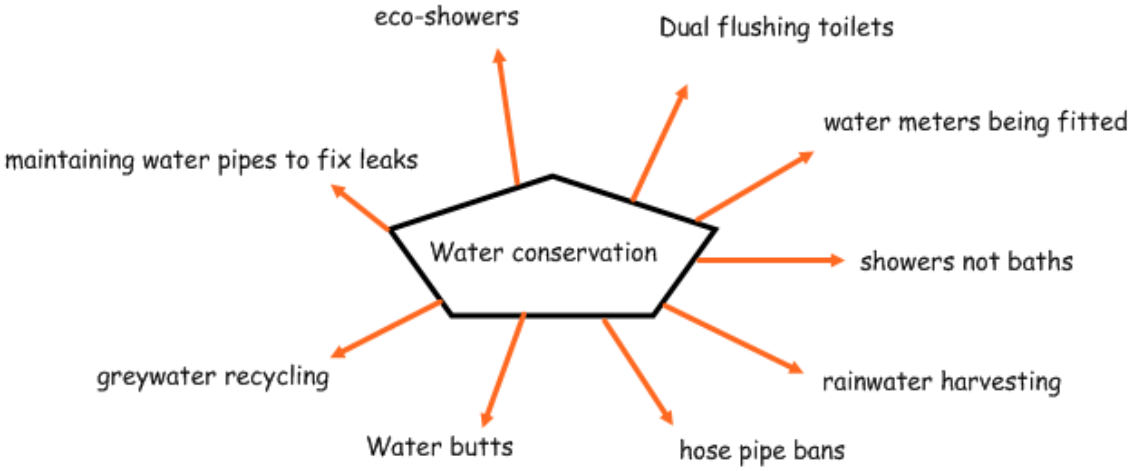
Advantages	Disadvantages
• Has provided flood control. The risk of flooding downstream went from a 1-in-10 year event to a 1-in-100 year event. • The dam will benefit over 15 million people living in high-risk flood areas, • The dam will protect over 25,000ha of farmland. • Improved navigation for ships and boats • Produces Hydroelectric power for homes, factories and businesses.	• Up to 200 million tonnes of soil is being deposited behind the dam every year which reduces the storage capacity of the reservoir • Water in the reservoir is becoming heavily polluted from shipping and waste discharged from cities • Toxic substances from factories, mines and waste tips submerged by the reservoir are being released into the water • 1.4 million people were forcibly moved from their homes to accommodate the dam, reservoir and power stations. • Corrupt local officials have taken over $30 million set aside for compensation for those being forced out of their homes

Water Stress and Demand

Key terms:

1. **Water stress** occurs when the amount of water available does not match the required demand. This may be due to an inadequate supply or may relate to water quality
2. **Areas of deficit** are locations where the rain that falls does not provide enough water on a permanent basis. Shortages may occur under certain conditions e.g. long periods without rain.
3. **Areas of surplus** are areas that have more water than is needed – often such areas receive a high rainfall total but have a relatively small population.





Water supply management: Kielder Water Reservoir

Kielder Water is in Northumberland and is the biggest man-made reservoir in northern Europe. It is 12km long and up 52m deep. It cost £167 million to build and was completed in 1982. It was built to meet an expected increase in water demand from north-east England because of the rising population there and the expected growth of the steel and chemical industries. However, these industries haven't grown as expected, in fact they've declined.

Kielder water is a water-transfer scheme – where water is transferred from one area to another. The water is released in the Rivers Tyne, Derwent, Wear and Tees. This helps to maintain river flows when levels are low. Extra water can be released for household and industrial use. Kielder water can provide up to 909 million litres of water a day.

Advantages	Disadvantages
• Kielder Water is a major tourist attraction. This has created jobs and benefited the local economy • The north-east now has the most reliable water supply in England • Only a few families have been moved and re-housed when the reservoir was built • The release of clean water into the Tyne has encouraged salmon and sea trout to migrate upriver to breed • Forest Park, surrounding Kielder Water is harvested for timber and employs about 200 people • If pollution occurs downstream, clean water can be released to dilute it and flush it out to sea. • The water is used to generate renewable HEP at the dam.	• One and a half million trees were cut down to build the reservoir