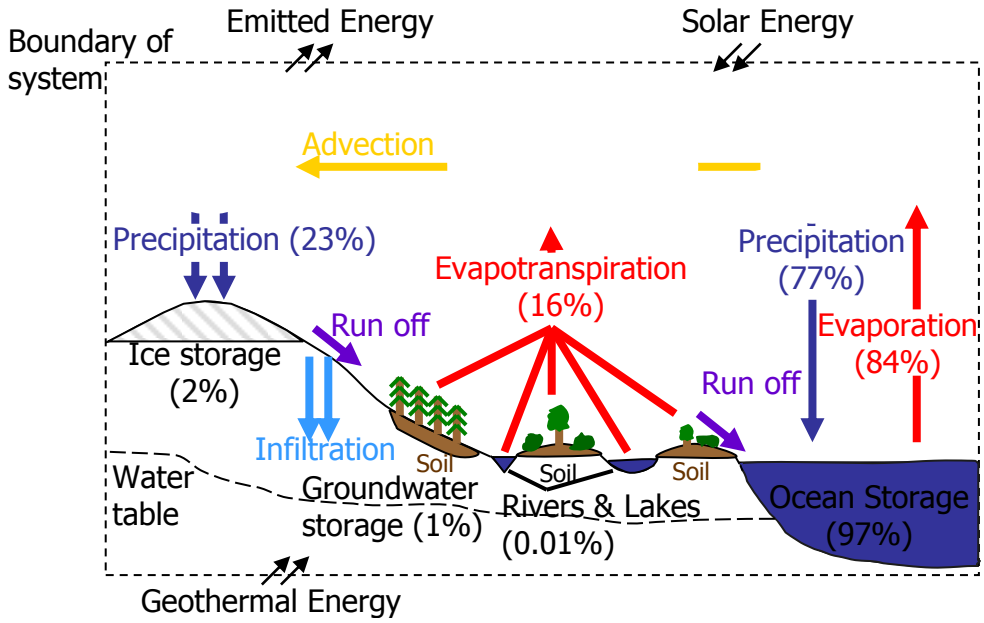
Hydrosphere – Course notes

You should be able to draw a diagram of the hydrological cycle and describe the main elements of the diagram.

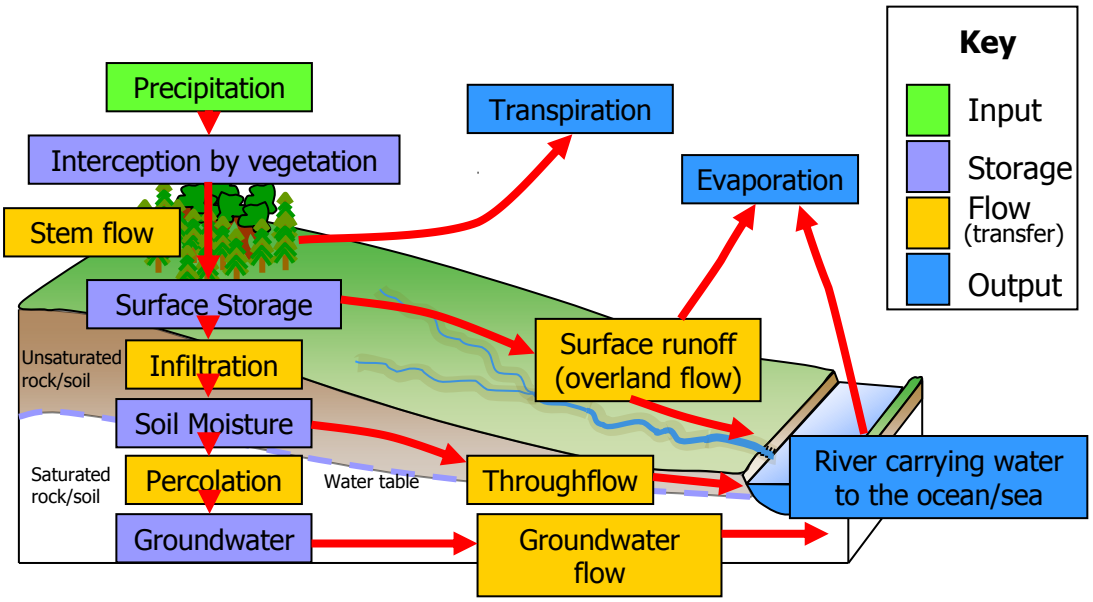
The Global Hydrological Cycle



The H.C. is a closed system in that the amount of water that is contained in the system remains constant. The system is powered by energy from the sun.

The Drainage Basin

Drainage basins are part of the global hydrological cycle.
A drainage basin is an area of land drained by a river and its tributaries.
Unlike the closed system of the hydrological cycle, the drainage basin system is open. It has inputs, stores, flows and outputs.
The boundary of a drainage basin is called a watershed. This is usually found on higher ground.



The definitions for all these words are on pages 47 and 48 of the Core Higher Geography text book.

The precipitation that falls in a drainage basin is sometimes intercepted by vegetation. If this happens then the rain water will take longer to reach the ground as it trickles and flows down the leaves and branches of the tree (stem flow). Once the rain water reaches the ground and it is **impermeable** then it will flow directly over the surface back into the river (run off).

There could be many reasons why the ground is impermeable, these could include it being made up of an impermeable rock (e.g. granite) or it may already be saturated with water, alternatively it may be covered with tarmac in a town or city. All these factors would encourage water to quickly run over the surface into the river and could increase the risk of flooding.

Rain water can soak into the ground if it is permeable. In this case water trickles down through the top soil (infiltration) and eventually back to the river as through flow. Sometimes water is held deep down in the bedrock and very slowly makes its way back to the river although this may take hundreds of years. This is called ground water. In such cases rivers which are fed mainly by through flow and ground flow have a far smaller risk of flooding as the water makes it way back to the river channel in a slow, gradual process.

The Work of Rivers

There are three main processes in the way that a river 'works'. These are:

1. Erosion

2. Transportation

3. Deposition

1. Erosion

The amount of erosion a river can achieve depends on its energy or discharge. A river's energy increases with its volume, velocity and regime (seasonal flow).

Erosion in a river is caused by 4 processes:

- **Attrition** – when boulders, rocks and pebbles crash in to each other and bits break off therefore being rounded and reduced in size.
- **Corrasion / Abrasion**– the wearing away of the river bed and the banks by the river's load. This is the main method of erosion.
- **Hydraulic Action** – the sheer force of the river breaks off particles from the river bed and banks.
- **Corrosion (Chemical Solution)** – dissolving of minerals from the rocks.

A river's valley is deepened by **vertical erosion** – entirely a river process.

A river's valley is widened by **lateral erosion** – affected by weathering on the valley sides and by the river on the river banks.

2. Transportation

A river transports its load in 4 ways:

- **Traction** – dragging of pebbles, gravel along its bed.
- **Saltation** – bouncing of the load.
- **Suspension** – light sediments of silt and clay are held in suspension by the river's turbulence (the greater the turbulence, the greater the size of particles which can be held).

- **Solution** – chemicals are dissolved in the water.

3. Deposition

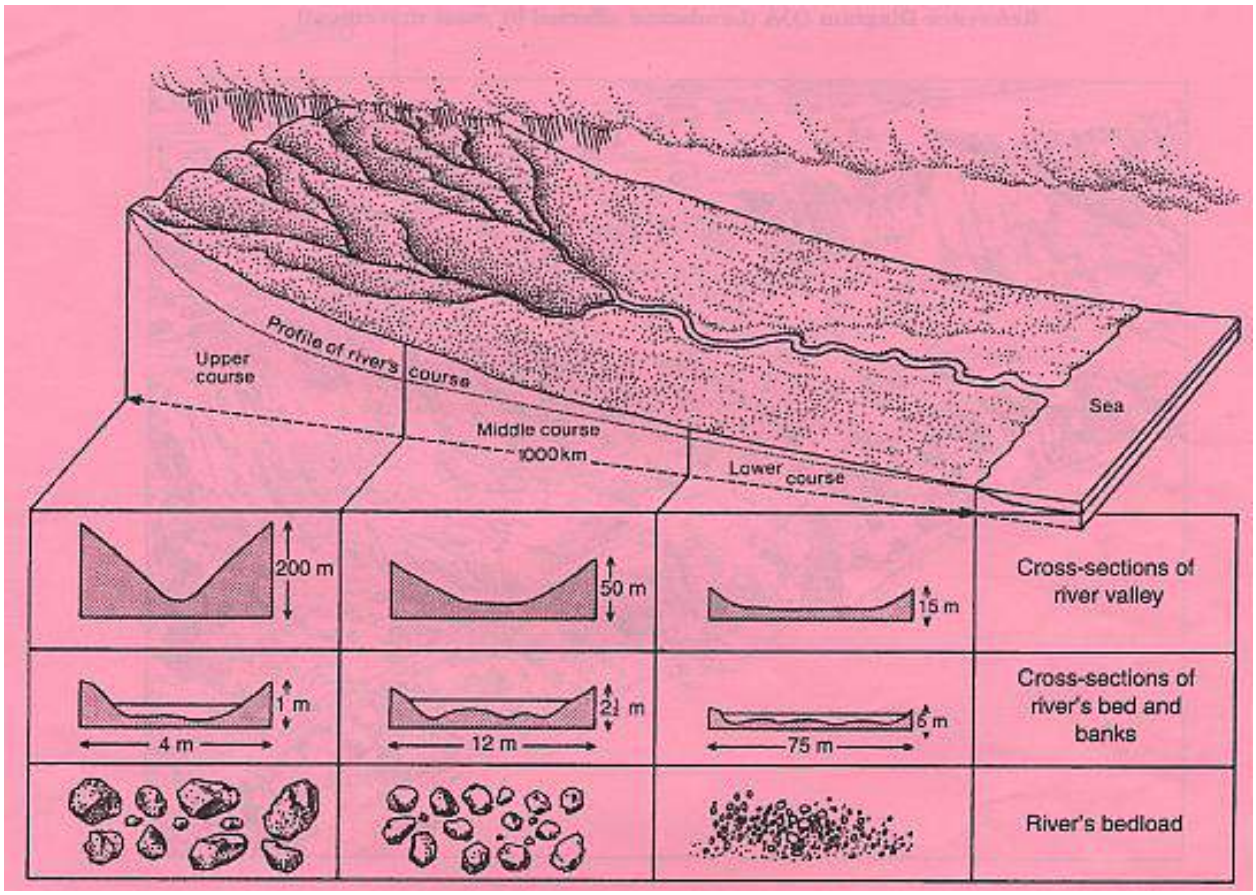
Sediments are transported by a river until it has insufficient energy to move them further and deposition takes place.

A river may lose its energy where:

- There is a decrease in gradient.
- There is widening or meandering of its channel.
- There is an increase in load.

A Typical River profile (SQA – exam paper)

You need to be able to explain the changes along the course of a river in



terms of these 3 main processes.

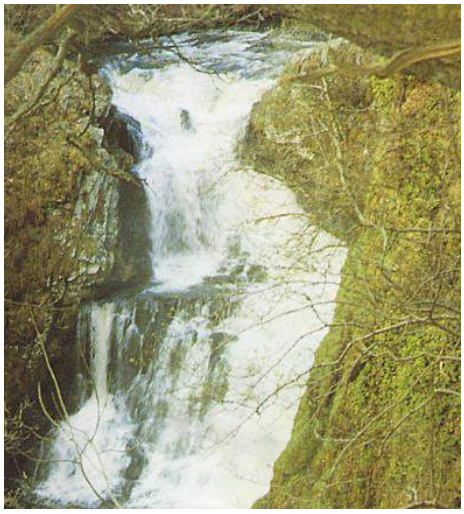
An 'ideal river' is divided into three sections – the Upper, Middle and Lower courses.

These courses all have characteristic features which form the river landscapes.

The Upper Course

Channel shape	The upper stretches of a river are rocky, often being covered with boulders of different shapes and sizes. The river channel is usually narrow and fairly straight.
Valley features	The valley is a V-shape in the upper course, meaning it is very narrow.
Main processes	As the river is fast flowing it has a high amount of energy to erode. This erosion usually happens vertically as the river bed cuts down into the valley floor. The main types of erosion operating in this stage of the river are hydraulic action and corrosion, due to the fast flowing nature of the water. Potholes form where pebbles and cobbles, rotated by swirling eddies, grind deep holes in the bedrock.
Gradient	The gradient is usually very steep in the early stages causing the river to be fast flowing. This encourages the main work of the river to be erosion.
Discharge	Under normal conditions the discharge is fairly low.
Rivers load	Boulders of varying shapes sizes occupy the river bed. Large stones and rocks travel down the river channel by traction and saltation.
Features you need to learn	Waterfalls, gorges, V-shape valleys, Interlocking Spurs, potholes.

Waterfalls

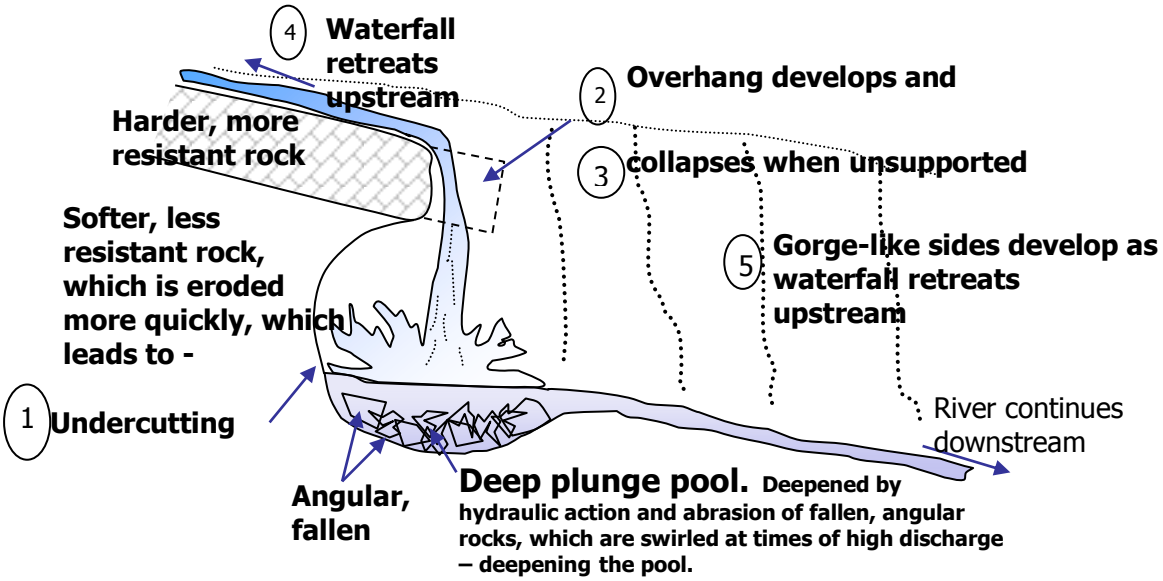


Usually found where there are differences in rock hardness. A fast flowing river has a large amount of energy to erode vertically. The soft rock is eroded faster than the hard rock, usually through the process of corrasion and hydraulic action, *(explain the meaning of these processes in an exam answer)* creating a step in the landscape.
Over time the river will undercut the hard rock creating an overhang. This overhang of hard rock is no longer supported and

eventually breaks off and collapses in to the river below. This hard rock is then swirled around at the base of the waterfall and helps to carve out a deep plunge pool. As this process repeats itself time and again the waterfall gradually retreats back up the valley leaving a steep sided gorge in its wake.

Corrieshalloch Gorge

(Source: www.panoramio.com/photos/original/1217468.jpg)



V-Shape Valleys

1. Vertical erosion (in the form of abrasion, hydraulic action and solution) in the river channel results in the formation of a steep sided valley.

2. Over time the sides of this valley are weakened by weathering processes and continued vertical erosion at the base of the valley.

3. Gradually mass movement of materials occurs down the valley sides, gradually creating the distinctive v-shape.

V-shape valley with interlocking spurs.
www.bws.wilts.sch.uk/.../Geog/geography.html

4. This material is then gradually transported away by the river when there is enough energy to do so.

(Source: http://geobytesgcse.blogspot.com)

Potholes

A pothole is formed in the river bed when boulders are too heavy to be carried along with the river therefore they just swirl, gradually drilling deep smooth sided potholes.

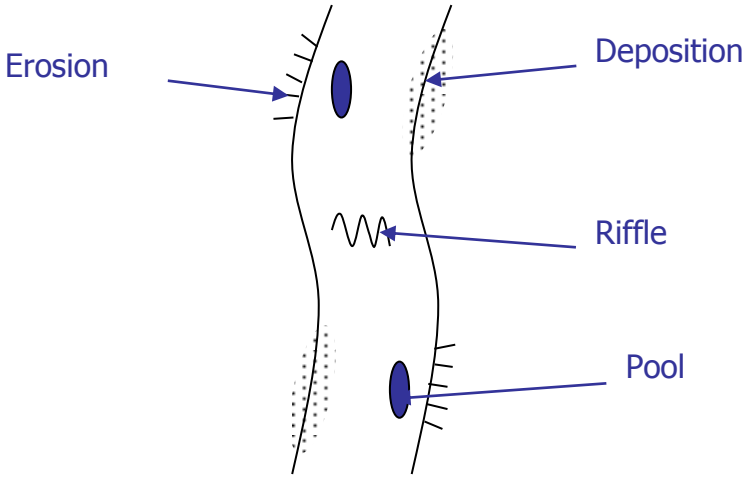
www.winona.edu/Geology/MRW/LateProterozoic.htm

The Middle Course

Channel shape	The channel is now wider and deeper and has smoother banks and floor.
Valley features	The valley sides are less steep and there is a more gentle gradient
Main processes	As the valley has flattened out the river starts to expend its energy horizontally rather than vertically. This **lateral *(side ways)* erosion** leads to the formation of meanders, which broaden the valley, and create floodplains.
Gradient	The gradient becomes less steepbut the river remains fast flowing as the it has a smoother channel to flow through. Erosion and deposition can now be found in the middle course. Erosion mainly takes place on the outside of meanders where the current is faster and the river has more energy. Deposition takes place on the inside of meanders where the current is slow flowing and therefore does not have the energy to carry it's load.
Discharge	The discharge of the river increases as more tributaries flow into the main channel.
Rivers load	Traction and saltation still play an important part in transporting the rivers load. However, more of the rivers load is ground down through attrition so that silt and clay sized particles are carried in suspension and are increasingly deposited.
Features you need to learn	Meanders.

Meanders

1. A pattern develops of alternating pools and rifles.
   - Pools = deeper stret6ches of slow moving water.



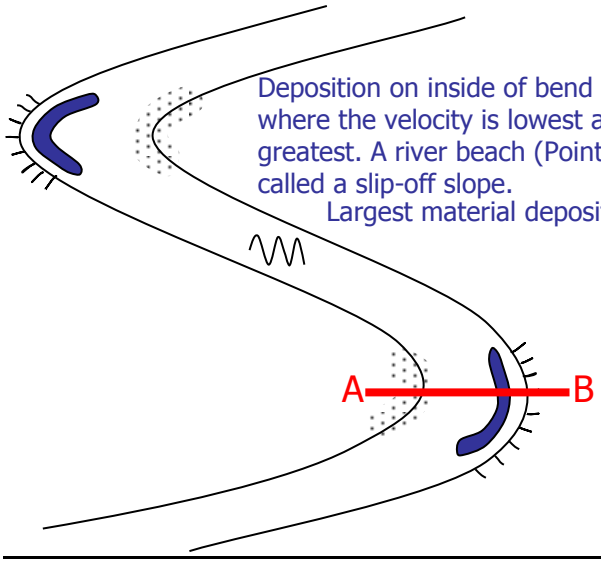
- Rifles = shallower sections of faster water

2. This causes the water to develop a side to side swing.

3. The process is assisted by erosion and deposition.

4. In the pools the river currents start undercutting the river cliffs. This happens on the outside of the river bend where velocity is fastest.

On the other side where the current is weakest deposition takes place to form a river beach or point bar.

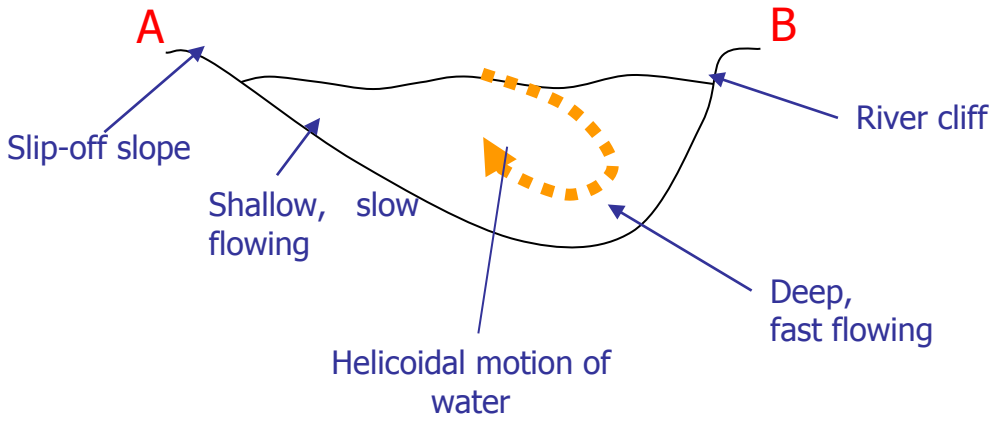


Deposition on inside of bend (convex bend) where the velocity is lowest and friction is greatest. A river beach (Point-bar) forms also called a slip-off slope.
Largest material deposited on upstream side.

Erosion on outside of bend (concave bank) by hydraulic action and corrasion. This is where velocity is greatest and friction is minimal. River cliff develops.

5. Meander formation is assisted by helicoidal flow of water. This is a corkscrew like movement. This causes the meander to migrate down stream.

- **Cross Section A - B**



Erosion on concave bank – river cliff develops

Deposition on convex bank – slip-off slope develops

The Lower Course

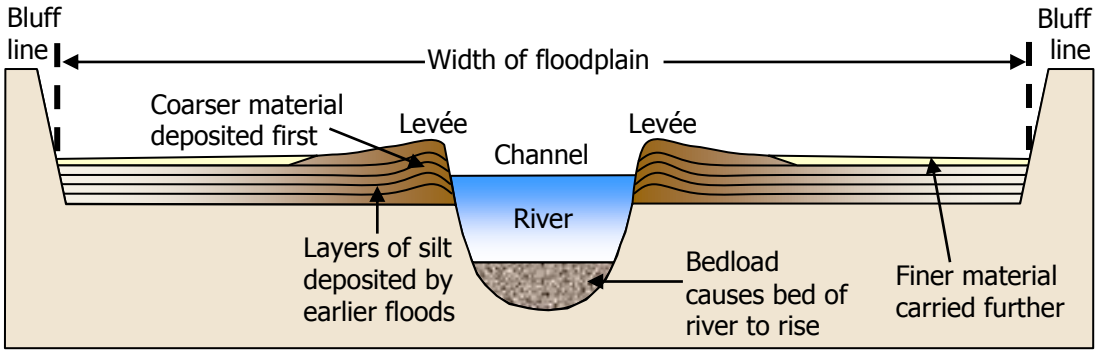
Channel shape	The channel is now at its broadest and deepest.
Valley features	Due to lateral erosion valley sides may be several kilometres away. The valley is dominated by wide floodplains.
Main processes	Deposition is now the dominant process particularly during floods when the rivers load is spread out over the valley floor.
Gradient	The gradient is now very gentle and in some cases may appear totally flat. This encourages deposition to take place.
Discharge	The discharge of the river is at its greatest as large volumes of water pour out into the sea.

Rivers load	The river's load is carried entirely in suspension and solution consisting mainly of fine sediments.
Features you need to learn	Floodplains, levees, braiding, ox-bow lakes, deltas, river terraces (rejuvenation).

Floodplains and Levees

- Over many years, the river has covered the valley floor with enormous quantities of alluvium (sedimentary deposits). It was deposited by migrating meanders and floodwater. Across the resulting level floodplain, variations in relief are very slight so that any rapid increase in discharge almost inevitably results in flooding.

- When a river floods, the floodwater's speed reduces most quickly at the sides of the channel. Consequently coarser alluvial



sediments are deposited at the channel edge, gradually building up into natural ridges or levees. Occasionally levees act as natural embankments and often they have been strengthened by man as a part of flood prevention measures.

Braiding

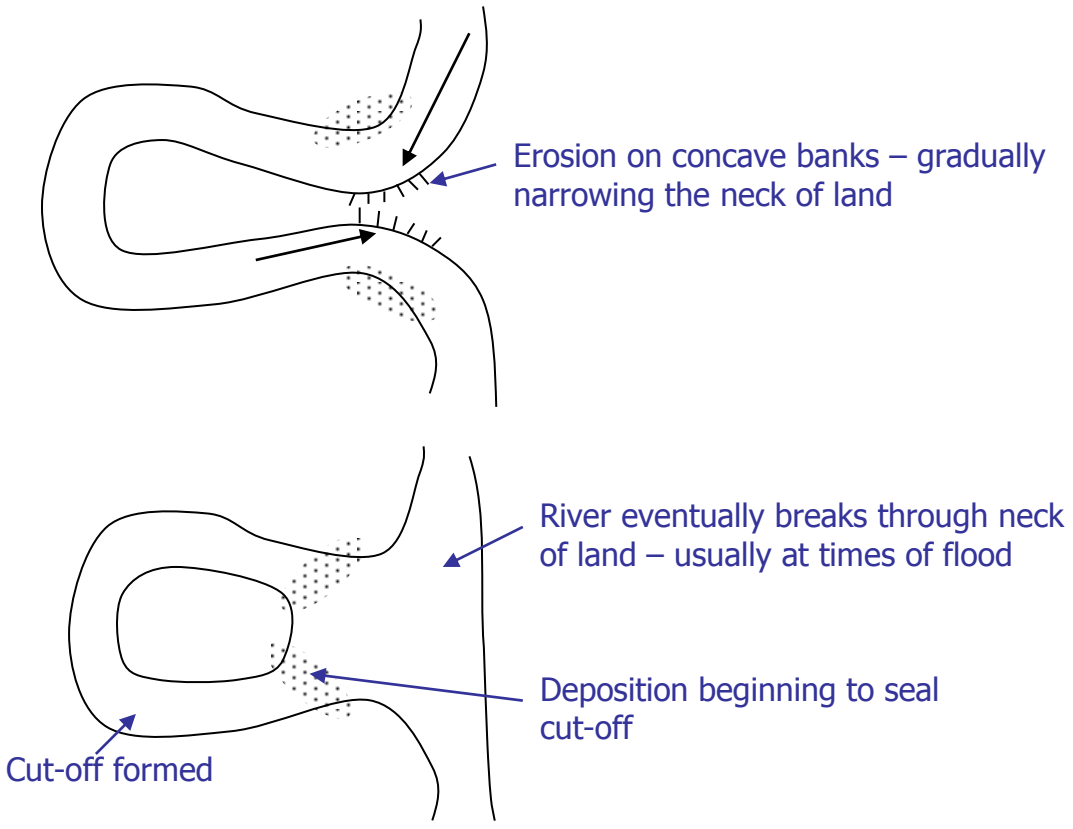
- For short periods of the year, some rivers carry a very high load in relation to their velocity. When a river's velocity falls rapidly, the channel may become choked with material, causing the river to braid i.e. the channel splits up into several smaller channels which flow around fresh 'islands' of deposited material before rejoining and further dividing.

Ox-bow Lake

In an exam when explaining how ox-bow lakes are formed it is important to first explain how meanders develop in a river.

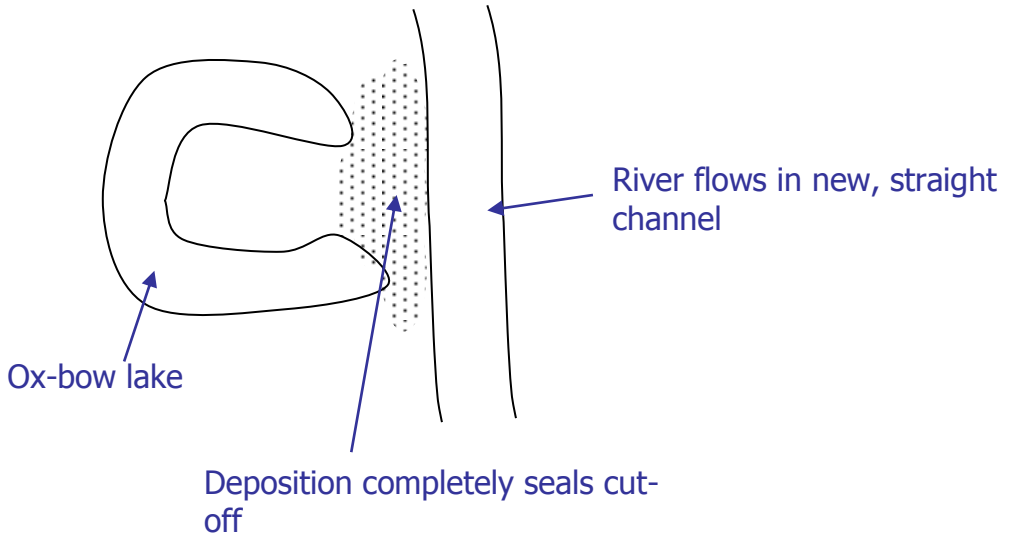
- As can be seen in the diagrams below the neck of the meander becomes narrower.
- During flood conditions the river breaks through the neck of the meander.

- The fastest flowing current is now flowing in a straight line.
- The water in the meander rapidly loses energy and therefore deposits material, this seals off the meander from the main channel.



- The ox-bow lake ma

y eventually dry up.



Estuaries and Deltas

- When a river enters a loch or the sea velocity is reduced and load is deposited.

- Where the river's mouth broadens to form an estuary, tidal currents are able to scour out most of the sediments, transferring them to the sea's transportation system. The sediment that is not removed from the estuary forms extensive sand and mud banks, often colonised by salt-tolerant vegetation and exposed at low tide.

- Deltas are essentially the seaward extension of the floodplain and form when tides are weak. They also grow where streams enter freshwater lochs.

Distributaries are the small streams which have formed due to braiding in the river channel.


Source: Wikipedia

Terraces

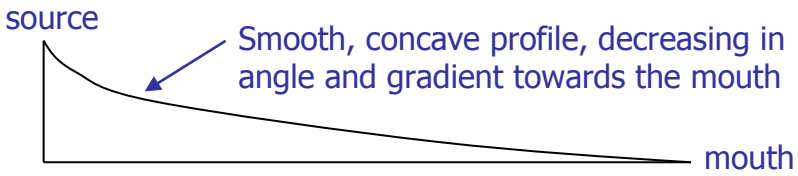
- A river terrace is a remnant of a former floodplain, which after

rejuvenation has been left at a higher level.

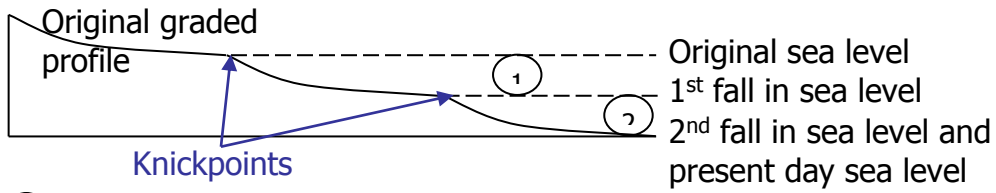
- Rejuvenation is where a fall in sea level relative to the land or rise in land relative to the sea enables a river to revive its erosional activity.

- After the ice age when all the ice had melted from the land there was less weight pressing down on countries. The land rose up from the sea which meant rivers had to erode further down into the landscape to reach sea level (as rivers can not flow up hill.) Once the river has eroded down to sea level a new flood plain is created. The old flood plain is left sitting up above new floodplain and further back from the river channel. The point of change to the existing profile is known as the knick point.

Graded profile of a river



Effect of rejuvenation on the long profile

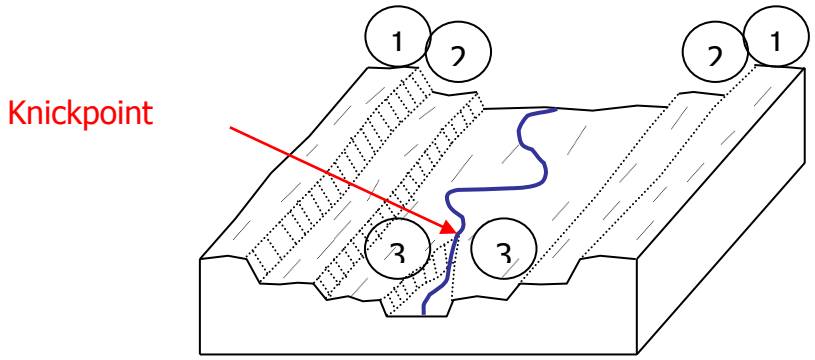


1 1st regraded profile

2 Most recent regraded profile

- If a river is rejuvenated, the downcutting (vertical erosion) of the river produces terraces.

- These are paired i.e. the height of the terraces on one side of the river will correspond with the heights of the terraces on the other side.



O.S Map work

- In the hydrosphere question it is possible that you will be given a question relating to the Ordnance Survey map. The most typical type of question is

"Using appropriate grid references describe the **physical characteristics** of the river …… **and** its valley from GR… to GR…."

- The following should be taken into account when describing the river and its valley.

River	Valley
Direction of flow	Degree of straightness
Width	Height and Steepness of valley sides
Tributaries	Width and gradient of valley floor
Meandering / Straight	Features e.g. glacial, upland course
Features? E.g. waterfalls ox-bow lakes	

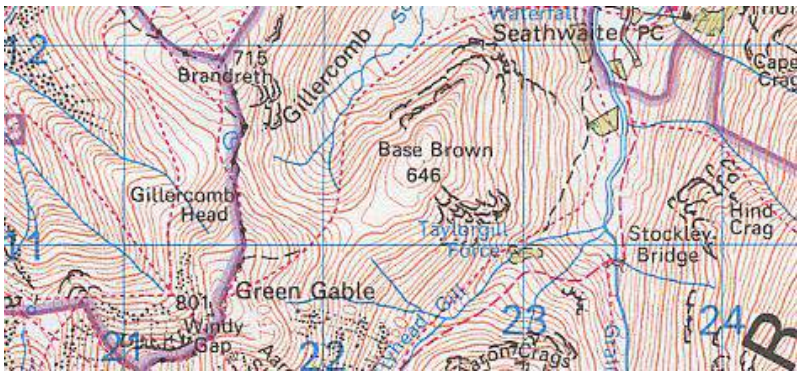
Example:

Recognising features on an O.S map:

The following is an example of an answer. The map is divided into a number of sections, however, if you would prefer to follow the whole map, you should be able to borrow the map from the Geography department. The map is the Thirlmere map.

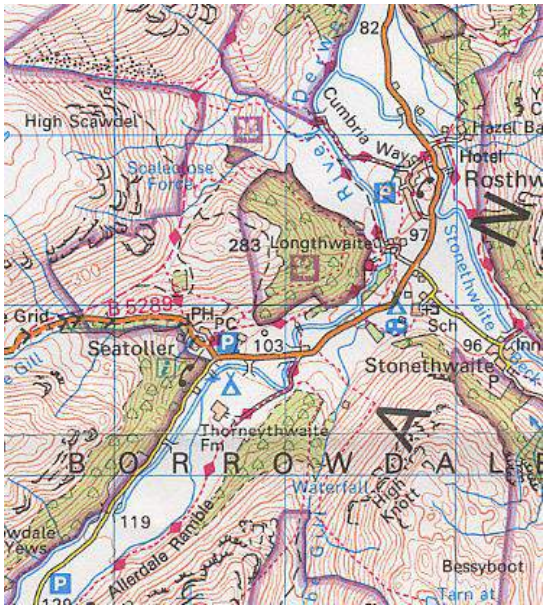
- **The question is -**

"Using appropriate grid references, describe the physical characteristics of the River Derwent and its valley from 235109 (Stockley Bridge) to 263193 (its entrance to Derwent Water)."



The river flows in a general South to North Direction. At 235111, just North of Stockley Bridge, three streams meet to form the main River Derwent. This increases the volume of water in the river and the river increases in width. The river is flowing relatively straight in a narrow valley, between steep slopes and falls from 170m to 140m. At 234120 the river enters the floor of a U-shaped valley.

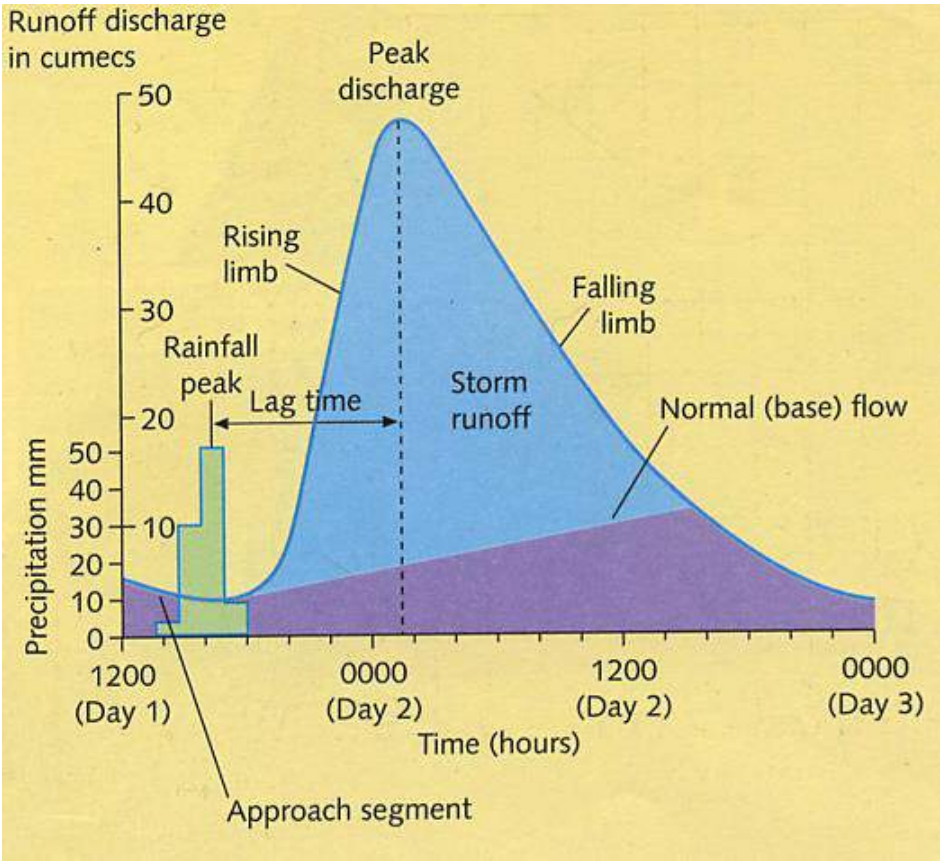
Here, the river flows along the West side of the valley in almost a straight line hugging the base of the valley side. A number of tributaries flow down and join the river on the eastern bank in G.S. 2312. At 246136 the river begins to meander and continues to do so until its confluence with the Stonethwaite Beck at 253154. During this stage, the valley varies in width from 0.2km to 1km wide in G.S.'s 2514 and 2515 where both those rivers occupy the valley.



Unusually, the river valley then narrows through Borrowdale. Here the river appears to be flowing through a gorge with steep sides. The river has no floodplain at this point. At 253174, the river emerges from the gorge and again meanders across a wide floodplain (1km). The river enters Derwent Water at 263193. Here the river is forming a delta (arcuate), extending the land into the lake. This land is marshy.

River Hydrographs

- A hydrograph is a record of channel flow in a stream or river.
- It shows variations in discharge with time.



A Hydrograph has a number of main characteristics:

- Precipitation – shown as a bar graph but sometimes not always shown
- Base Flow – flow supplied by groundwater. This is a slow movement therefore base flow rises slower and later.
- Quickflow/Storm Flow – flow supplied by overland flow and soil throughflow. This gives the peak flows.
- Rising Limb – includes (a) rainwater that fell into stream
  (b) water flowing overland and into stream channels as the soil water becomes saturated.
  (a) & (b) lead to peak discharge.
- Lag Time – the time it takes from peak rainfall to peak discharge.

The shape of the rising limb depends on:

- The length of the rainstorm – a long period of rainfall causes rise in the water table and increased overland flow.
- The intensity of rainfall –
  If heavy – considerable quick flow if the soil is incapable of soaking it in and storing it a steep rising limb.
  If light – less steep rise and flatter shape since rain is easier to store.

- The condition of the soil – If the soil is already saturated more water flows overland into streams and this leads to a higher and earlier peak.

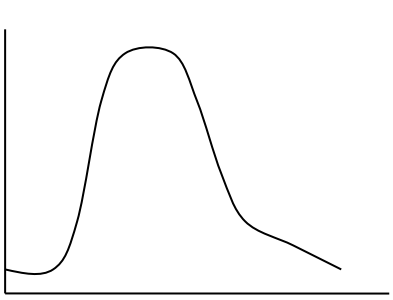
- Shape of the drainage basin - a long narrow basin with tributaries joining the main channel at regular intervals gives a less steep rise.
  - a wide basin with tributaries more closely spaced gives a steep rise.

Lag Time – the difference in time between peak rainfall and the peak discharge. Lag time depends on:

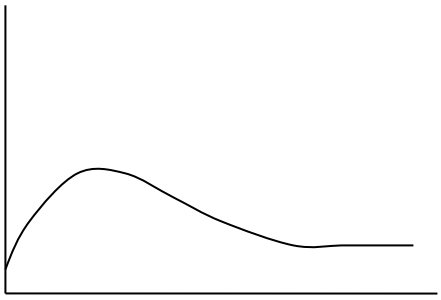
- The condition of the soil – if the soil is fairly dry, the longer the lag time since rainfall can be stored at first before the excess flows to the channels.
- Angle of slopes – the more gentle the slope the longer the lag time compared to steep slopes.
- Intensity of rainfall – prolonged, steady rainfall has a longer lag time than intense rainfall.
- Size of drainage basin – small basins have a small lag time; larger basins with more tributaries have a longer lag because the tributaries act as temporary storage before run-off increases rapidly.

Recessional/Falling Limb – shows the speed at which the drainage of the rivers return to normal (base flow) once the storm has passed. The water level falls off as the effects of the storm die away.

Example – explaining the shape of the two graphs



Graph A



Graph B

A	B
Steep slopes No Trees Impermeable rocks Urbanised Intense thunderstorm	Gentle slopes Forested Permeable rocks Fields Light steady rain

Exam questions

One type of question that can arise about hydrographs is a comparison between different hydrographs.

- When answering these types of questions you must not only describe the features of the hydrographs, but explain why the hydrographs have certain shapes. It is likely that you will be given a diagram or information to help and you should think about what effects on the hydrograph the following have:
  - Size of the drainage basin
  - Steepness of the slopes
  - Rock or soil type (Permeable or Impermeable?)
  - Stream density
  - Vegetation