2.2 RIVERS

Hydrological cycle

Stores: Those places where water is held for a period of time.

- Interception
- Water in the atmosphere (water vapour / water droplets in clouds)
- Surface stores (puddles, lakes, rivers, reservoirs)
- Aquifers (permeable rocks which can hold water)
- Ice & snow
- Seas & oceans

Flows: The ways in which water is moved around the hydrological cycle.

- Evaporation
- Condensation
- Transpiration/Evapotranspiration
- Precipitation
- Overland flow
- Infiltration
- Percolation
- Throughflow
- Groundwater flow

Interception: How precipitation is prevented from reaching the ground, usually by being caught on leaves or branches.

- **Why amount of interception varies from place to place**
  Different amounts/types of plants/vegetation/trees
- **Why amount of interception varies in different times of the year**
  Many plants/vegetation/trees will not have leaves all year

Transpiration: The changing of water to water vapour by plants.
Evapotranspiration: The combined transfer of water vapour from the earth's surface, and from plants.

Precipitation: The transfer of water from the atmosphere to the earth's surface in the form of hail, snow or rain.

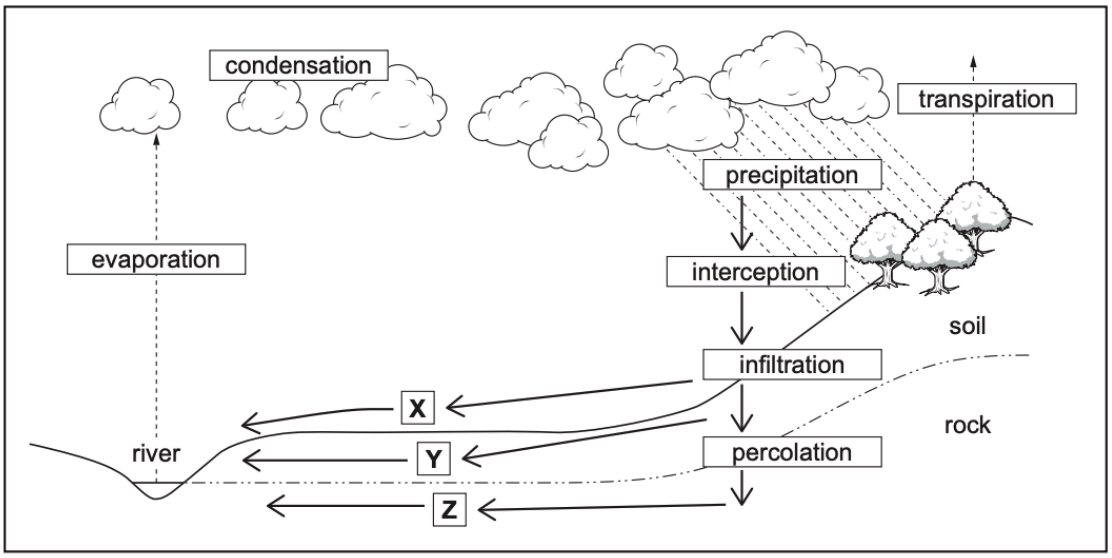
Overland flow/surface runoff: When water flows over the earth's surface.

- **Why overland flow may occur in a drainage basin**
    - Precipitation exceeds infiltration

- Heavy rainfall
- Saturation of rock/soil
- Melting snow/ice
- Water within the rock/soil could be frozen
- After deforestation
- When an area is covered by concrete/tarmac

- **Why amount of overland flow in drainage basin varies from place to place**
  - Angle of slope
  - Rock type
  - Thickness/type of soil
  - Vegetation cover
  - Land use will vary
  - Precipitation will vary
- **Why amount of overland flow in drainage basin varies from season to season**
  - Amounts of precipitation/rainfall will vary
  - Temperature will vary // evaporation
  - In some seasons, there is snow melt
  - Amount/density of vegetation will vary // transpiration

Infiltration: Occurs when water soaks into the soil, from the earth's surface.
Percolation: Transfer of water down into the rocks & aquifers
Throughflow: Water flows through the soil (to reach the river).
Groundwater flow: Water flows through rock (to reach the river).



X = Overland flow/surface runoff
Y = Throughflow
Z = Ground(water) flow/base flow

Drainage basin

An area of land drained by a river (and its tributaries) // the catchment area of a river // the area within the watershed of a river.

Features of a drainage basin

Watershed: Area of highland surrounding a drainage basin/between two drainage basins // the area which separates drainage basins from each other.
Source: The point furthest from the mouth, where the river starts.
Confluence: The place where 2 or more rivers/streams meet.
Tributary: A river/stream which joins/flows into into the main/larger river.
Mouth: Where the river enters the sea/ocean/sometimes a lake.

Factors affecting amount of discharge in a drainage basin

River discharge: the amount of water flowing in a river
Formula to calculate river discharge = width × depth × speed of flow

1. **Physical characteristics of basin**
    - Size: larger basins take longer to flood, so decreased discharge.
    - Shape: circular basins flood faster, so increased discharge.
    - Elevation/steepness: steep drainage basin has increased discharge.
    - Soil type: sandy soils have higher infiltration rate, so decreased discharge.
    - Rock type: porous rocks (contains holes) & pervious rocks (contains cracks) cause decreased discharge.
    - Vegetation: Vegetation increases interception, so decreased discharge.

2. **Meteorological factors**
    - Rainfall: heavy & intense rainfall/ longer periods of rainfall result in surface runoff, therefore increased discharge.
    - Temperature/rate of evapotranspiration: high evapotranspiration = decreased discharge.

3. **Human factors**
    - Deforestation & urbanisation (increased use of concrete/tarmac/drains): reduces infiltration & increases surface runoff, so increased discharge.
    - Extraction of water for domestic/industrial purposes: decreased discharge.

Why river flow varies during the year

- Variation in amount of precipitation/in one season there is lots of rain
- Variation in intensity of precipitation
- Heavier/more intense precipitation lead to more surface runoff

- Variation in temperature
- Different amount of moisture lost to evapotranspiration/transpiration/evaporation in different seasons
- Degree to which ground is saturated
- Glaciers/ice/snow melt could cause higher levels in Spring
- More extraction of water in summer

River processes

Erosion

Wearing away/breaking away of material by the river

Vertical erosion	**Lateral erosion**
Dominant in the upper course.	Dominant in middle & lower course.
It increases depth of river & valley, as it erodes downwards.	It increases width of river & valley, as it erodes sideways.

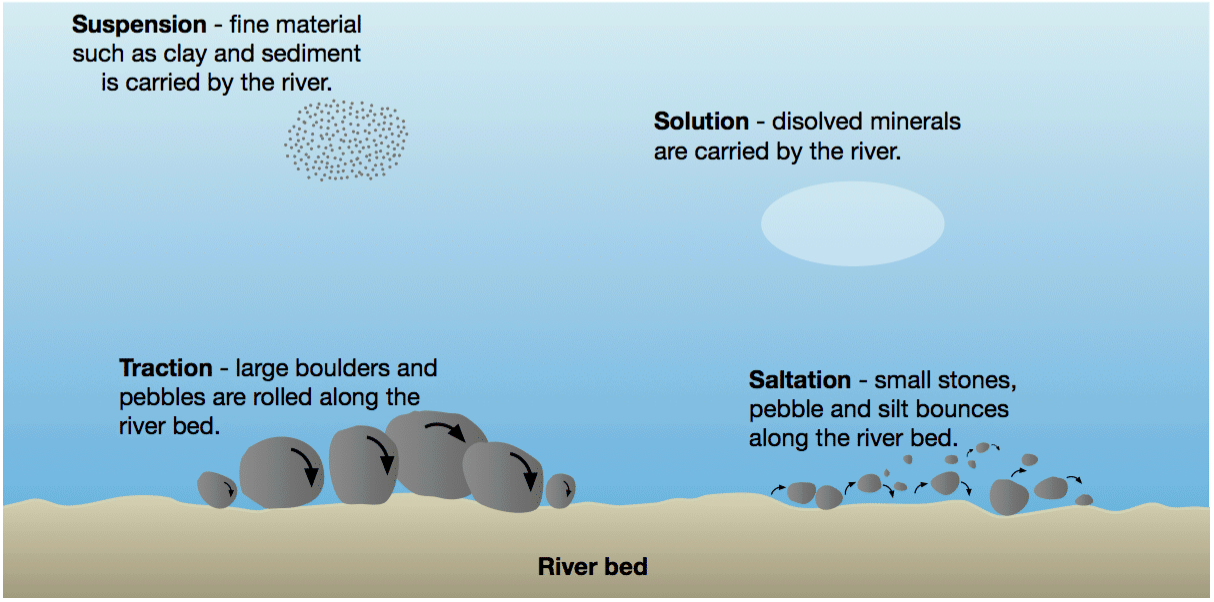
How erosion takes place along a river

- Hydraulic action: Power of water wears away bed and banks, releasing air compressed/pressurised in cracks
- Abrasion/corrasion: Loose material carried by river grinds the bed & banks; sandpaper action
- Corrosion/solution: Rocks like limestone dissolved by chemicals/acids in river water
- Attrition: Load reduced in size as they hit each other when being carried by river
- Vertical erosion in the hills/ near the source
- Lateral erosion near the mouth
- Erosion on the outside of meanders

Factors affecting erosion

- Load: heavier & sharper load = increased erosion rate
- Velocity & discharge: higher velocity & discharge = increased erosion rate
- Gradient: higher gradient = increased rate of erosion
- Geology: soft/unconsolidated rocks (sand/gravel) easily eroded
- pH: when water is acidic/low pH = increased erosion rate
- Human impact: deforestation/dams/bridges interfere with natural flow of river = increased rate of erosion

Transport



How rivers transport their load

- Traction: Large boulders moved/rolled along the riverbed
- Saltation: Stones bounce along the river bed
- Suspension: Light materials are carried/held up in the water
- Solution: Material dissolved in the water
- Flotation: Leaves & twigs are carried on the surface of the river

Deposition

When a river does not have enough energy to carry materials it drops them.

- Heaviest material is deposited first = bedload
- Lighter materials: gravel, sand, silt carried further downstream = alluvium
- Dissolved materials carried out to sea

Causes of reduced energy

- Reduced discharge due to a lack of precipitation / abstraction upstream
- Decreased gradient
- Slower flow on the inside of a river bend / where the river is shallower
- When the river enters sea/ocean/lake

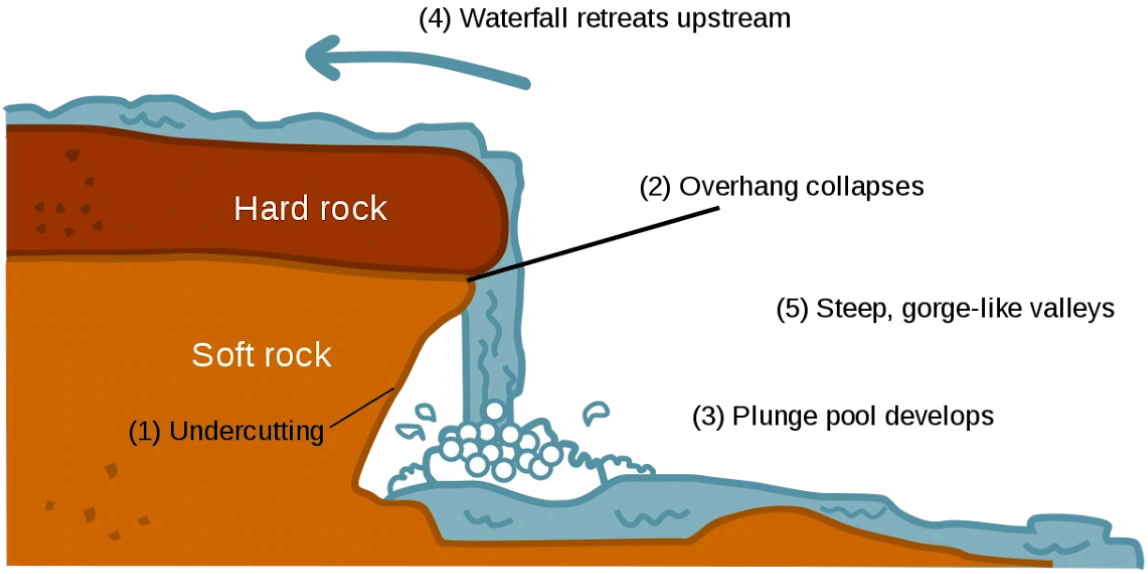
Features of erosion & deposition

Waterfall

Formation

- Erosion by river, by abrasion/hydraulic action
- Hard rock overlies softer rock / soft rock underlies hard rock
- Hard rock resists erosion / softer rock is eroded rapidly

- Undercutting of soft rock
- Overhang develops
- Overhang (hard rock) collapses
- Plunge pool formed
- Gorge formed
- Retreat of waterfall / process repeats



How waterfall may change in future due to natural processes

- Further or more erosion/undercutting
- Collage of more rock
- Waterfall retreats
- Formation/extension of gorge
- Plunge pool gets bigger/deeper

Features of waterfalls

- Vertical/steep/high drop/cliff
- Layers of rock/ rocky
- Stepped/ ledges
- White water
- Plunge pool

Meander

Explain why both erosion and deposition are likely to occur on meander

- Different speeds of flow within channel/river
- Fast flow on outer bend
- Where water is deeper
- So erosion/undercutting occurs on outer bend; river cliff formed on outer bend

- By hydraulic action/abrasion
- Slow flow on inner bend
- Where there is more friction
- Results in deposition/river unable to carry load; slip off slope formed in inner bend
- Helicoidal flow: Helicoidal flow is the cork-screw-like flow of water in a meander

How slip-off slope is formed

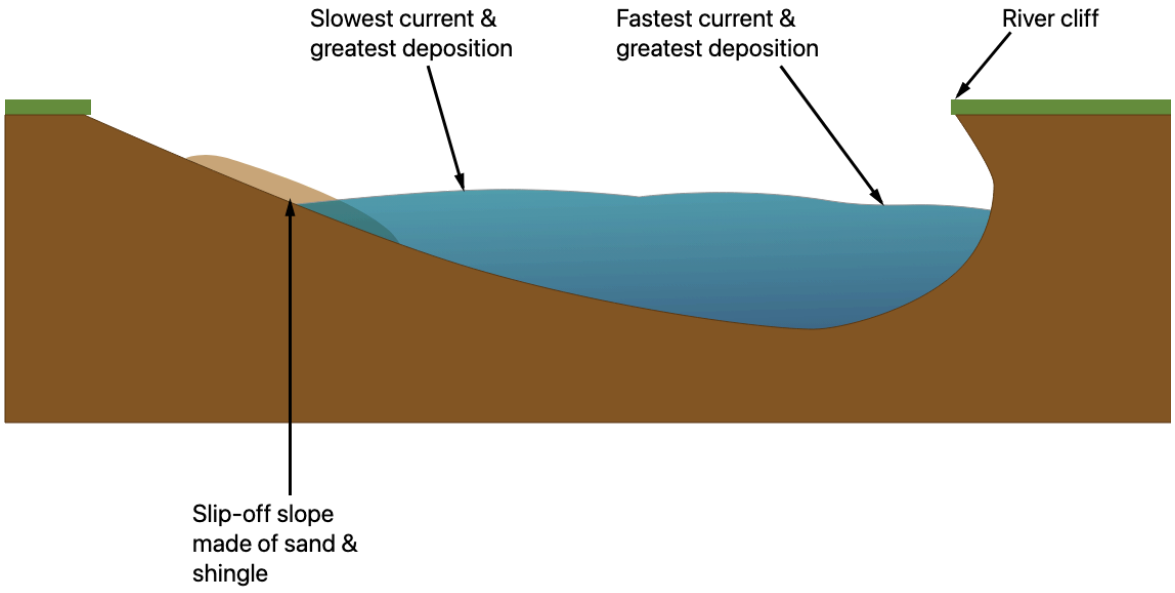
- Speed of flow is slow/reduced/less energy
- Deposition of materials
- Insufficient energy to move them
- Accumulation over time

Characteristics of slip-off slope

- It is flat/gently sloping
- It is made from fine materials/ small stones/mud/sediment/soil
- It is just above the level of the river
- It is on the inside bend

How river cliff is formed

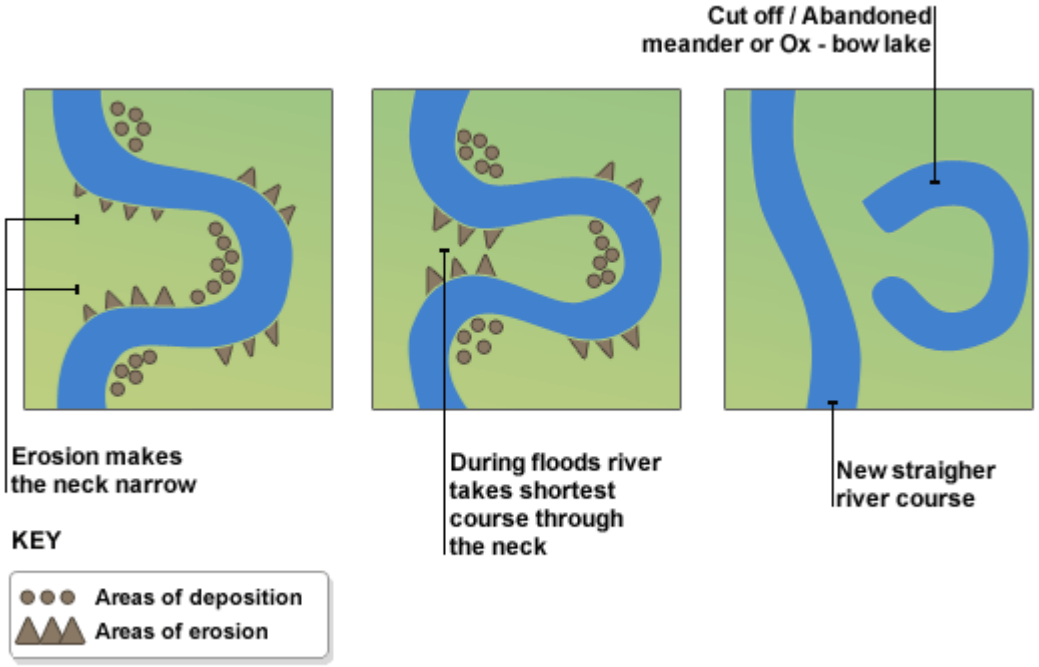
- Water flows quickly on outer bend
- Lateral erosion
- Water erodes bank/wears away side
- By hydraulic action/abrasion
- Undercutting
- Collapse
- Helicoidal/helical flow



Oxbow Lake

Formation

- River flows around a meander
- Fast flow on outer bend = Erosion on outer bends, by hydraulic action/abrasion
- Slow flow on inner bend = Deposition on inside bends
- Helicoidal/helical flow
- River becomes more sinuous/winding/extreme meander
- Neck of meander reduced in thickness
- Eventually river erodes across neck/river flows straight on/cuts off meander
- During time of flood
- Former meander sealed by deposition



Features (to describe features of an oxbow lake from an image)

- Curved/C-shaped/horseshoe shape/crescent shape
- Orientation: eg. from north to south
- Long and thin
- Exact figure for length (eg. 500 metres long)
- Exact figure for width (eg. 100 metres wide)

Floodplains & Levees

Floodplain: area covered by water when a river floods.

Formation of floodplain

- Lateral erosion

- Deposition in channel/ on bed of river
- Displacement of water
- Flooding of river/ overflows bank
- Carrying large amount of sediment
- Slow moving/ stationary water/ friction
- Deposition of sediment on flood plain/ deposition of alluvium
- Build up of layers

Levées: when forming a floodplain, the river drops the coarser, heavier material first, forming raised banks called levees.

Delta

Flat, low-lying deposit of sediment found at a river's mouth. For a delta to be formed:

- River needs to carry large amount of sediment
- River needs to enter a still body of water

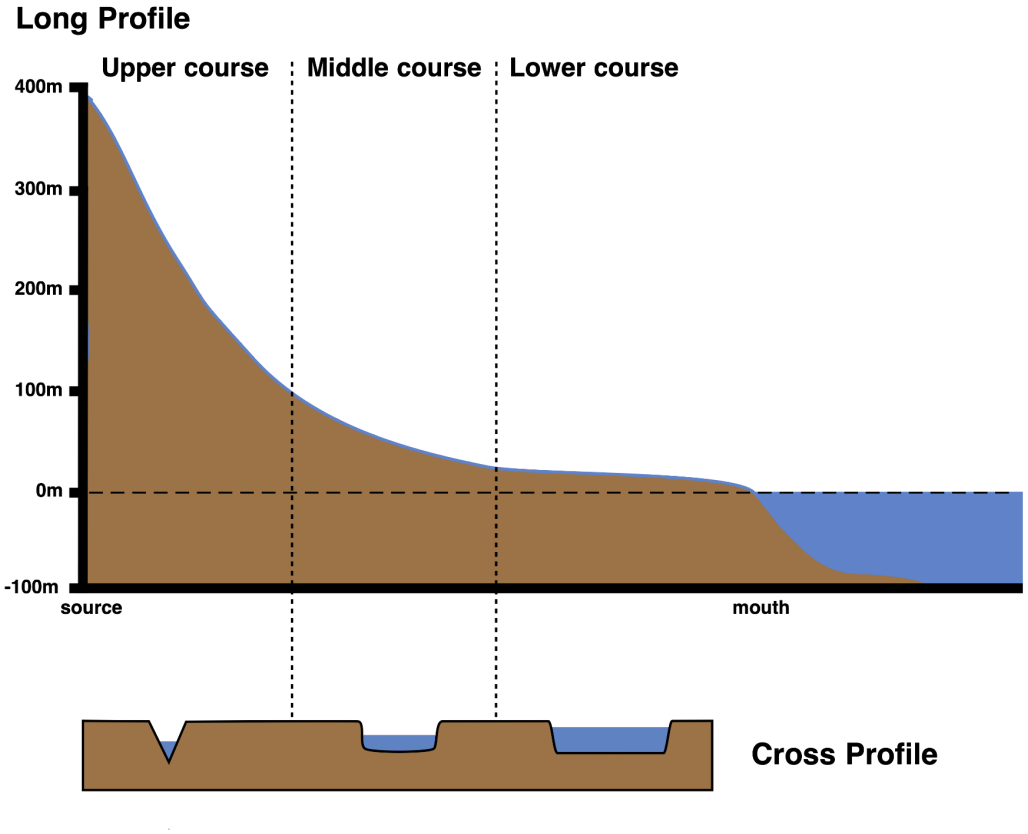
Formation

- Large amount of sediment/load brought downstream by river
- River slows down/loses strength/can't carry sediment
- Causes deposition to occur in the lower course
- Flocculation occurs due to salt in the water
- Deposited silt blocks course of the river
- So river splits into distributaries/new channels/finds new routes
- Deposited materials are not washed away
- Due to lack of strong currents
- Build up of islands/new land
- Colonisation by vegetation

Features (to describe features of a delta from an image)

- Many distributaries/small rivers
- Shape: Birds foot OR fan/arcuate/triangular
- Exact figure for width (eg. width approximately 120 km)
- Exact figure for length (eg. length approximately 100km)
- Orientation; eg. South/south east facing

Changes in river characteristics as it flows



Difference between cross sections of upper course & lower course

- Lower course is wider/upper is narrower
- Lower course has gentler slopes/upper steeper slopes
- Upper course is deeper
- Upper course is more V shaped
- Lower course has flood plain but upper does not,

How river & its valley will change downstream / from source to mouth

- Width: wider
- Depth: deeper
- Speed of flow: faster flowing
- Volume/discharge: greater volume/discharge
- Total load: gets larger
- Size of load: gets smaller
- Erosion: less erosion/ more lateral erosion
- Deposition: more deposition
- River becomes more meandering/sinuous/winding; oxbow lake present
- Higher hydraulic radius/wetted perimeter/smoother riverbed
- Gradient: less/more gentle/ even long profile
- Valley sides will be less steep/flatter

- Channel bed gets smoother
- A floodplain may develop

How course of river with meanders changes in future due to natural processes

- River becomes more sinuous/winding/meandering
- Outer bank retreats/moves outwards/goes out further
- Slip off slope moves inwards/builds up
- Neck of meander narrows/reduces in size/narrow neck will be formed
- Cut across/river becomes shorter/straighter
- Meander sealed by deposition
- Formation of oxbow lake

How long profile & cross section of valley of river changes from source to mouth

- Long profile will become less steep/gradient becomes gentler
- Long profile will become smoother/less irregular
- Cross section/valley sides will become more gently sloping
- Cross section of valley will be wider/more open valley
- Flood plain/flat land alongside river as it gets closer to sea
- Levees alongside river as it gets closer to sea

Benefits of living close to rivers

- Flat land: easy to build on
- Fertile land/land for agriculture/grazing/high yield of crops
- Water for irrigation
- Water supply for drinking/washing
- Water for industry/HEP
- Ease of transport/communication along river/valley/floodplain
- Fishing
- Scenic beauty
- Leisure activities
- Work in tourism industry

Why people continue to live near rivers, despite risk of flooding / despite hazards

- Flooding is infrequent
- Warning usually given before flooding
- People have time to evacuate
- People are able to take precautions/ flooding can be prevented
- Have jobs nearby/ in the area
- Emotional attachment/lived there all their lives/religious significance
- Near friends/family

- Population pressure/high population density

Problems of living close to rivers

- Flooding/impacts of flooding
- Erosion of land: threatens farmland/homes
- Crocodiles/alligators/snakes
- Mosquitoes/malaria risk
- Waterborne disease e.g. typhoid.
- Difficulty of crossing/bridging river

Flooding

Causes of flooding

- Surfaces are impermeable
- Water is not able to soak into soil/rock/less infiltration
- Trees have been removed/ deforestation
- Less interception/transpiration
- More overland flow/surface runoff
- Artificial drains move water rapidly to rivers
- Building settlements on a floodplain/ urbanisation

Why rivers sometimes continue to flood for many hours after the end of a period of heavy rain

- Most of the rain does not fall on the channel
- Takes time for overland flow to reach river
- Water has to travel downstream
- Much of the water gets to the river slowly through soil/rocks/percolation/ groundwater/throughflow

Problems of flooding

- Loss of lives: people die/drown
- Farmland flooded: loss of crops/food shortages/soil eroded farm animals die/drown
- Natural vegetation/trees/habitats/wildlife destroyed
- Damage to property/homes/settlements/possessions
- Disruption to transport/road/railways/bridges
- Electricity supply disrupted
- Damage to businesses/shops/close down
- Loss of earnings/jobs
- Drinking water contaminated/ spread of waterborne diseases

Methods to reduce river flooding

- Dredging: increase depth of river; this enables more water to flow within its banks
- Raise banks/artificial levees/embankments
- Widen the river
- Straighten rivers
- Line with concrete; concrete banks/beds
- Dams/reservoirs
- Use sluice gates
- Overflow channels/diversionary spillways
- Afforestation/planting trees
- Avoid building on flood plains
- Allow river to flood farmland / meadow areas upstream

Flood prediction

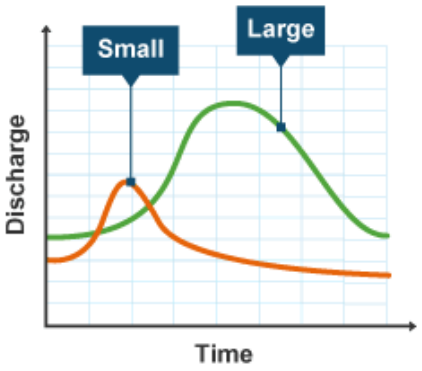
Flood hydrograph

- Used to predict the reaction of river discharge to rainfall event
- Shows the changes in river discharge after a storm event
- The graph shows a short period of time, usually 24 hours

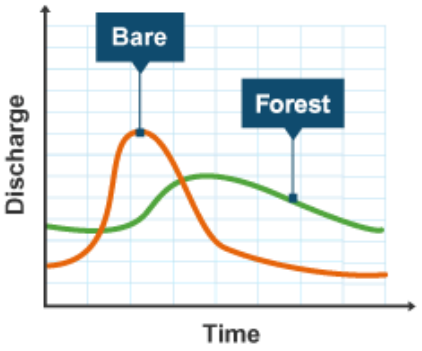
Features of flood hydrograph

- Base flow: the normal level of river discharge
- Peak rainfall: the highest rainfall level during the storm
- Rising limb: shows the increase in river discharge
- Peak discharge: highest level of discharge
- Lag time: time difference between peak rainfall and peak discharge
- Recessional limb: shows the river discharge returning to normal (base flow)

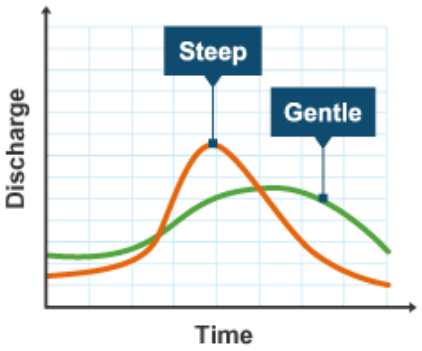
Size of drainage basin



Vegetation



Valley side steepness



Soil type