Fluvial Processes

The work of rivers

Fluvial Processes

- Three basic processes at work
  - **Erosion**,
  - **Transportation**
  - **Deposition**

- **Weathering** does not play a significant role in rivers
- The effectiveness of these processes depends on the River's **Energy** level, it's overall **shape** and it's **depth**
- (Deep rivers more powerful than shallow, young rivers more powerful than old age)

A River's Course

The area drained by a river = **Drainage Basin**

A drop of rain falling <u>anywhere in this area</u> will eventually find its way into the river.

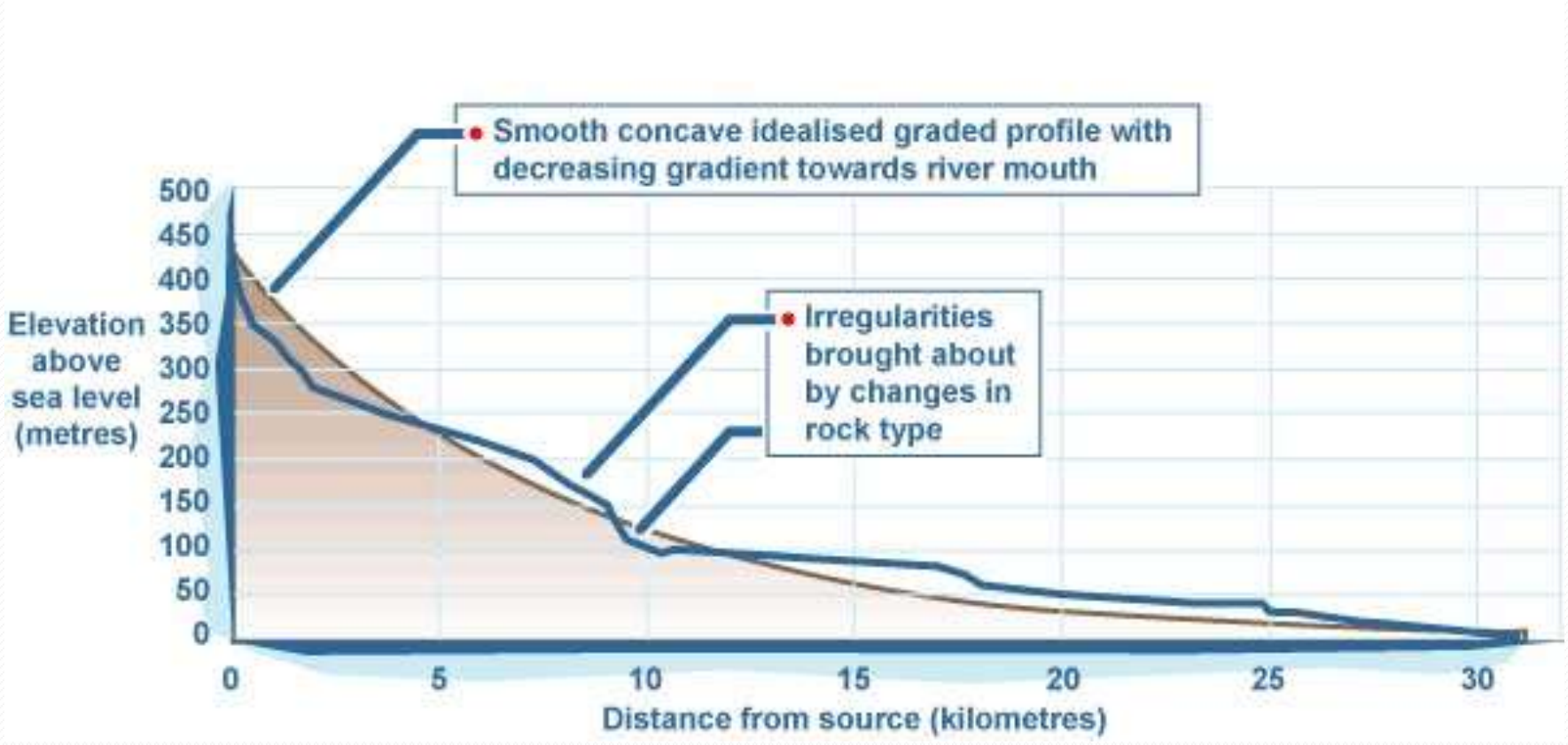
Drainage basins are separated from each other by **watershed**s

What is at X?

Definitions

- River Source _____
- Drainage Basin _____
- Confluence _____
- Tributary _____
- Watershed _____
- Estuary _____
- River Mouth _____

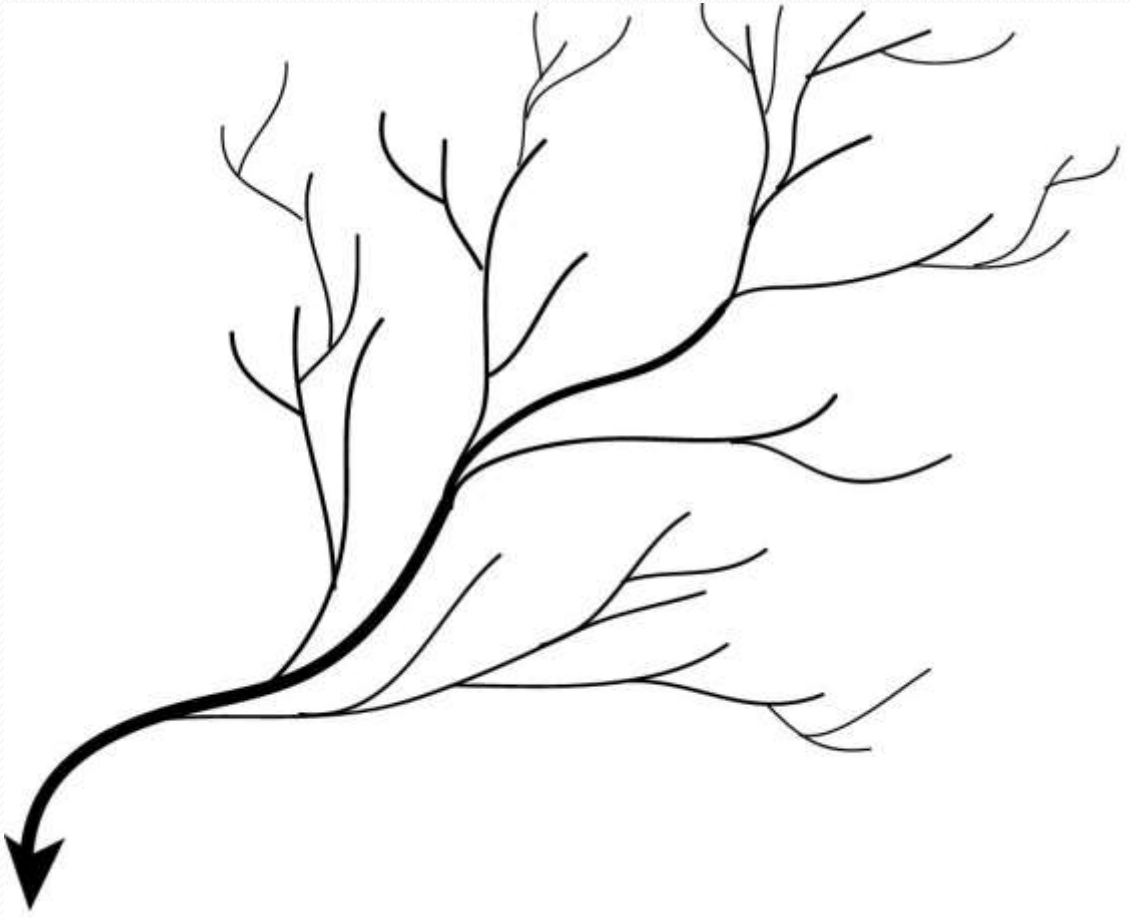
Long (real) and Graded (ideal) Profile



Drainage Patterns

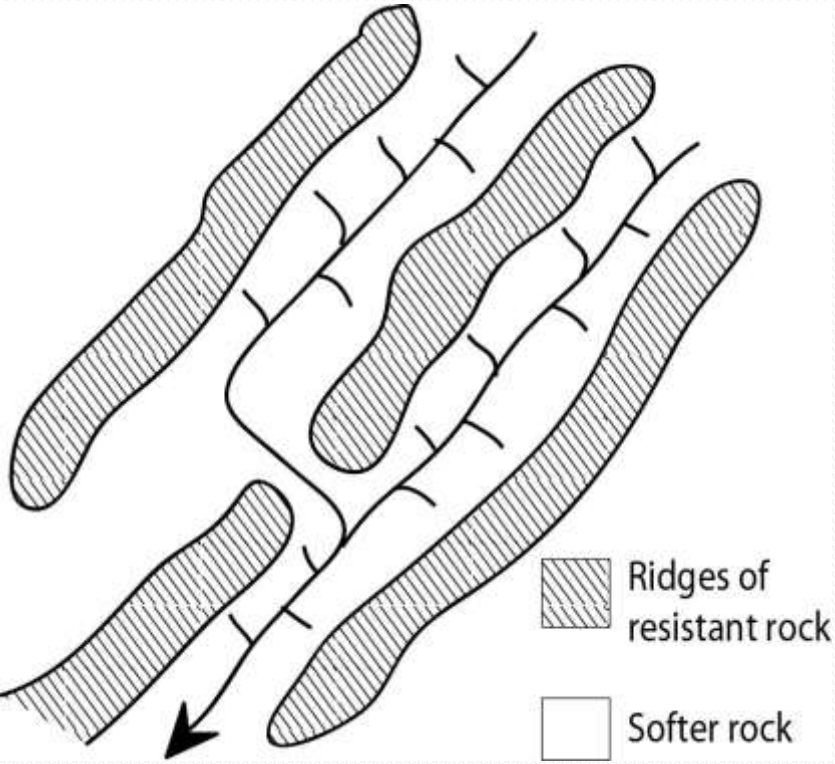
- The shape made by a river and it's tributaries (note, <u>not</u> **dis**tributaries) on the landscape
- Three main patterns
  - Dendritic (tree like) patterns
  - Trellis (right angles) patterns
  - Radial (like radius of a circle) patterns
- The drainage pattern of a river depends on relief, rock types and river size

Dendritic (tree like) Patterns

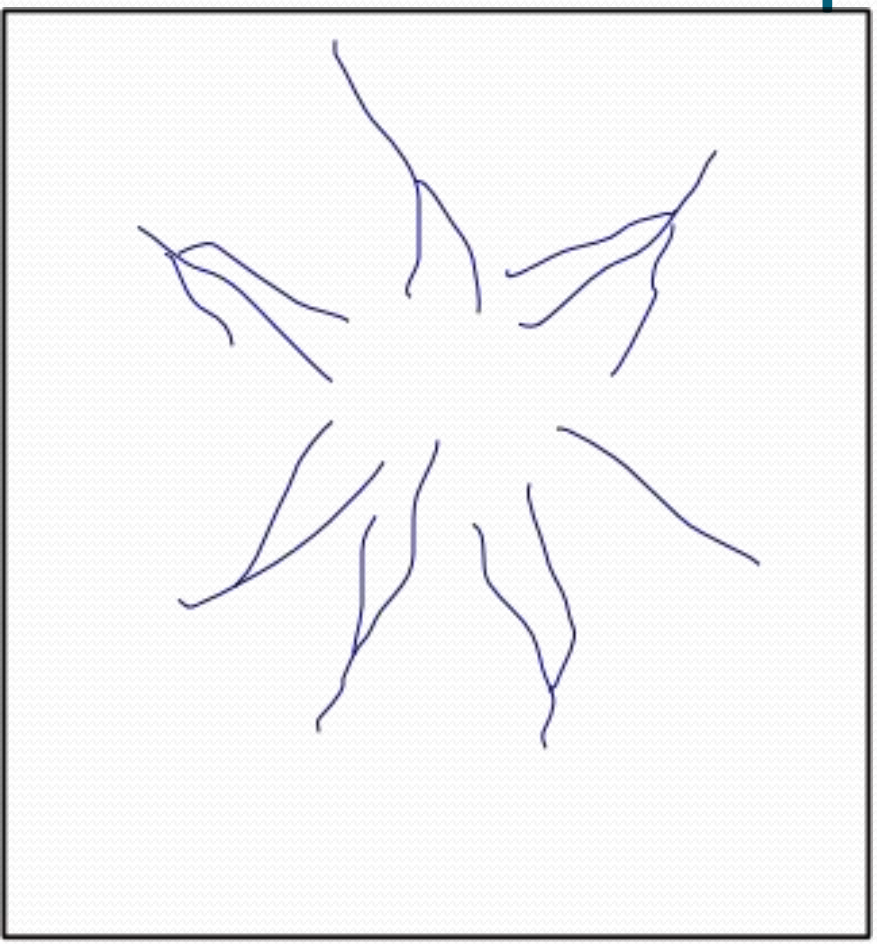


Dendritic Patterns

Trellis (right angled) Patterns



Radial Patterns (out from a central point)



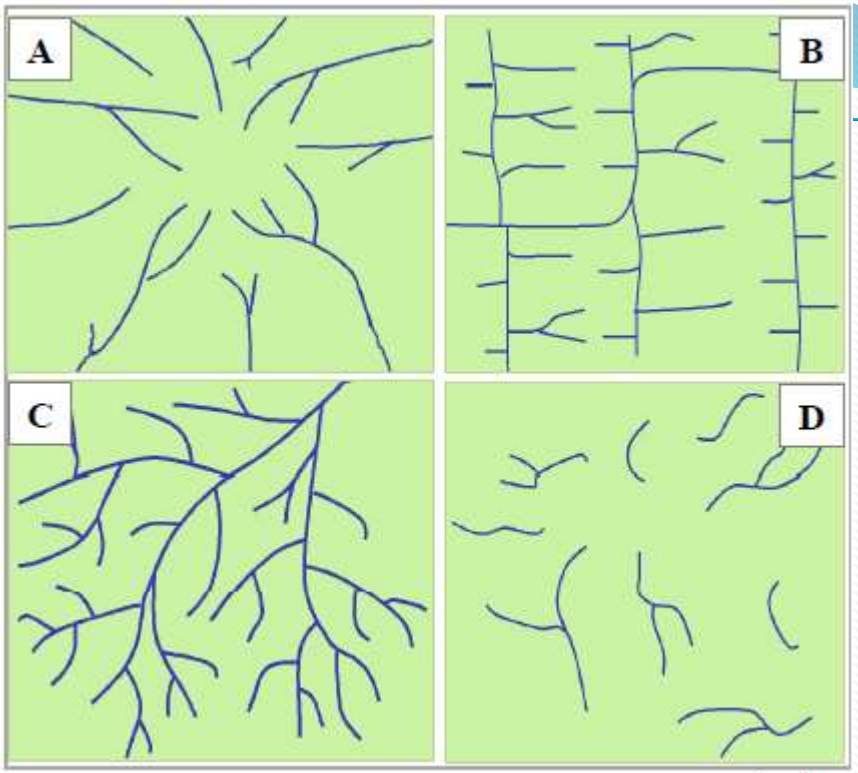
2007 Leaving Cert Hons

11 Drainage Systems

A **B**

Name the drainage pattern shown in Diagram A	
Name the drainage pattern shown in Diagram B	
What is the name given to an area of high ground which separates two river basins?	
What is the name given to the point where a tributary joins a larger river?	

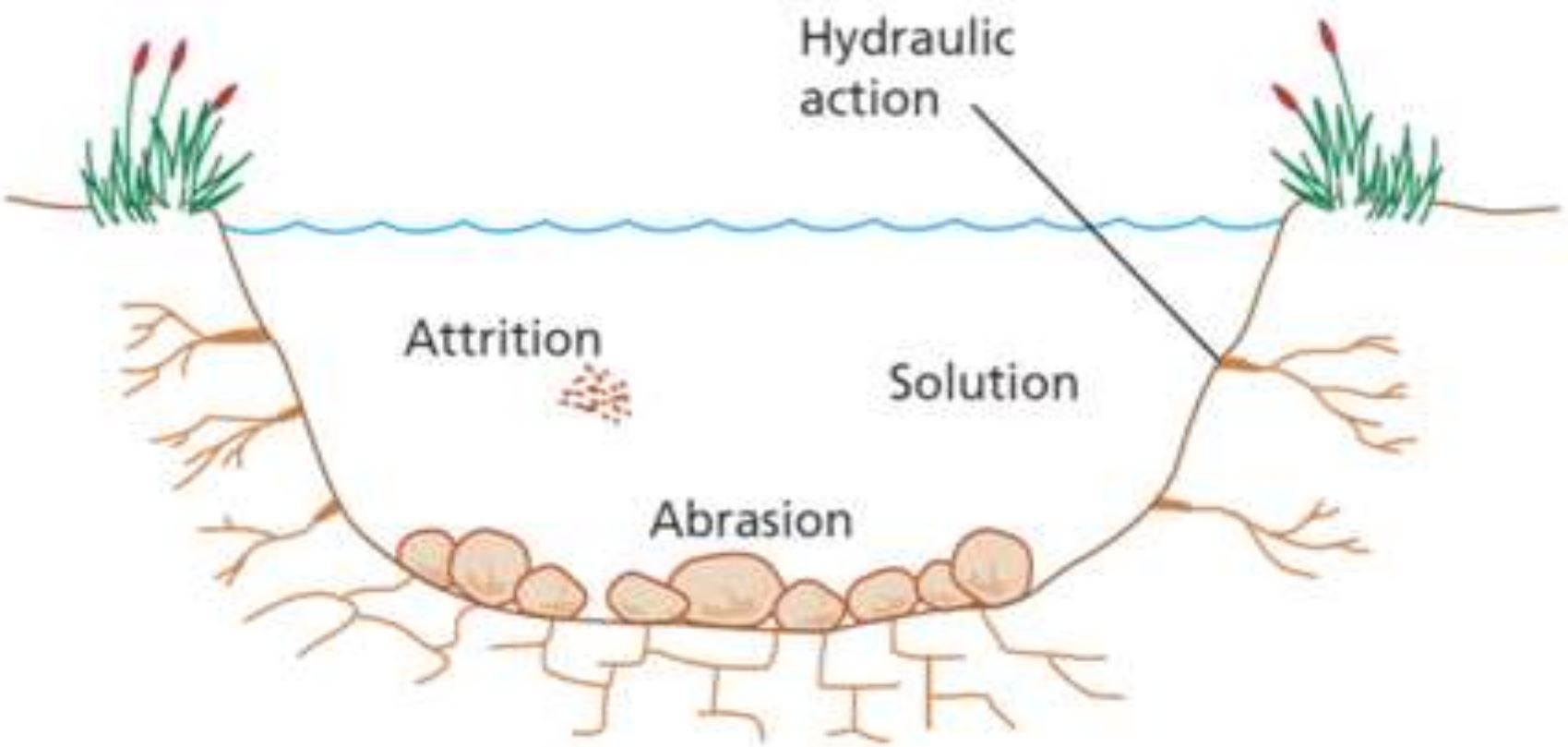
[8]



Drainage Pattern	Letter
Dendritic	
Deranged	
Trellis	
Radial	

Factors affecting fluvial (river) processes – P107

- River Volume
- River Speed/Velocity
- Slope
- Width and Depth of a Channel
- Load (material carried by a river)



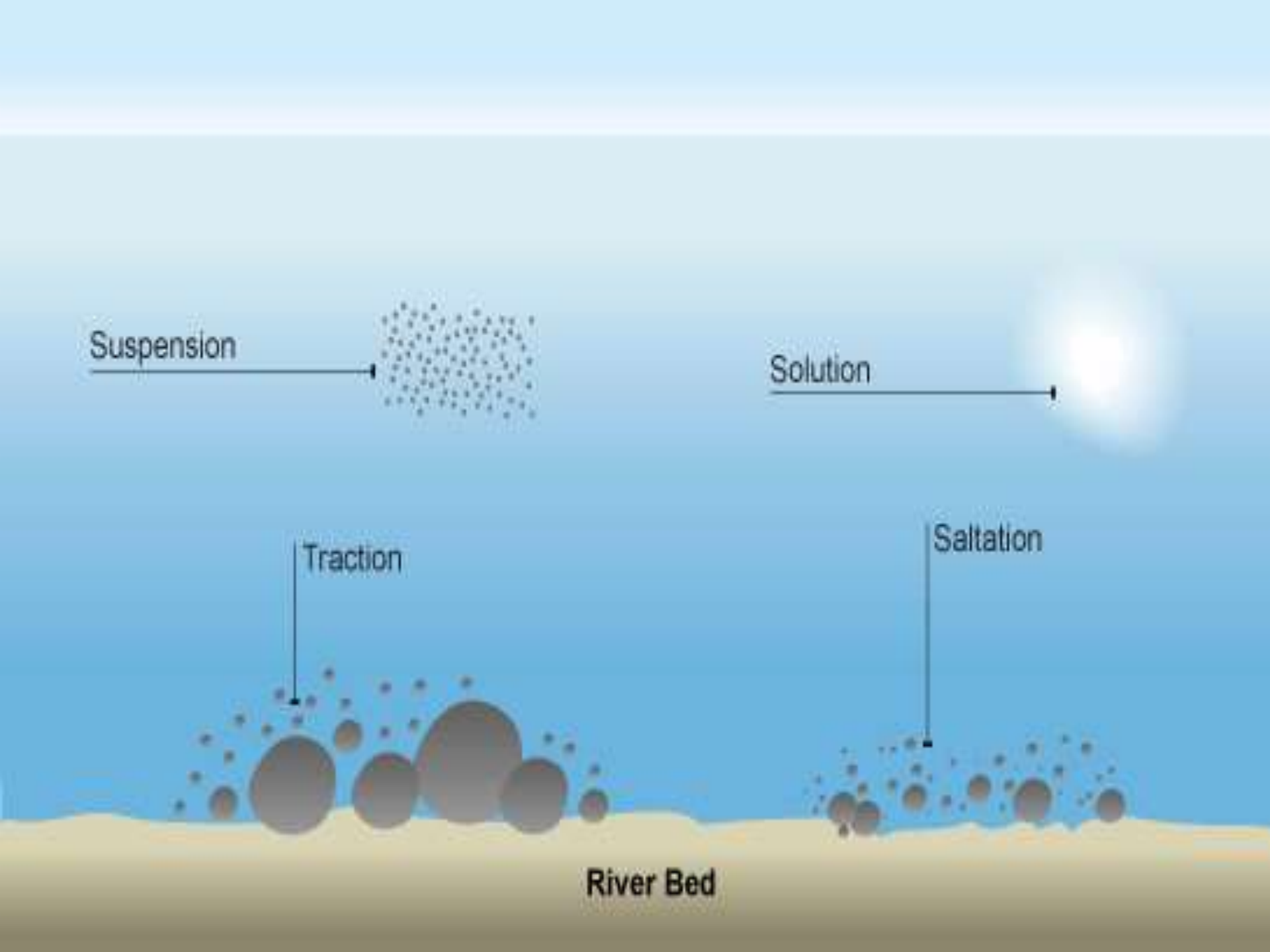
- Hydraulic Action
  - The force of moving water, aided by the process of **cavitation** (popping of air bubbles in the river, creating tiny explosions)
- Abrasion (a.k.a. Corrasion)
  - The river's load (stones and sand/grit carried by the water) wears away the bed and sides – river "sandpaper"
- Attrition
  - Rocks hitting each other and being worn away
- Solution
  - Chemicals in the river water wearing away the bed and banks

Bank Caving

- Formed by **hydraulic action** eroding the river banks
- Leads to a small temporary “cave” in the bank – this usually collapses after a short period

River transport

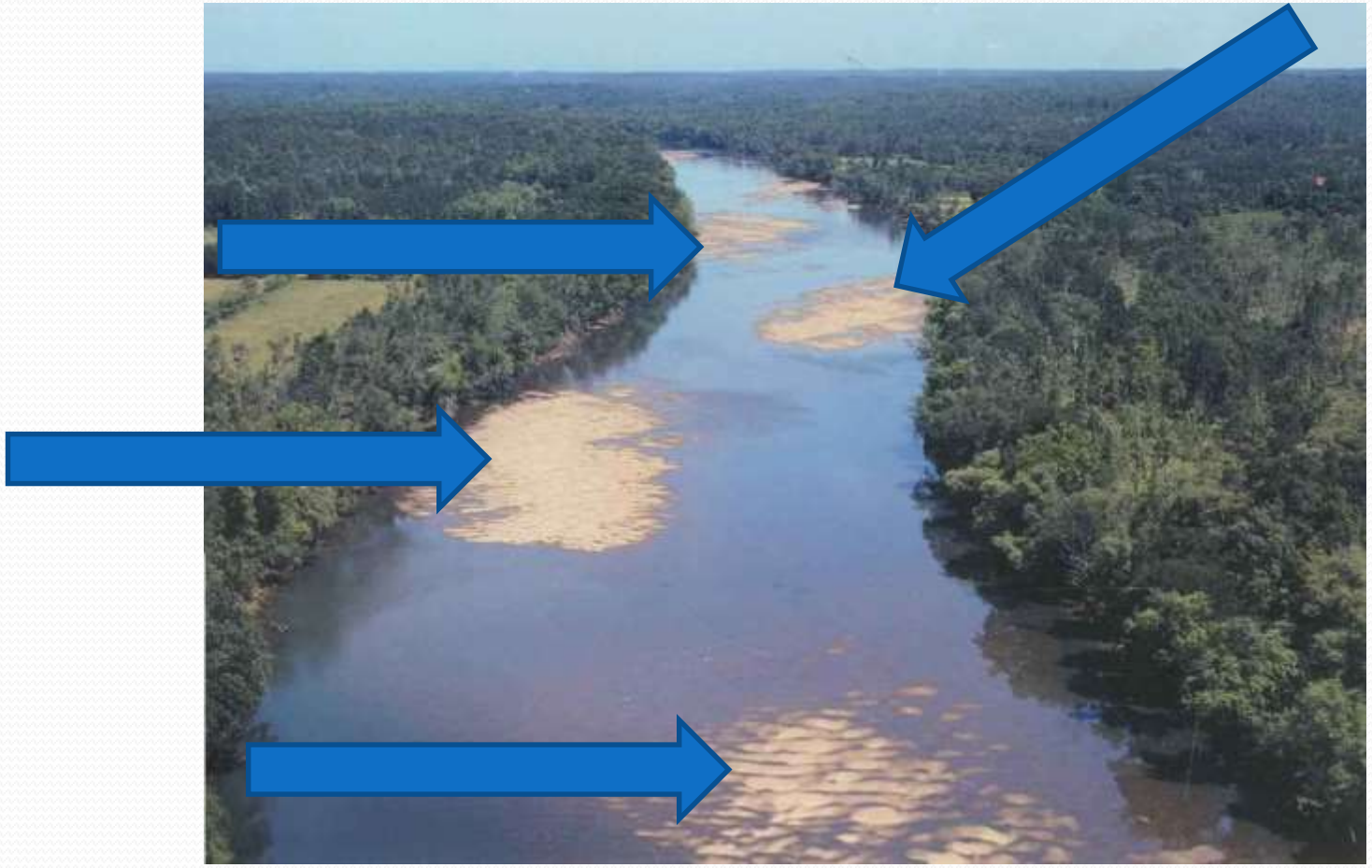
- **Solution** – material is dissolved in the water and is carried along by it. Salt carried in solution is the reason why seawater is salty. **NOT VISIBLE**
- **Suspension** – fine material is carried along by the river. If the river slows down this material can be dropped on the bed of the river – this is how rivers & canals “silt up”. **VISIBLE**
- **Saltation –** stones bouncing along the river bed – easily seen **(bedload)**
- **Traction –** Heaviest stones dragged along river bed **(bedload)**


Suspension
Solution
Traction
Saltation
River Bed

Deposition

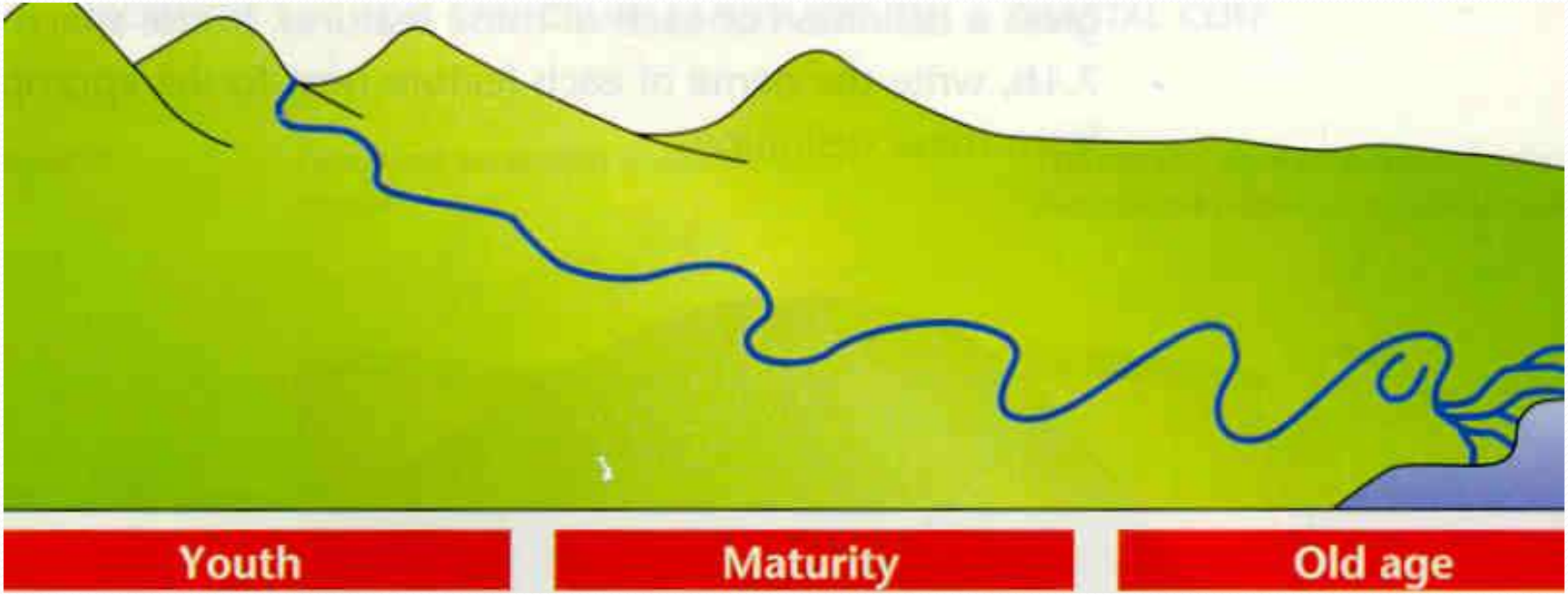
- Rivers can drop (deposit) their material for a few reasons
  1. Reduction in velocity – when entering a lake, sea, other slow moving river, encountering an obstacle, a change to a gentler slope or when drought causes the river to dry up
  2. If the river's load increases suddenly beyond it's ability to carry (e.g. a landslide into a river)
  3. Evaporation of water

Deposition



Deposition – Nile enters the sea

Stages of a river



Youthful Stage

Mature Stage

Old Age Stage

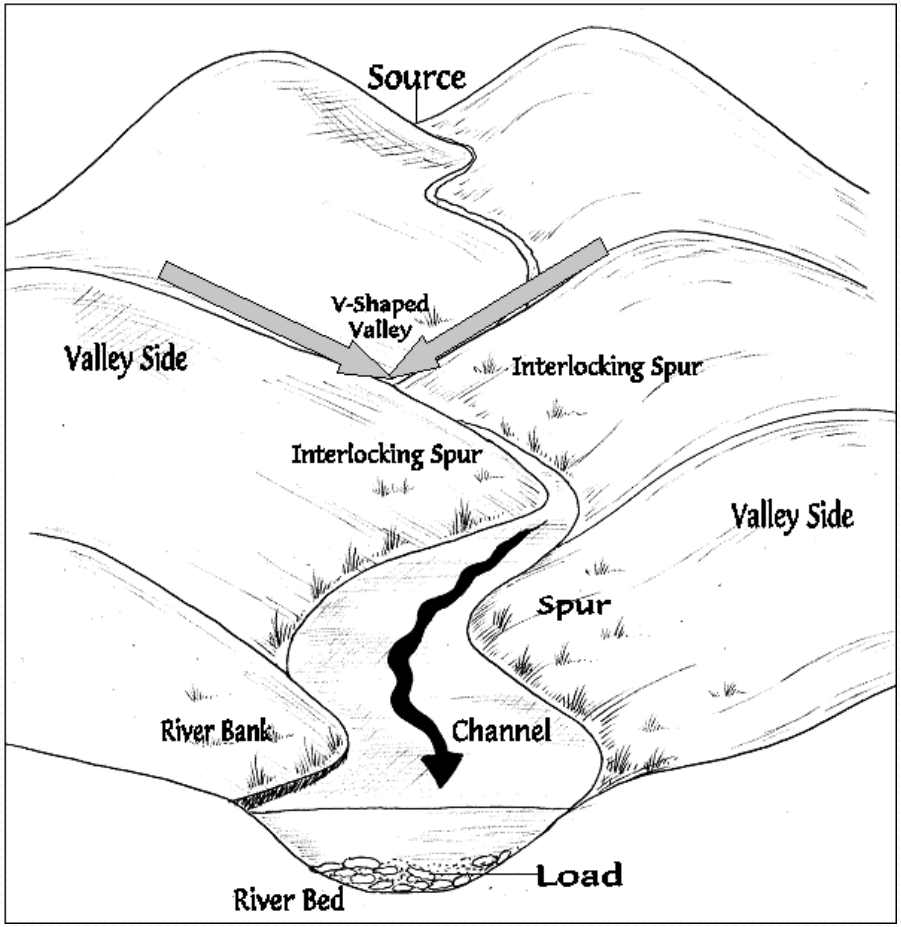
Drainage

- The area drained by a river is known as its **Drainage Basin**
- A drop of rain falling anywhere in this area will eventually find its way into the river.
- Drainage basins are separated from each other by **watershed**s– usually high ground between two drainage basins.
- Sketch (Montpellier Hill)

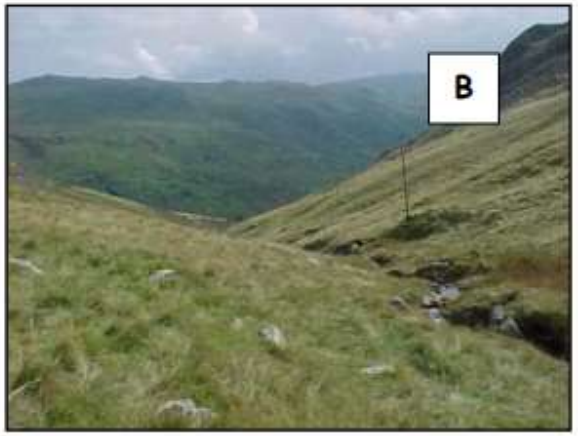
River Landforms

- Each stage of a river (youth, mature, old age) creates different landforms as different processes are at work.
- **Youth – Vertical erosion dominant, almost no deposition**
- **Mature – Lateral (horizontal) erosion, some deposition**
- **Old age – deposition predominant, some lateral erosion**

River landforms - youthful



12. River Landforms



(i) Examine the photographs above and match each of the named landforms in the table below with one of the letters on the photographs.

Landform	Letter
Waterfall	
Interlocking Spur	
Meander	

Source of river

- Where the river starts, usually in a mountainous area
- River source often bears no resemblance to the river we know.
- River Shannon Source

Source of the Liffey

River Landforms - youthful

- As a river is eroding downward in this stage, it leads to narrow rivers in steep sided valleys (V – Shaped). Eg. Fig 12 p 101
- Depth of **V** controlled by several factors
- V Shaped valleys appear distinctive on OS Maps – contours “kink” at the river

V Shaped Valley

Interlocking Spurs

- Bands of harder rock which the river cannot erode straight through and is forced to flow around
- As the river is forced to “swerve” around the spurs, lateral (horizontal) erosion increases due to centrifugal force – making the curves more developed
- On a map, interlocking spurs give a youthful river a “squiggly” appearance

Interlocking Spurs

Waterfalls

- Formed when a band of hard rock lies across the river.
- Hard rock erodes more slowly, leading to a “bump” in the river – this grows and develops into a waterfall.
- Example:
- http://www.youtube.com/watch?v=Nhi4cf9yCPs

Waterfalls

- As waterfall grows, the force of falling water (hydraulic action) creates a pool at the base of the waterfall (plunge pool).
- The **splash back** leads to the back of the waterfall being eroded and the waterfall retreats upstream
- This is known as **headward** erosion
- On maps, waterfalls are straight flowing streams flowing over tightly packed contours at right angles

Glencar Waterfall, Leitrim

Mature Stage Features

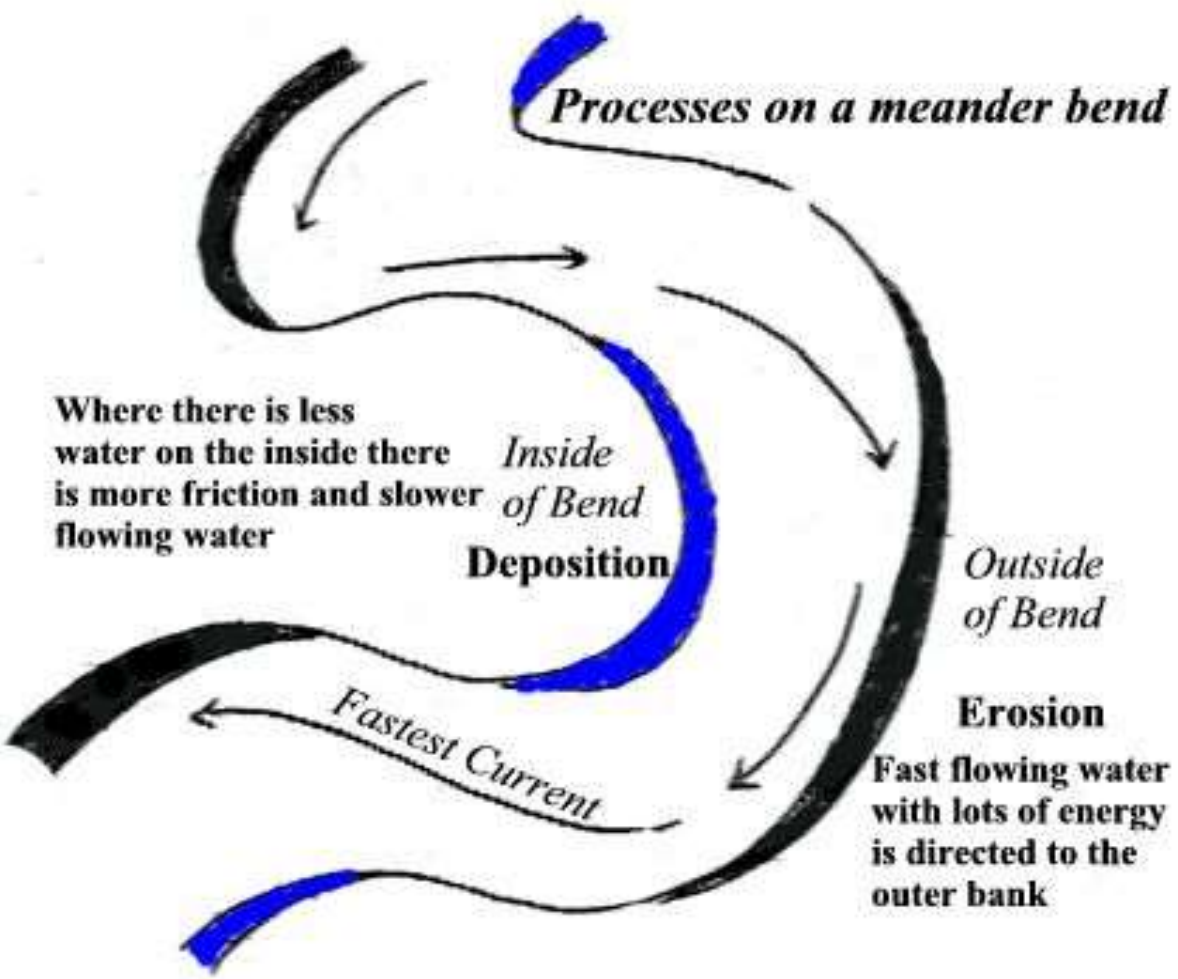
- In a mature stage, horizontal (lateral) erosion is predominant, along with some deposition
- The river valley is therefore **wider**, often with a large plain (known as a flood plain) in the centre

Mature Stage Valley

Mature Stage Features - Meanders

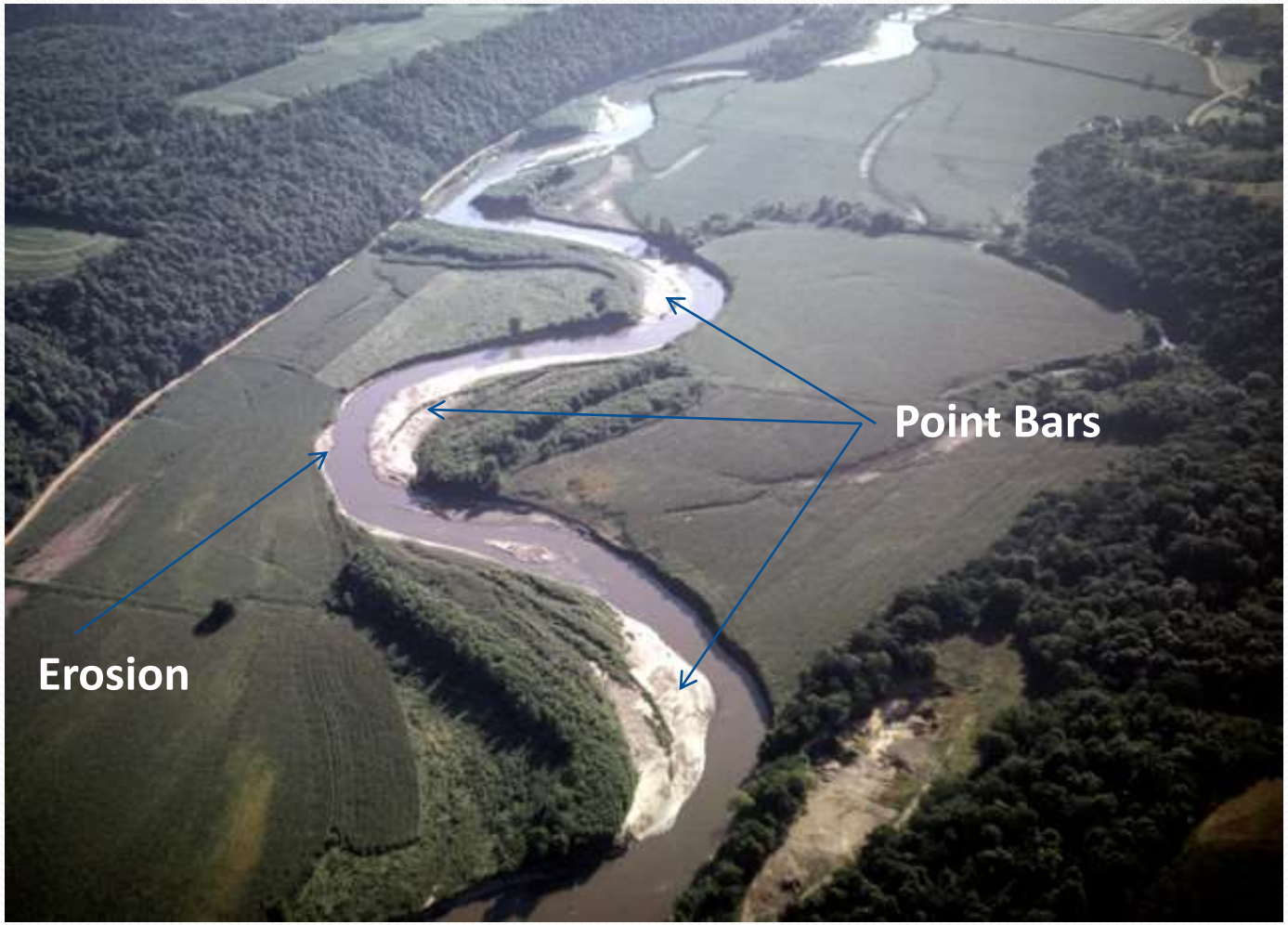
- Meanders are features formed from both erosion AND deposition
- As the river enters the mature stage, it begins to flow in a winding manner (forming S bends)
- River water flows fastest on the outside of the bend (forming erosion) and slowest on the inside (causing deposition)
- Easily spotted on a map as prominent curves in a river

Meanders


Processes on a meander bend
Where there is less water on the inside there is more friction and slower flowing water
Inside of Bend
Deposition
Outside of Bend
Erosion
Fast flowing water with lots of energy is directed to the outer bank
Fastest Current

Meanders

Point bars & erosion



2008 OL

(v) Read the statement below and place an **X** in the correct box. "The river in the photograph is in the middle or lower course and meandering."

True ☐

False ☐

2007 OL

(iv) Read the statement below and place an **X** in the correct box.
"The river in the photograph on the left is in the upper course and eroding."

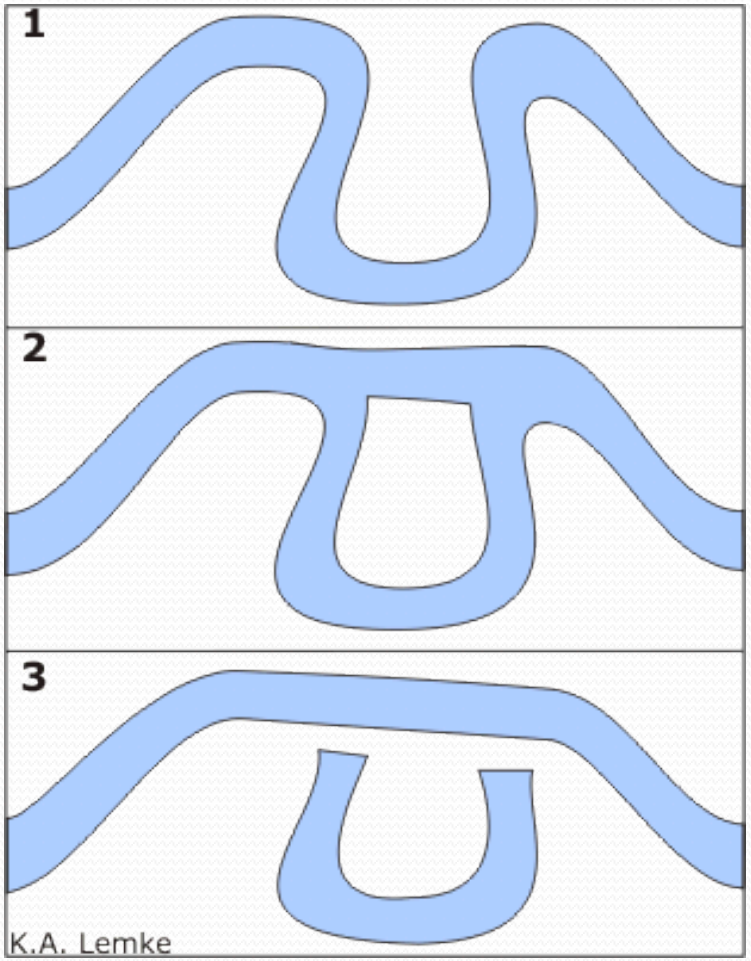
True	☐
False	☐

Ox Bow Lakes

- Formed when a river erodes through the narrow “neck” of a meander.
- Only happens when a meander is *very* developed
- Meander needs two processes to form – erosion and deposition – ox bow lake needs a third – **Flooding**
- In times of flood, the river gains so much hydraulic energy that it breaks through the narrow neck of the meander
- http://www.youtube.com/watch?v=8uV-BuBpIFw&feature=related

Ox Bow lakes - formation

1. Meander becomes very developed
2. In times of flood, the river cuts through the meander "neck"
3. Deposition seals off the old meander, forming an ox bow lake, which can eventually dry out



Ox Bow Lakes

Flood Plains

- A flat area on either side of the river that is covered by water in times of flooding
- Act as a safety valve for rivers – major problems have been caused in the past decade by building on flood plains - leaves river with no place to go (and worthless “ghost” housing estates)
- Caused by a meandering river slowly eroding interlocking spurs and other areas of high ground to form a wide flat valley

Flood Plains

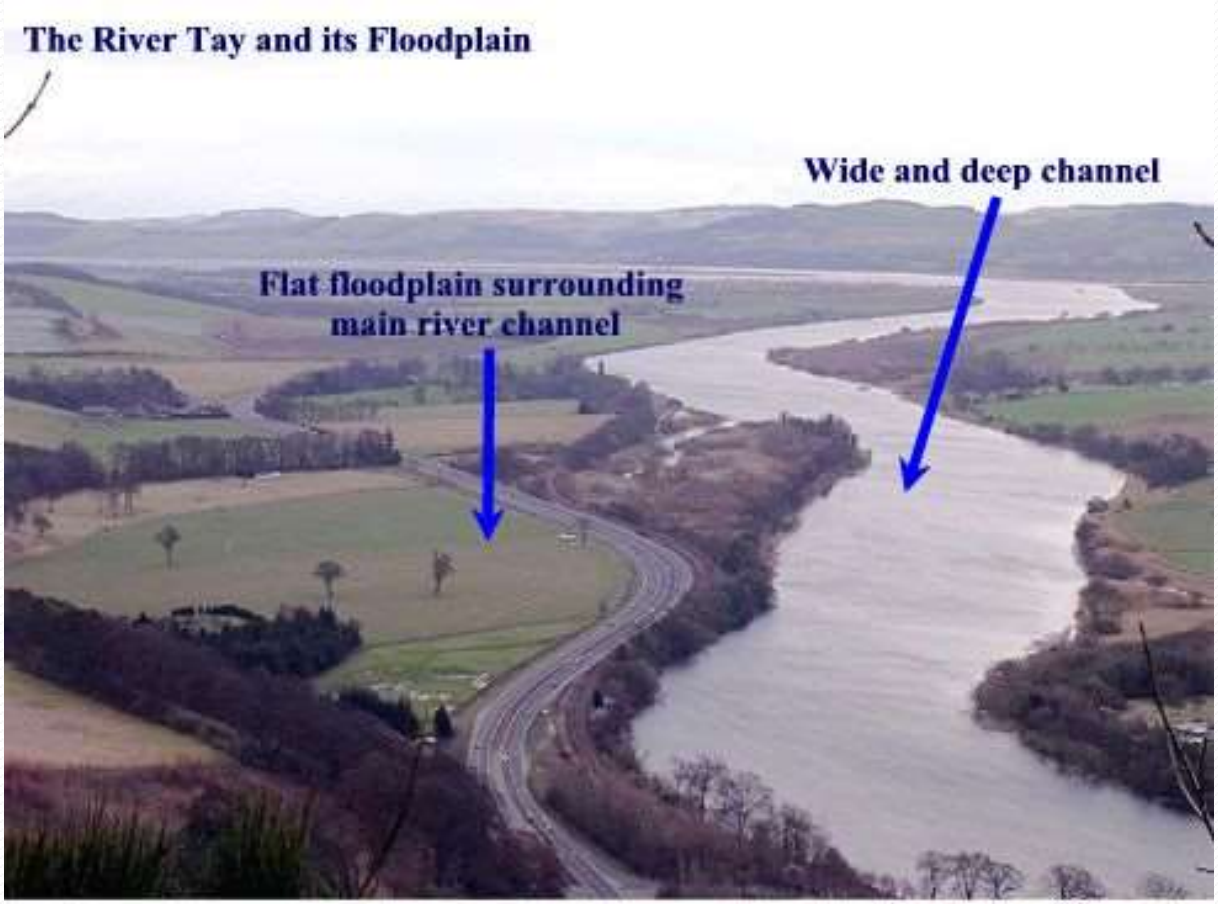


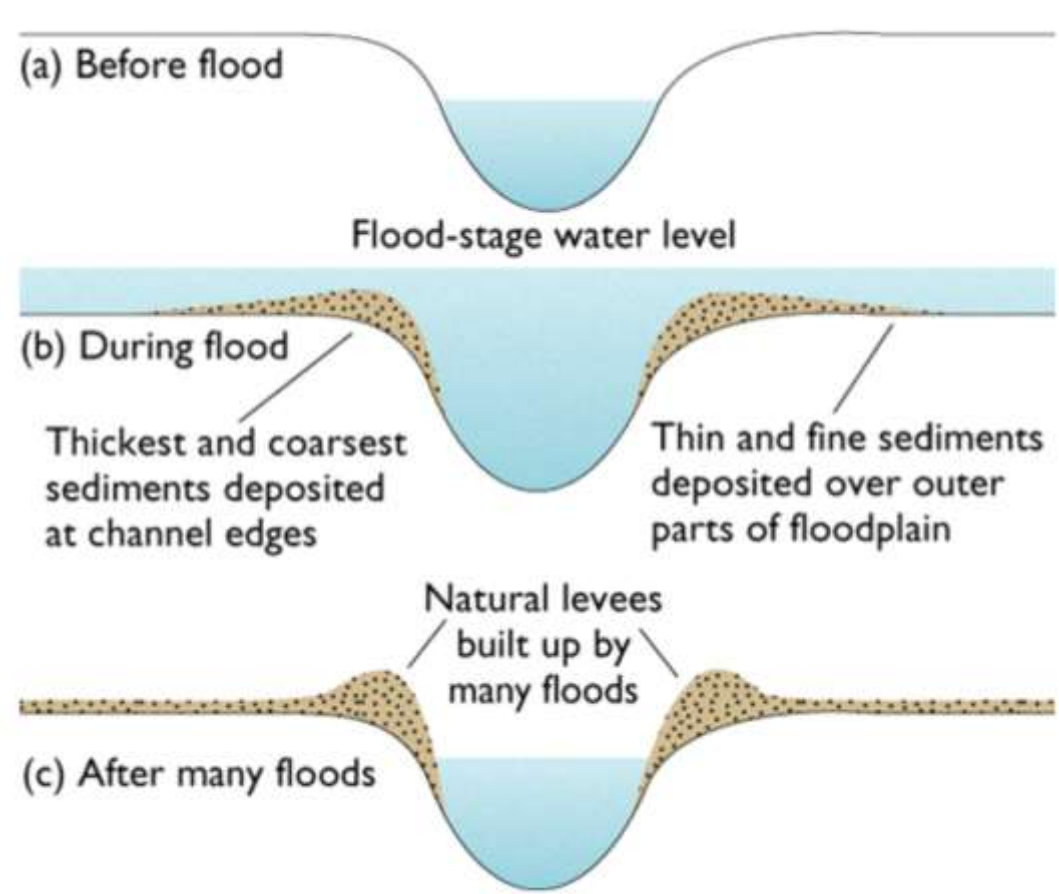
Photo Source:V Vannet - on www.geographyphotos.com

….and some obvious problems

Old Stage Landforms

- In this stage deposition is the main process and it creates features such as **Levees** and **Deltas**
- The land over which the river flows is virtually flat – as a result old age stage can also contain many meanders and ox-bow lakes
- Levees are naturally occurring wide, low ridge of river sediment (known as alluvium) that is deposited on river banks
- Are often raised in height to act as a flood barrier (e.g. New Orleans, USA)

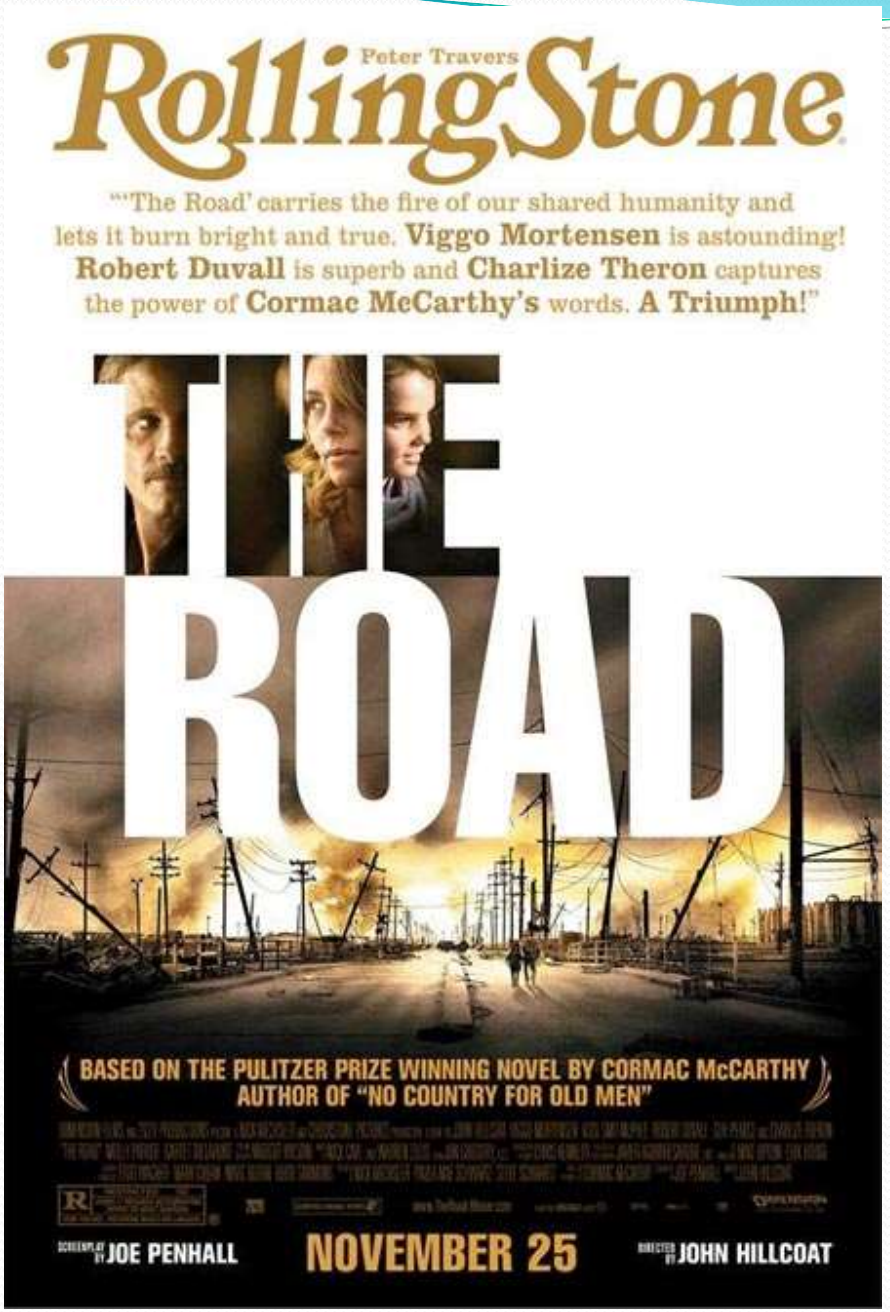
Levees - formation



Levees

- Levees are useful as natural flood protection
- However can cause particular problems if people build too close to the river and levee breaks.
- Hurricane Katrina (2005) broke the levees protecting New Orleans, resulting in widespread damage

Levees broken in New Orleans


Peter Travers
Rolling Stone
"'The Road' carries the fire of our shared humanity and lets it burn bright and true. Viggo Mortensen is astounding! Robert Duvall is superb and Charlize Theron captures the power of Cormac McCarthy's words. A Triumph!"
THE ROAD
BASED ON THE PULITZER PRIZE WINNING NOVEL BY CORMAC McCARTHY
AUTHOR OF "NO COUNTRY FOR OLD MEN"
R
SCREENPLAY BY JOE PENHALL
NOVEMBER 25
DIRECTED BY JOHN HILLCOAT

Deltas

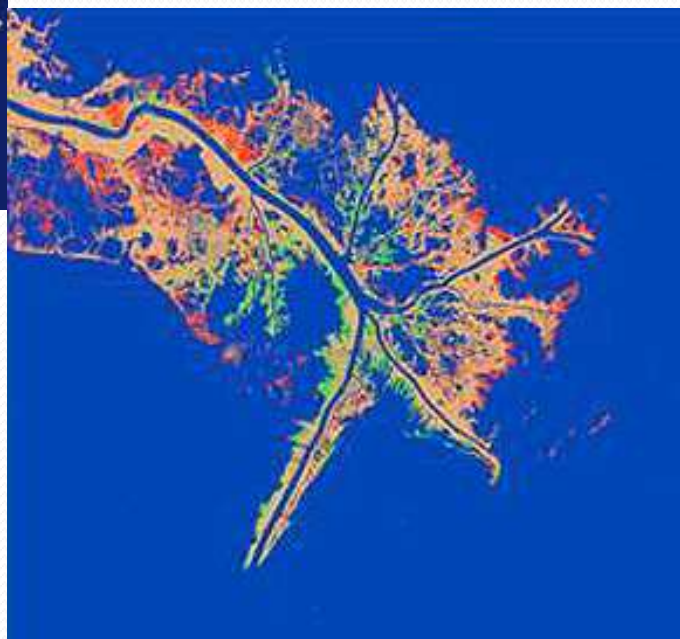
- Deltas are the final feature formed in the river's course
- Formed from deposits of alluvium when a river enters the sea (called **marine** deltas), a lake (called **lacustrine** deltas), or another slow flowing river
- When a river loses speed suddenly, it drops it's alluvium load, which build up in layers known as **beds**
- **First layers deposited – bottomset beds**
- **Second layer – foreset beds**
- **Last layer – topset beds**

Deltas

- As the sediments build up, the river is forced to split into a number of smaller channels called **distributaries**
- Not to be confused with **tributaries,** (small rivers joining a larger one)
- Number of different types of delta

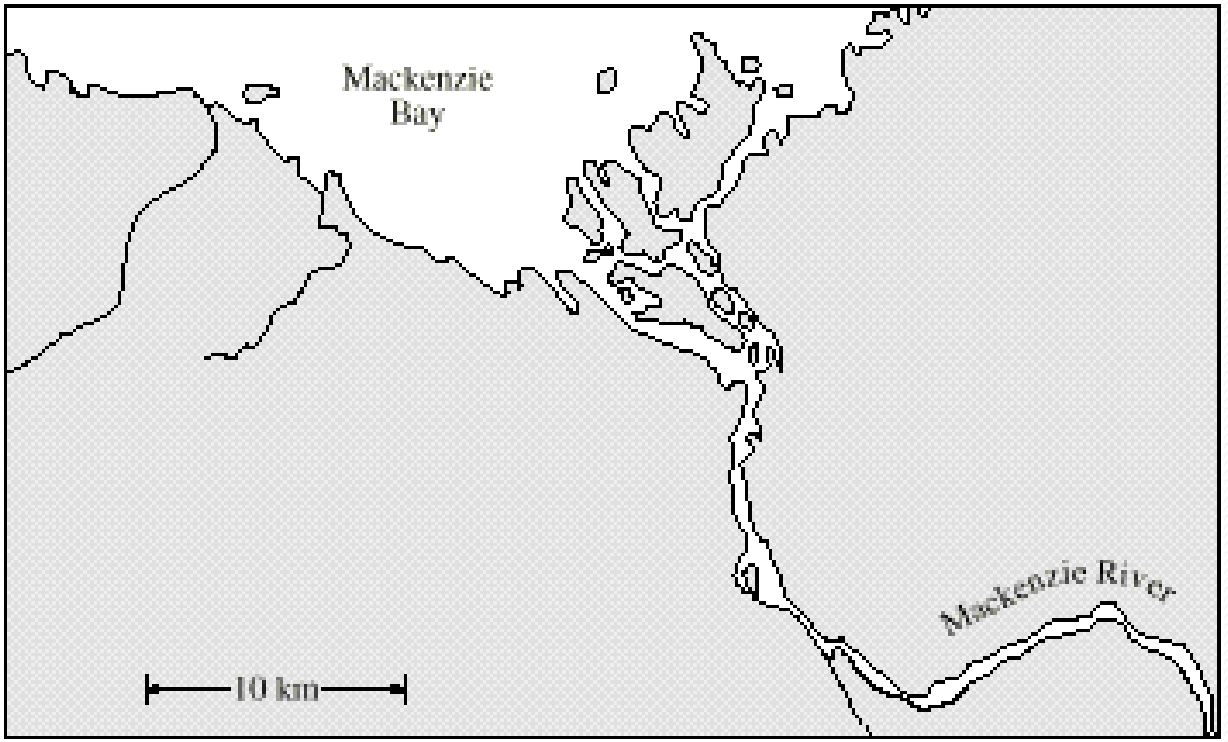
Bird's foot deltas

- Birds's foot delta (page 125)
- As the material is deposited, the river is forced to carve out new channels to get to the sea



Estuarine Delta

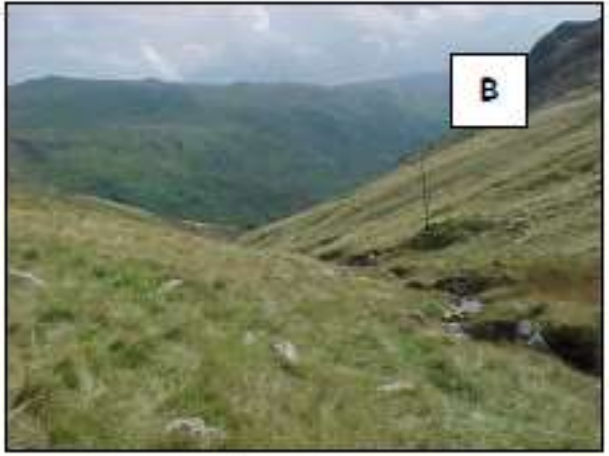
- Formed when deposits are dropped in long narrow lines, an example being the Mackenzie river below



Arcuate Delta (arc-shaped)

- An arc, fan or triangular shaped delta which has the apex (tip) of the triangle pointing upstream
- Most famous example is the Nile Delta on page 113
- The alluvium in these deltas can often be very fertile (Egypt's delta produces most of the country's agricultural output, and half the country's population live on it)
- These deltas contain many distributaries

Nile Delta at night from ISS



(i) Examine the photographs above and match each of the named landforms in the table below with one of the letters on the photographs.

Landform	Letter
Waterfall	
Interlocking Spur	
Meander	

2009 Ordinary Level

(ii) State **one** reason why farming might be popular in the floodplain of a river valley.

_____

_____

(iii) State **one** reason why farming might not be popular in the floodplain of a river valley.

_____

_____

[10 marks]

Exam Question

- 2008 HL Question 1(b):

Examine with the aid of a labelled diagram or diagrams the processes that have led to the formation of any one Irish landform of your choice

- Marking Scheme
  - Identify landform – 2 marks
  - Name one process – 2 marks
  - Irish example – 2 marks
  - Label Diagram – 4 marks
  - Examination – 10 SRPs (10 x 2 marks = 20)

Human Interaction with rivers

- Humans have interacted with rivers by building Dams, raising Levees (to reduce flooding) and attempting to change the course of rivers
- These projects have led to successes and failures.
- Successes
  - Hydroelectric power generated (e.g. Ardnacrusha, Three Gorges)
  - Improved economic use of rivers (Rhine)
  - Flood management (Clonmel)
  - Tourism potential (Blessington, Co. Wicklow)
  - Irrigation (Central valley scheme in California)

Human interaction with rivers

- Failures
  - Some hydroelectric (HEP) schemes (e.g. Three Gorges) have had negative environmental impact
  - Flood management often leads to overconfidence and overdevelopment of flood plains
  - Economic cost – drowned farmland, houses etc
  - Irrigation can lead to salt build up in soil
  - Straightening rivers can lead to erosion

The Rhine – Impact of Canalisation

- **Canalisation** is the construction of canals alongside a river to improve accessibility for boats
- In Ireland, the River Barrow and the River Boyne were both partly canalised in the 19th Century
- Advantage of Canalisation
  - Ease of transport – saves time and money
  - Able to manage small flooding incidents
- Disadvantage of Canalisation
  - Greater flooding risk
  - Environmental damage

Canalised Rhine

Three Gorges Dam, China

Ardnacrusha (HEP Plant on the Shannon)

3 Gorges - Impact of Dam Building

- Erosion affected (surges of water vs steady flow)
- Deposition of alluvium behind Dam
- Flooding of Land during building
- Floods managed after construction
- Seawater invasion of River Estuary (?)
- Deltas deprived of sediment

Flood Control - Clonmel

Clonmel – human and natural factors leading to flooding

- Human factors (narrow bridge, weir preventing quick river flow)
- Natural factors – (Confluence of rivers, flood plain, heavy rainfall)

- Solutions:
  - Remove blockage points on river
  - Improve levees and flood defences

Old Bridge on Suir – a chokepoint

Weir on Suir – a Chokepoint

Aral Sea – a victim of irrigation

July - September, 1989

August 12, 2003

Aral Sea

- Rivers that used to flow into it have been diverted for irrigation of farmland
- As a result the salt from dried up seabed has been blown by wind over farmland – making it useless
- Weather patterns changed – leading to desertification

Aral Sea - today

HUMAN INTERFERENCE 2008 Ordinary Level LC

People try to control the natural processes at work in the landscape that may cause disasters such as landslides or flooding (as seen in the above photograph).
With reference to an **example** which you have studied, describe and explain **one** way humans can control river processes or marine processes or mass movement.

Scheme
One way in which humans can control natural processes @ 30 marks graded.

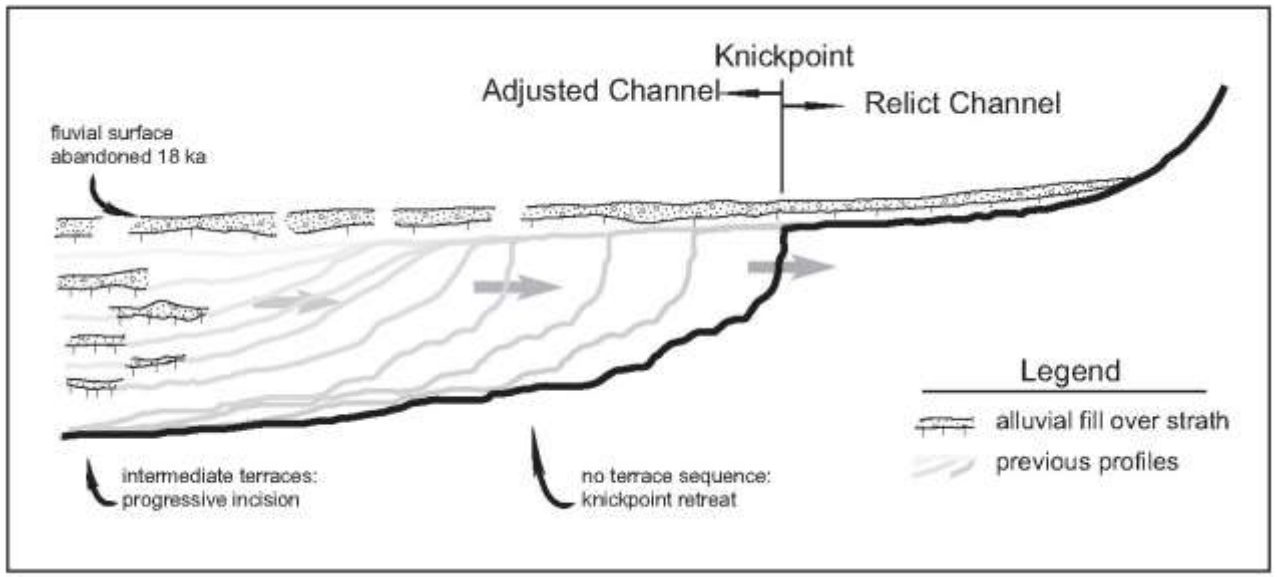
Control named =	**2 marks**
Naming a process to be controlled	**2 marks**
Way explained/described.	
8 SRPs @ 3 marks each	**24 marks**
Any valid example	**2 marks**
	Total Marks 30

River rejuvenation

- Rejuvenate – to restore to a former state: to make new again
- River rejuvenation refers to the river flowing faster with more energy to reach sea level (Known as the river's **base level**)
- Can happen either because the sea level falls (e.g. during an ice age) - this is known as **eustatic changes**
- ….or because land rises because of uplift (**isostatic** uplift)
- Ireland's rivers show evidence of rejuvenation because the sea levels fell (during the last ice age) and also because Ireland's landmass has risen over millions of years (much of Ireland was underwater at the time of the dinosaurs)
- A rejuvenated river begins to **erode vertically** in the **old age** section of the river

Knickpoints

- These are points at which the river gains speed and as a result it's ability to erode increases
- Happens when the river leaves its old profile and begins to erode a new profile to reach it's new (lower) base level
- Usually marked by waterfalls or rapids



Knickpoint – river increases speed

Incised meanders

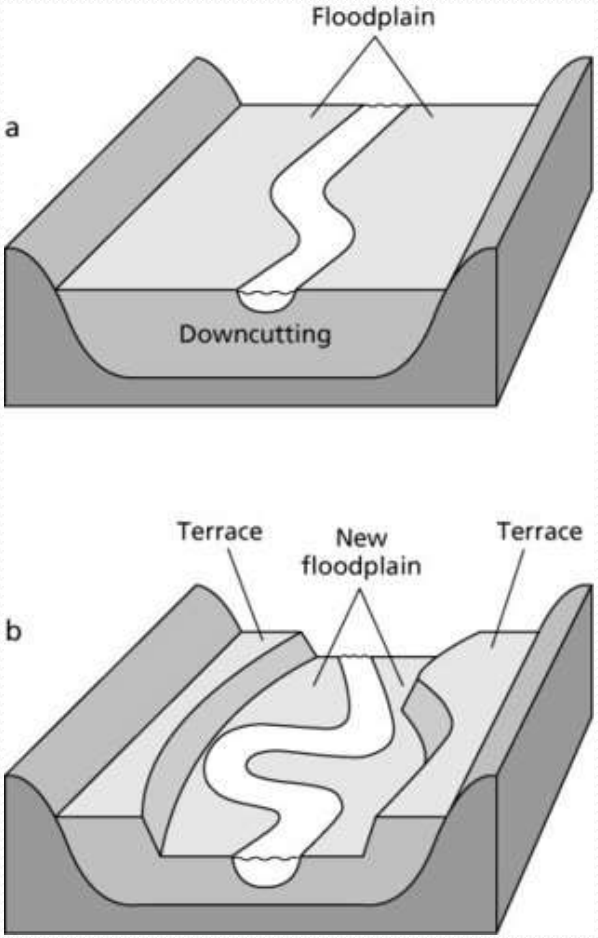
- As the river gets a boost in velocity from rejuvenation and from knickpoints, “old age” features such as meanders are subject to vertical erosion
- This leads to the creation of very deep meanders where the river has begun to vertically erode into the river bed.
- Irish example: River Nore, Kilkenny

Incised Meander, Nevada, USA

River Terrace

- These occur when a river flowing across a flood plain is rejuvenated
- The faster flowing river cuts a deeper channel for itself – this leads in time to a new flood plain “below” the old plain
- Old flood plain is left high and dry as a River Terrace

River Terraces



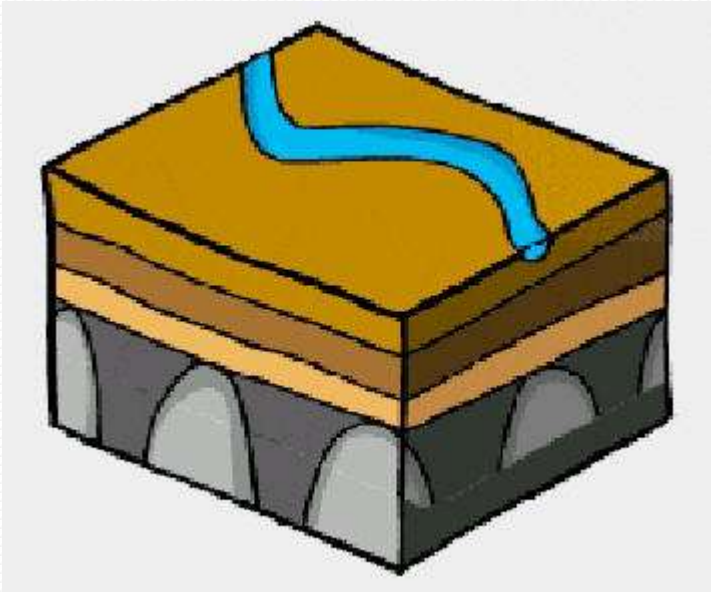
Superimposed Rivers

- Superimposed rivers are rivers that don't seem to follow the course that they should – cutting through hills rather than going around them

Superimposed Rivers

- For most rivers, the direction of flow is a result (a consequence) of the landscape over which they flow.
- These rivers are thus known as **consequent** streams
- However if the area over which the river flows is subject to erosion and/or uplift then the river can erode through the landscape as it is being slowly exposed
- This ends up with the river seemingly able to flow through hills, seemingly in violation of the laws of nature
- Irish Example: River Lee and Shournagh River, Cork

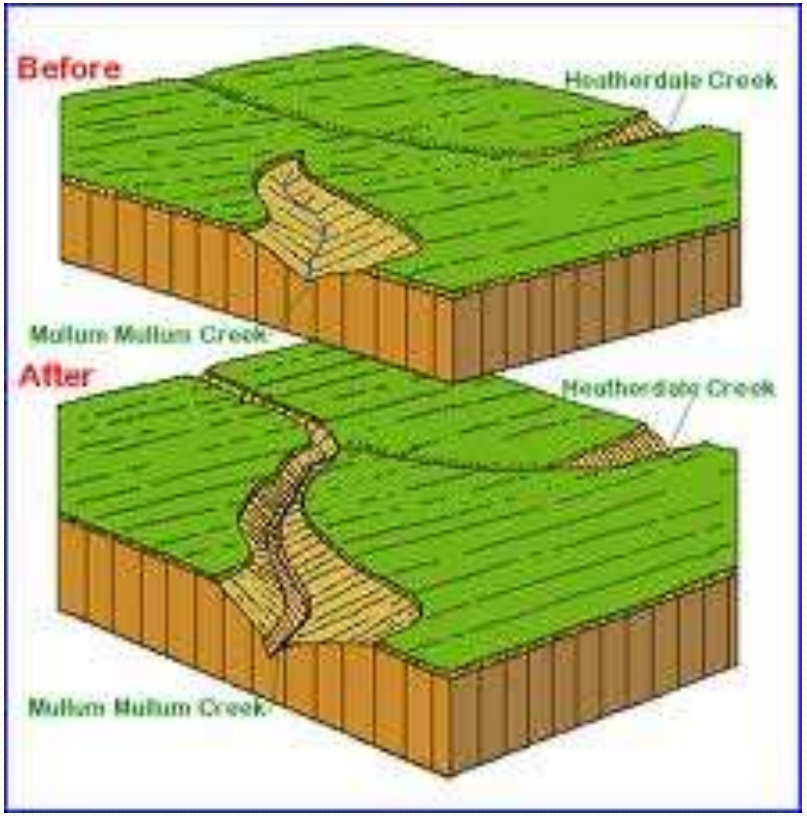
Superimposed Rivers



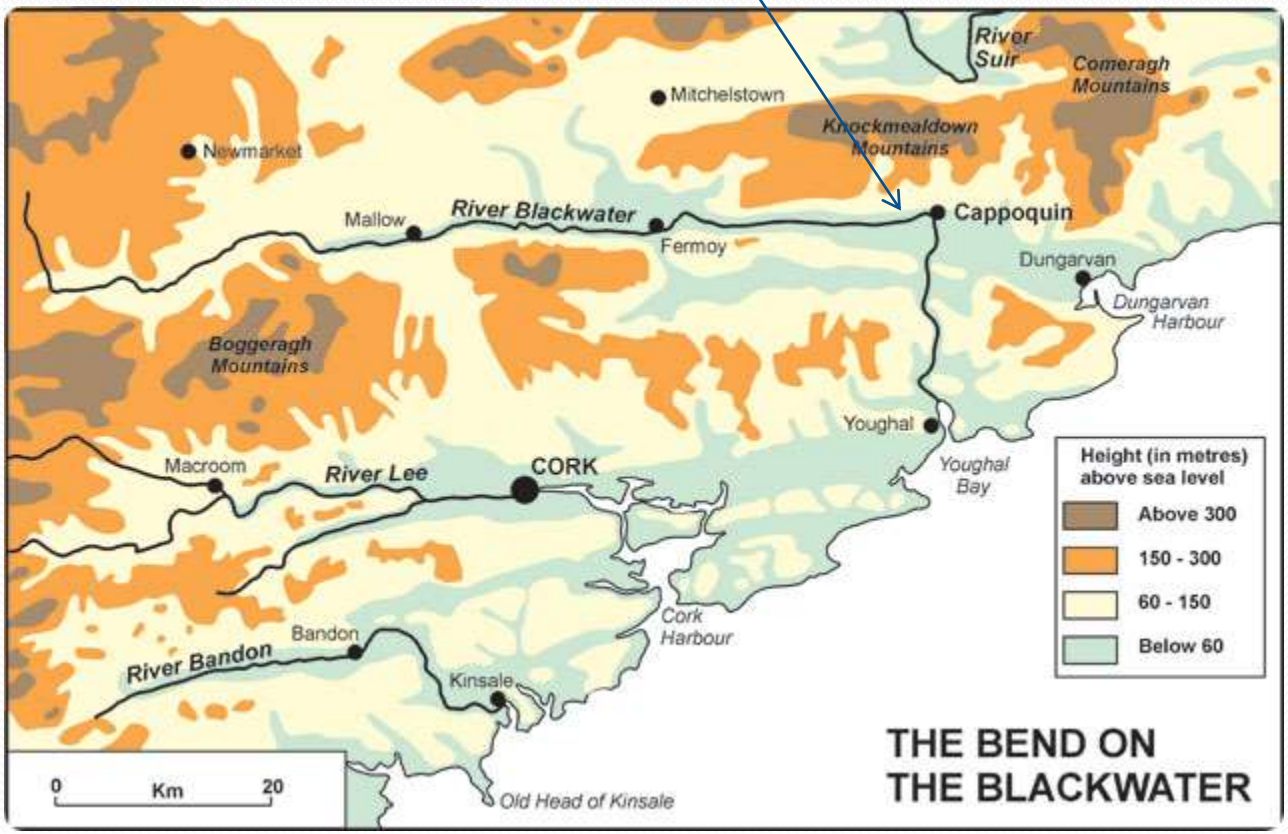
On the left, the subsequent river is flowing over layers of soft rock. As these layers are slowly eroded away, the river cuts through the exposed hard rock ridges and has superimposed itself on the landscape

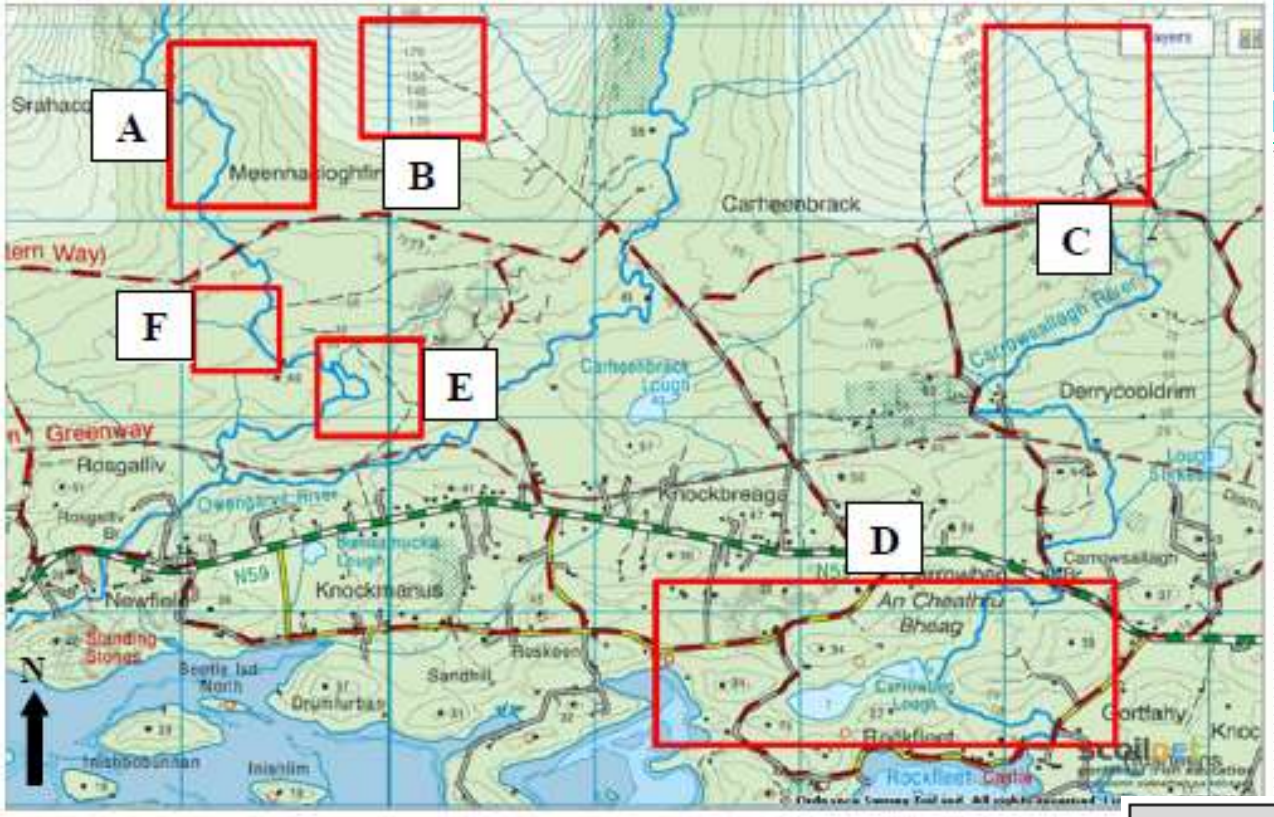
River Capture

- This can be caused by “headward erosion” as the river erodes back from it’s source until it reaches another river and “captures” it



River Capture





Landform / Pattern	Letter
Trellis drainage	
Even slope	
Dendritic drainage	
Concave slope	
Drumlins	
Cut-off meander	

2011 LC Paper (Higher)

- Explain how isostatic changes have impacted on the Irish landscape, using examples that you have studied [30m]

- Impact /Feature identified 2 + 2 marks
- Example 2 + 2 marks
- Explanation 11 x SRPs
- Accept features of emergence only
- Accept river features of rejuvenation
- Give credit for 1 SRP for a 3rd named feature
- All other features must be explained
- Give credit for 1 SRP for diagram without annotation
- Credit relevant diagrams with extra information

2010 LC Paper (Higher) – 30 Marks

- With reference to an example you have studied, describe and account for one way in which humans attempt to influence or control natural processes. In your answer, refer to one of the following:

- Fluvial processes
- Marine processes
- Mass movement.
- Influence / Control identified: 2 marks
- Named Example / Location: 2 marks
- Reference to natural process: 2 marks
- Discussion: 12 x SRPs
- Max 6 SRPs for discussion without reference to influence or control
- Question not tied to Ireland
- Amalgamate all relevant discussion

Conflict over Rivers

- Not just a factor in landscape creation, rivers are becoming vitally important to modern society for water supply, power (hydroelectricity), irrigation of farmland, access for shipping and as a waste management system
- In a Warming World, rivers will become an even more vital to our well being
  - Status of River Jordan is a sensitive issue in Israeli – Palestinian peace process – both sides want **access** to the river

River Jordan – a border

Conflict in Ireland over water

- http://www.rte.ie/news/2010/0713/water.html#video
- http://www.shannonprotectionalliance.ie/

Conflict over water

- In favour of the proposal or against?
  - Positives?
  - Negatives?
  - For Dublin?
  - For the Midlands?
  - Solutions?