GCSE Geography

Unit One: The Coastal Zone.

Question 7.

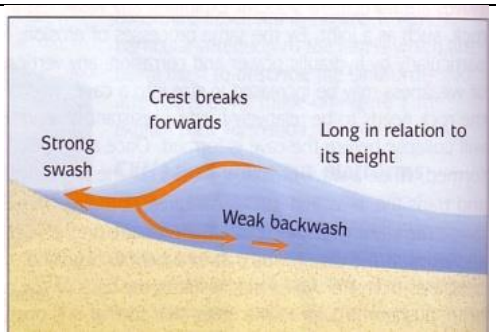
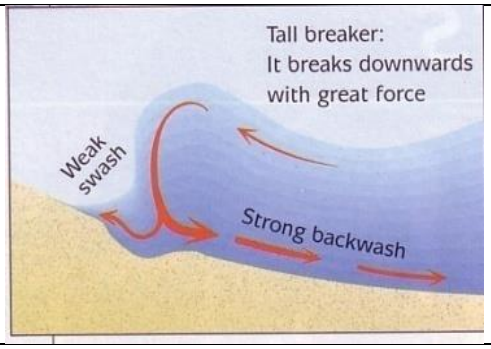
The Coastal Zone

Section of Topic	Pages:	Notes?	Understanding?
COASTAL PROCESSES: Weathering: mechanical & chemical. Mass movement: sliding & slumping. Waves: constructive & destructive. Erosion: hydraulic power, abrasion, attrition & solution. Transportation: longshore drift, traction, saltation, suspension & solution. Deposition: what it is, and where & why it happens.	**64/66**		
COASTAL LANDFORMS: Erosional landforms: characteristics and formation of headlands & bays, cliffs &wave cut platforms, caves, arches & stacks. Depositional landforms: characteristics and formation of beaches, spits & bars.	**65/67**		
RISING SEA LEVELS: Reasons: global warming, the greenhouse effect & greenhouse gases, thermal expansion & melting ice caps. Case study: illustrating the economic, social, environmental and political impact of coastal flooding.	**69/70**		
COASTAL EROSION & CLIFF COLLAPSE: Case study: rates of coastal erosion, reasons why some areas are susceptible to undercutting by the sea and collapse, how people may worsen the situation, the impact of people's lives and the environment.	**71**		
COASTAL MANAGEMENT STRATEGIES: Hard engineering: the costs and benefits of sea walls, groynes & rock armour. Soft engineering: the costs and benefits of beach nourishment, dune regeneration, march creation, & managed retreat. Case study: assessing the costs and benefits of coastal management strategies.	**72/73**		
COASTAL HABITATS: Case study: a coastal habitat's environmental characteristics, the resulting habitat, the species inhabiting it, and the reasons why. Strategies to ensure the environment is conserved and also used in a sustainable way.	**74**		

Key Terms

Fetch	The distance over which a wave travels
Beach	A deposit of sand or shingle at the coast, often found in a bay
Swash	The forward movement of a wave up the beach
Backwash	The backward movement of water down the beach after the wave has broken
Constructive Wave	A powerful wave with a strong swash that surges up the beach
Destructive Wave	A wave perhaps formed from a local storm that crashes onto a beach and has a powerful backwash

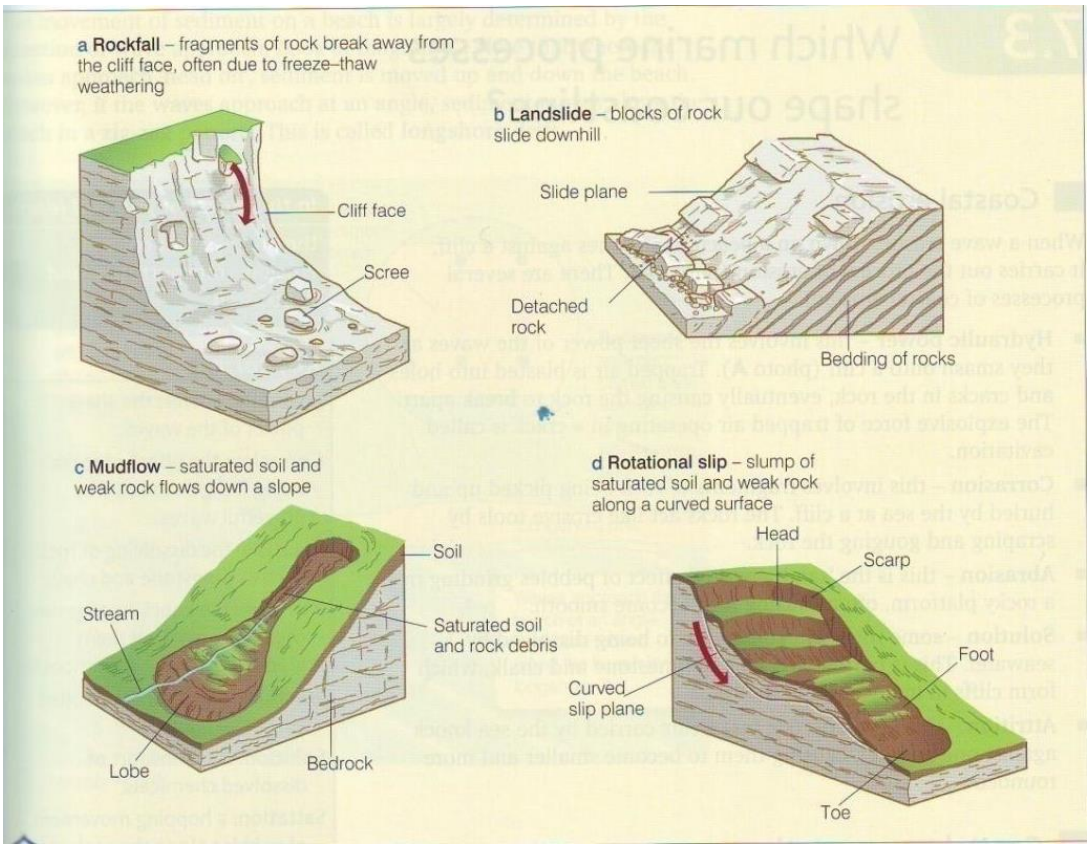
Types of Waves

Constructive Waves	**Destructive Waves**
	
• Short fetch	• Long fetch
• Light breeze	• Stormy conditions
• Waves roll gently	• Waves collapse vertically
• Swash bigger than backwash	• Backwash stronger than swash
• Builds beach	• Removes material from beach

Types of Weathering

Mechanical **Freeze-thaw**	Successive freezing & thawing of water trapped in cracks between rocks. Over time this causes cracks to widen and rock to break free
Mechanical **Exfoliation** (Onion Skin)	Repeated heating and expansion, then cooling & contraction of the surface layers of rock. Over time this causes surface layers to peel off like sunburnt skin
Chemical **Solution**	This is the dissolving of rock or minerals by rainwater
Chemical **Carbonation**	Similar to solution but only affects chalk and limestone by acidic rainwater
Biological	Root action from trees and burrowing from animals

Mass Movement



Types of Erosion

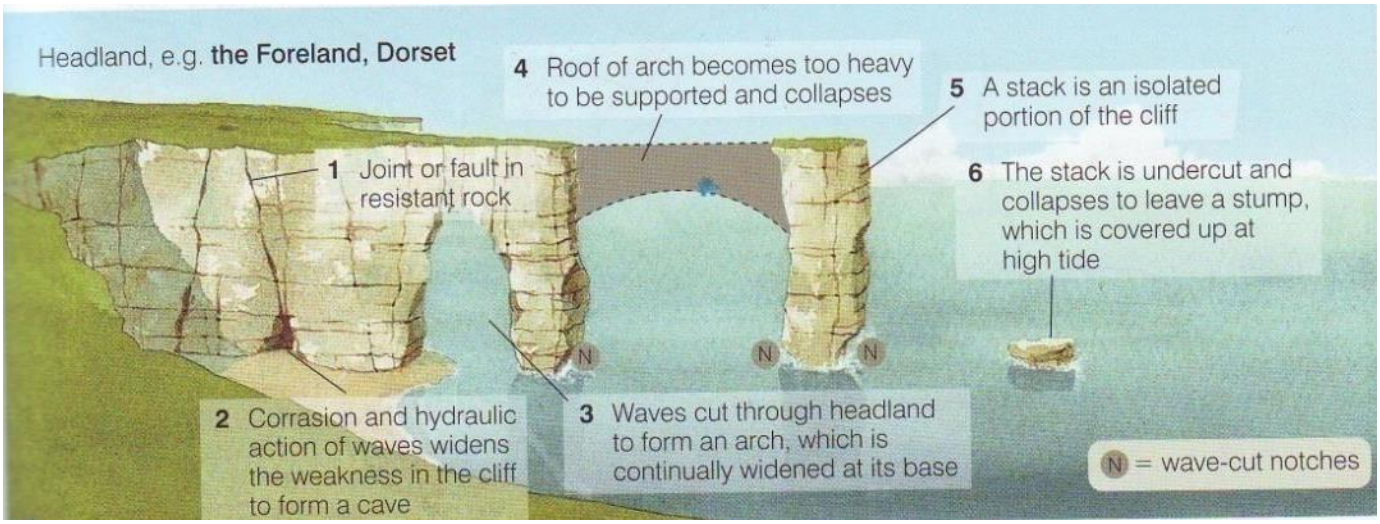
Abrasion	This is the process by which the coast is worn down by material carried by the waves. Waves throw these particles against the rock, sometimes at high velocity.
Solution	This is the chemical action of sea water. The acids in the salt water slowly dissolve rocks on the coast. Limestone and chalk are particularly prone to this process.
Hydraulic action	This process involves the force of water against the coast. The waves enter cracks (faults) in the coastline and compress the air within the crack. When the wave retreats, the air in the crack expands quickly causing a minor explosion. This process is repeated continuously.
Attrition	Material carried by the waves bump into each other and so are smoothed and broken down into smaller particles.
Corrasion	Rocks being picked up and thrown against a surface

Types of Transportation

Solution	Minerals are dissolved in the water and carried along in solution
Suspension	Fine light material is carried along in the water
Saltation	Small pebbles and stones are bounced along the river bed
Traction	Large boulders and rocks are rolled along the river bed

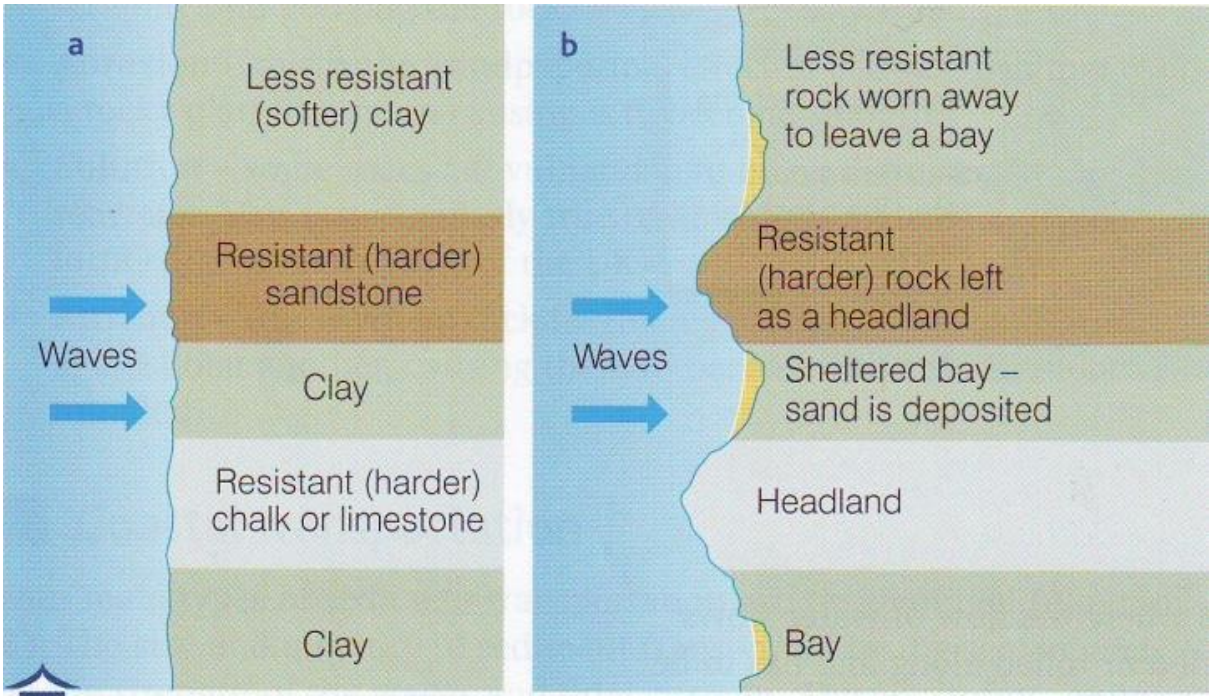
Erosional Coastal Landforms

Stack formation



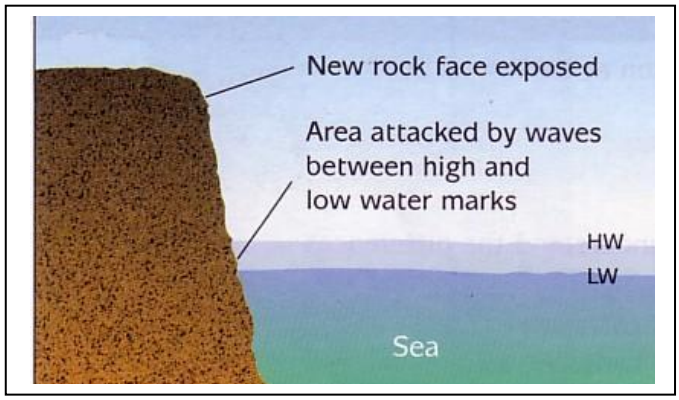
1. **Headland** attacked by **hydraulic action, corrasion and attrition**. **Cracks** begin to appear.
2. **Cracks** are widened to create **sea caves** on **either side of headland**.
3. Two caves may join up to create an arch. Eventually the roof of the arch will collapse…
4. …leaving a stack.
5. Hydraulic action, corrasion and attrition continue to erode the stack – especially at the base. Eventually the stack collapses leaving a stump and/or a wave-cut platform.

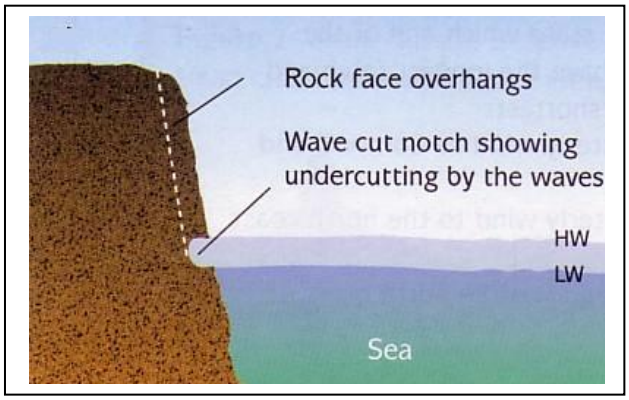
Bays & Headlands

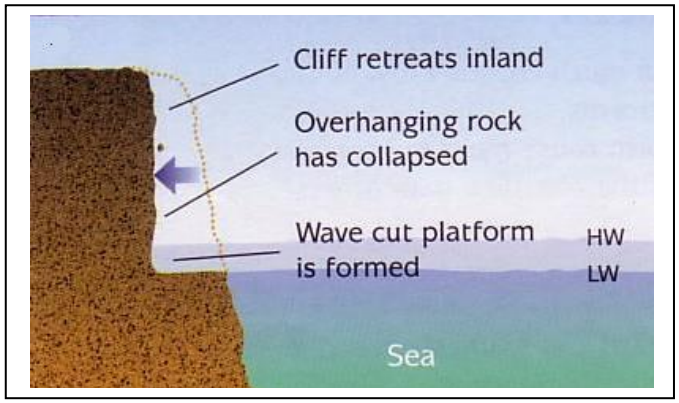


1. A bay forms where along a coastline where there are <u>two types of rock</u>, a band of hard and soft rock.
2. The <u>soft rock erodes quicker</u> than the hard rock, due to processes such <u>as hydraulic action, corrosion and abrasion.</u>
3. The <u>soft rock erodes backwards to form a bay</u>, leaving a headland either side sticking out to sea.

Cliff Retreat, Wave Cut Notches and Wave Cut Platforms







1. The foot of a cliff is attacked by the action of the waves.

2. Erosional processes such as hydraulic action, corrosion and attrition erode the foot of the cliff, to create a wave cut notch.

3. The wave cut notch is eroded deeper into the cliff, leaving an overhang.

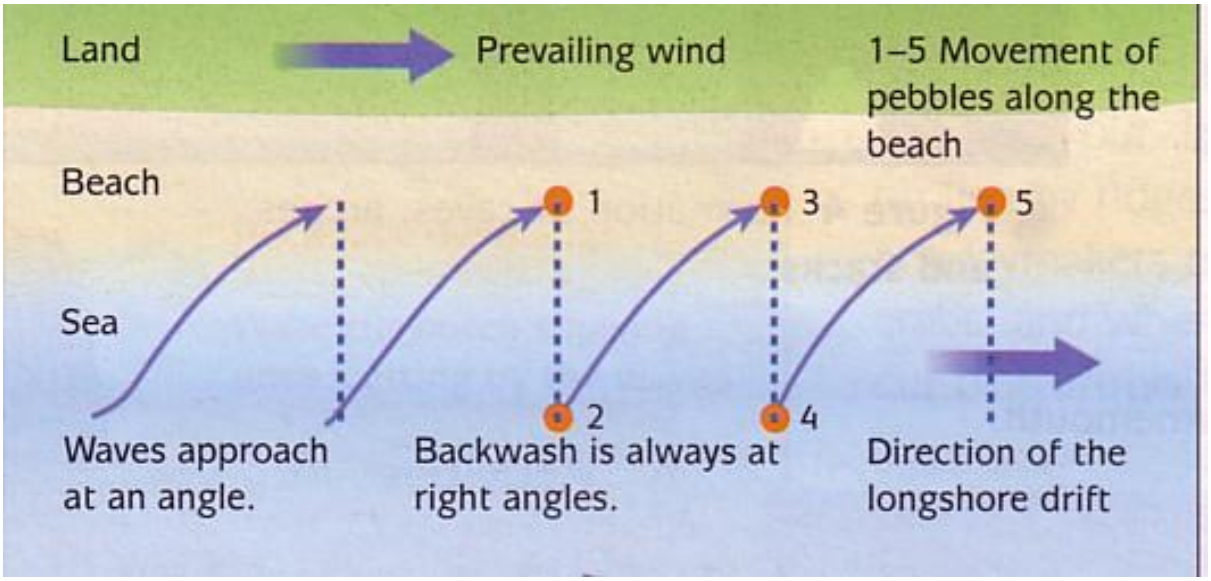
4. The overhanging rock eventually collapses under the force of gravity, causing the cliff to retreat.

5. The retreating rock leaves a wave cut platform, which is the very base of the cliff which is not eroded as it is below the low water mark.

A picture of a Wave Cut Notch

A picture of a Wave Cut Platform

Longshore Drift



- **Longshore drift** is the name given to the process by which **beach material** is **transported along the coast** by the **action of waves**.

- Waves rarely hit the beach at exactly right angles to the coast, and are far more likely to hit the beach at an angle.

- This is because in many areas **the prevailing wind** controls the **direction of the waves** and, obviously, very few long sections of coast are dead straight for miles and miles.

- When waves break on to a beach at an angle, material is pushed up the beach at the same angle by the **swash**, but pulled back down the beach by the **backwash at ninety degrees** to the coast.

- The sediment is moved **across** the beach as well as up it.

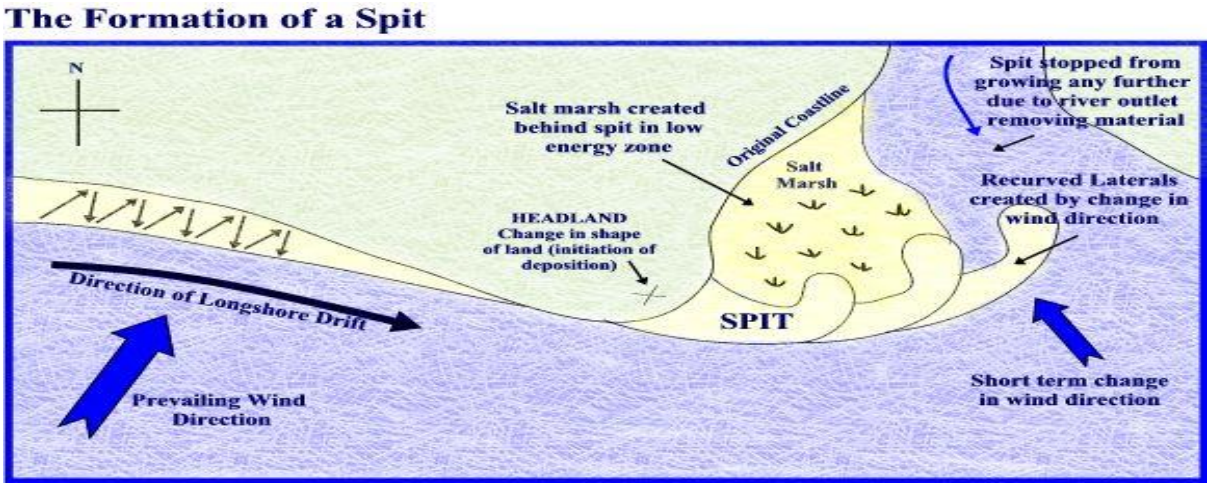
- When the wave runs out of energy the water starts to flow back towards the sea. Gravity pulls it straight down the beach, so the returning water follows a different path to the one it followed on the way up it.

- Each wave can move the **sediment** a little further across the beach.

Depositional landforms
Beaches

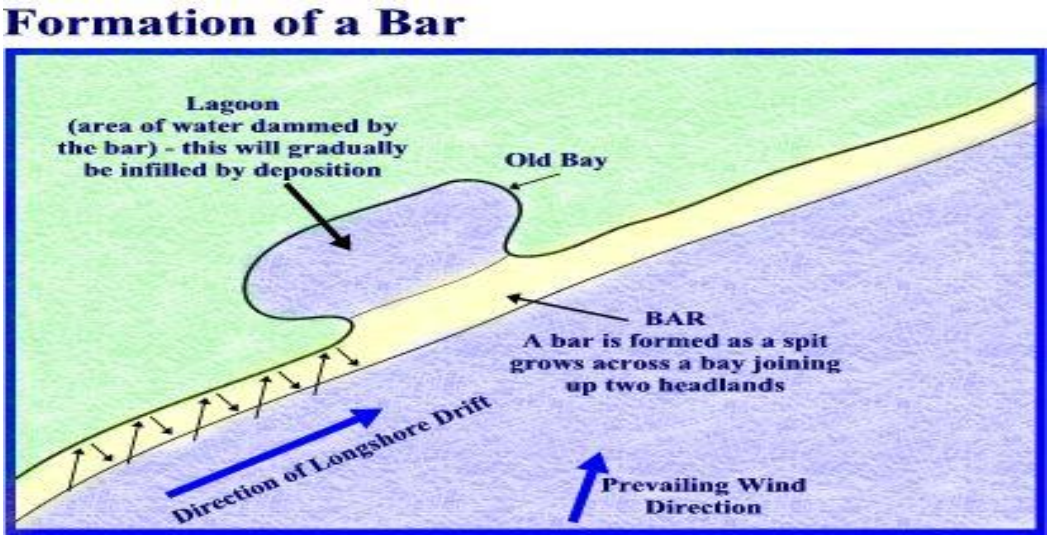
- **Beaches** are made up of **eroded material** that has been **transported** from elsewhere and **deposited** by the sea.
- **Constructive** waves help to build up beaches.
- The material found on a beach (ie sand or shingle) depends on the **geology** of the area and wave energy.

Spits



- **Spits** are **long narrow ridges of sand** and **shingle** which **project** from the **coastline into the sea**.
- spits begin due to a **change** in the **direction of a coastline**
- the main **source of material** building up a spit is from **longshore drift** which brings material from further down the coast.
- Where there is a **break in the coastline** and a **slight drop in energy**, **longshore drift** will **deposit material** at a **faster rate** than it can be removed and gradually a ridge is built up, projecting outwards into the sea - this continues to grow by the process of longshore drift and the deposition of material.
- A **change in prevailing wind direction** often causes the **end of spits** to **become hooked**.
  On the spit itself, **sand dunes** often form and **vegetation colonises** (Blakeney Point - North Norfolk)
- **Water** is **trapped behind the spit**, creating a **low energy zone**, as the water begins to stagnate, mud and **marshland** begins to develop behind the spit (Spurn Point, Holderness Coast)
- Spits may continue to grow until deposition can no longer occur, for example due to increased depth, or the spit begins to cross the mouth of a river and the water removes the material faster than it can deposited - preventing further build up (Spurn Point, Holderness Coast)

Bars



- These form in the same way as a spit initially but bars are created where a spit grows across a bay, joining two headlands.

Coastal Flooding

Coastal flooding can be caused by storm surges, sea level rise and tsunami:

Storm surges

Storm surges, **large waves** produced by **very strong winds**, are a main cause of coastal flooding in low-lying areas. The biggest floods occur when larger-than-**normal tides** and storm surges occur at the same time. (East Anglia, UK 1953)

Sea level rise

Sea level rise is a relatively slow process, connected to **Climate Change**, which may increase the **frequency and severity of storms**, bringing unusually high tides, and changes in winds, waves and currents. (Bangladesh)

Tsunami

Tsunami are giant waves that can flood coastal areas. They can occur after **earthquakes, volcanic eruptions, and deep sea landslides** (Sendai, Japan 2011)

What has been done to reduce the risk of flooding:

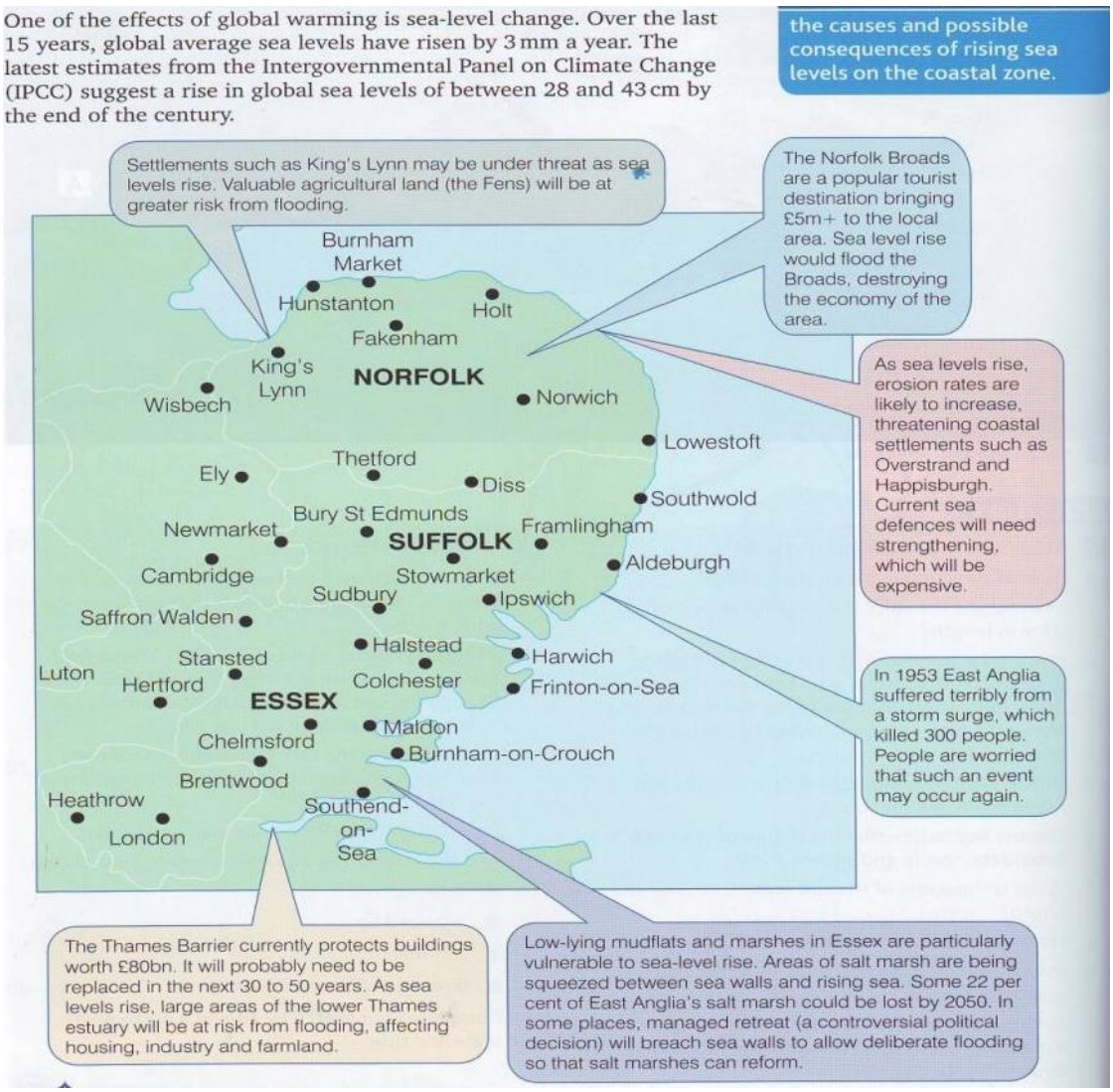
- Mangrove swamps being planted off coast to increase amount of land that makes storm surges etc... lose their energy
- **Embankments** have been built to protect coast - more importantly, they have been maintained.
- Efficient **early warning system**
- Large **concrete shelters** built above flood levels to protect people - strong enough to withstand strong winds.

Sea Level Rise

Causes –

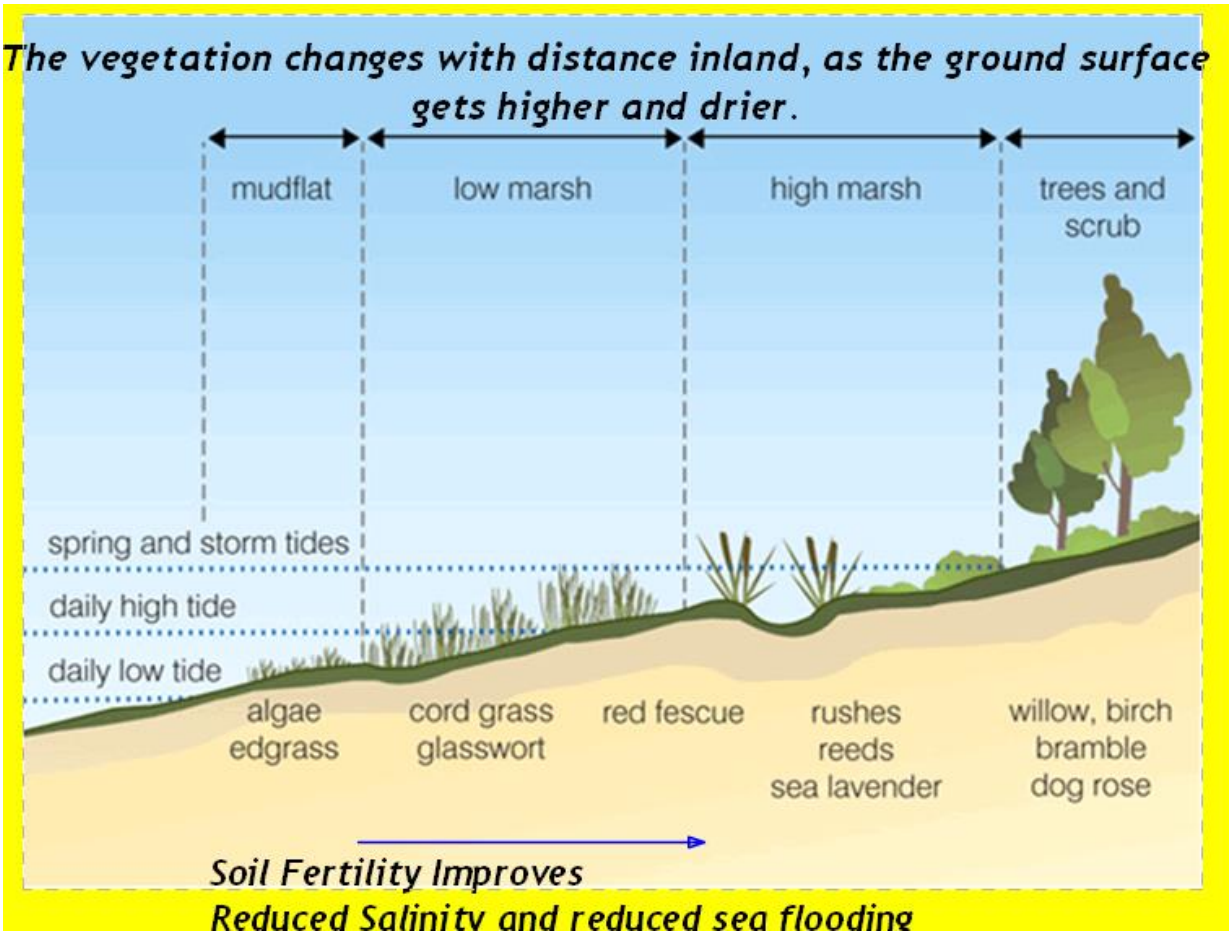
- Ice caps are melting due to global warming
- Thermal expansion of seawater due to global warming

Effects of Sea Level Rise



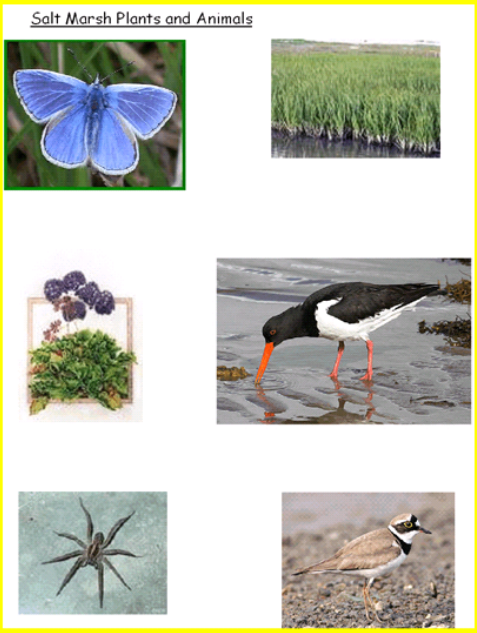
Salt Marshes

Salt Marsh Succession



Plants and Animals in Salt Marshes

- Wold Spider - clings submerged to cordgrass waiting for low tide
- Oystercatcher - feeds and nests in marshes
- Sea Lavender - in the high marsh - colourful flowers attract wildlife
- Ringed Plover - feeds intertidally and nests in salt marsh
- Common Blue butterfly lives in high marshes
- Cordgrass - grows fast on mudflats



Threats to salt marshes

1. Sea level is rising due to climate change & the land along the south east of England is tilting towards the sea
2. Recreational use - walkers can damage saltmarsh.
3. Grazing can be beneficial if it controls coarse grasses, but sometimes it reduces the height of the vegetation and the diversity of plant and invertebrate species. This reduces bird life
4. Defences to protect the land from the rising sea may be built on saltmarsh or they may change the movement of the sediment necessary to maintain saltmarshes and mudflats.
5. Ideally salt marsh need to be able to 'move' in response to changing conditions. Many saltmarshes are being 'squeezed' between the rising sea and fixed flood defence walls
6. Wave action (including wash from boats) can damage and erode the marsh
7. Oil & waste tipping can cause die-back, while sewage & water pollution can lead to the growth of green algae (eutrophication)

Management of Salt Marshes

Salt marshes are fragile environments. They need to be managed to be preserved.

1. Some areas have been designated SSSIs (Sites of Special Scientific Interest) because of the variety of flora and fauna found. This gives them legal protection and prevents unsuitable development.

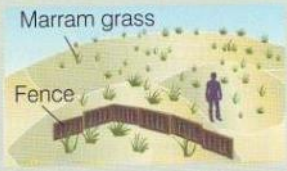
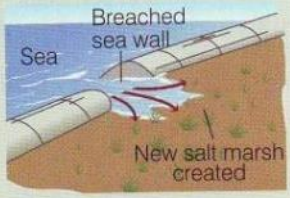
2. Some areas are used for grazing sheep which have to be moved regularly so they do not damage the environment. They are useful in keeping the long grass down.

3. Salt marshes have been preserved as conservation areas/nature reserves with controlled public access. They will often have:
    - Cord grass planted to protect the marsh
    - Boardwalks
    - Areas cordoned off to stop erosion
    - Education centres
    - Information signs

Coastal Management
Hard Engineering

Hard engineering	Description	Cost	Advantages	Disadvantages
Sea wall 	Concrete or rock barrier to the sea placed at the foot of cliffs or at the top of a beach. Has a curved face to reflect the waves back into the sea, usually 3–5m high.	Up to £6 million per km (south sea zones).	• Effective at stopping the sea. • Often has a walkway or promenade for people to walk along.	• Can be obtrusive and unnatural to look at. • Very expensive and has high maintenance costs.
Groynes 	Timber or rock structures built out to sea from the coast. They trap sediment being moved by longshore drift, thereby enlarging the beach. The longer beach acts as a buffer to the incoming waves, reducing wave attack at the coast.	£10,000 each (at 200m intervals).	• Result in a bigger beach, which can enhance the tourist potential of the coast. • Provide useful structures for people interested in fishing. • Not too expensive.	• In interrupting longshore drift, they starve beaches downdrift, often leading to increased rates of erosion elsewhere. The problem is not so much solved as shifted. • Groynes are unnatural and rock groynes in particular can be unattractive.
Rock armour 	Piles of large boulders dumped at the foot of a cliff. The rocks force waves to break, absorbing their energy and protecting the cliffs. The rocks are usually brought in by barge to the coast.	Approximately £1,000 –£4,000 per metre.	• Relatively cheap and easy to maintain. • Can provide interest to the coast. Often used for fishing.	• Rocks are usually from other parts of the coastline or even from abroad. Can be expensive to transport. • They do not fit in with the local geology. • Can be very obtrusive.

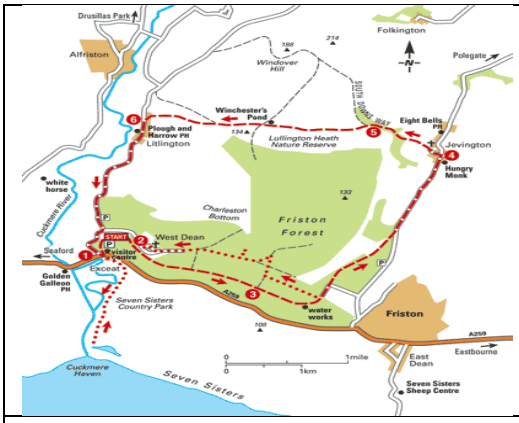
Coastal Management
Soft Engineering

Soft engineering	Description	Cost	Advantages	Disadvantages
Beach nourishment 	The addition of sand or shingle to an existing beach to make it higher or broader. The sediment is usually obtained locally so that it blends in with the existing beach material. Usually brought onshore by barge.	Approximately £3,000 per metre	• Relatively cheap and easy to maintain. • Blends in with existing beach. • Increases tourist potential by creating a bigger beach.	• Needs constant maintenance unless structures are built to retain the beach.
Dune regeneration 	Sand dunes are effective buffers to the sea yet they are easily damaged and destroyed, especially by trampling. Marram grass can be planted to stabilise the dunes and help them to develop. Areas can be fenced to keep people off newly planted dunes.	Approximately £2,000 per 100 m	• Maintains a natural coastal environment that is popular with people and wildlife. • Relatively cheap.	• Time-consuming to plant the marram grass and fence off areas. • People do not always respond well to being prohibited from accessing certain areas. • Can be damaged by storms.
Marsh creation (managed retreat) 	This involves allowing low-lying coastal areas to be flooded by the sea to become salt marshes. This is an example of managed retreat. Salt marshes are effective barriers to the sea.	Depends on the value of the land. Arable land costs somewhere in the region of £5,000 to £10,000 per hectare	• A cheap option compared with maintaining expensive sea defences that might be protecting relatively low-value land. • Creates a much-needed habitat for wildlife.	• Land will be lost as it is flooded by sea water. • Farmers or landowners will need to be compensated.

Useful video clips:
http://www.bbc.co.uk/learningzone/clips/topics/secondary/geography/coastal_environment_processes_and_landforms.shtml

http://www.bbc.co.uk/learningzone/clips/topics/secondary/geography/coastal_environment_conflict_and_management.shtml

Managed Retreat at Cuckmere Haven, East Sussex



Plan:

- To withdraw maintenance of sea defences & river defences over a 5 year period – currently costing £30,000 / yr
- To make 2 gaps in the levees near the mouth – aid tidal flooding
- To allow pasture to revert to salt marsh

Benefits:

It is sustainable because:

- It will allow the area to revert to its natural state & increase a habitat currently in decline in the UK
- It will increase biodiversity – RSPB in favour
- Salt marshes are an effective form of soft management – reduce wave energy
- DEFRA believe it may reduce erosion at Birling Gap by increasing sediment flow
- Will attract bird watchers to the area & therefore continue to support local businesses
- Educational benefits – fieldwork / case study for GCSE / AS / A Level students
- Cheap alternative in the face of rising sea levels – sacrificing land of low economic value
- The river will alter course & eventually develop a bar – a natural sea defence

Drawbacks:

- The world famous meanders will disappear
- No access to the beach at high tides
- The South Downs Way coastal path will need to be re-routed for walkers at high tides
- Current flora and fauna will be replaced – the transition period will be unattractive & local businesses will suffer (The Outdoor pursuit Centre / The Golden Galleon/ Exceat B&B)
- The river will alter its course over time

BEACHY HEAD & EASTBOURNE, S.E. ENGLAND
A Case Study of Coastal Erosion & Management

LOCATION:

- On the **Channel coast**
- Between **Beachy Head** to the west (chalk headland) & **Langney Point** to the east
- To the **west are chalk cliffs** (180m high) with seams of more resistant **flint**. This then runs into a heavily managed bay of beach replishment
- The **cliff line** is **retreating** at an alarming rate
- The **coastal resort of Eastbourne** is located in the **bay** & is home to around **90,000** people
- The town also has a **new marina** complex on the **low-lying land** to the **east** of the town

CAUSES OF RETREAT:

1. The **cliffs** form a **headland** & are made up of **chalk** which is **weathered** – freeze-thaw, biological & chemical & **eroded** – hydraulic action, corrosion, corrosion.

2. The Coast is exposed to **prevailing South Westerly winds** for much of the year.

3. **Beaches** beneath Beachy Head are **narrow** & afford **little protection** from **destructive waves** - eroding the base of the cliffs (hydraulic action etc.)

4. **Most of the material eroded** from the cliffs is **washed out to sea**, the rest is moved by **longshore drift** - the beaches are therefore narrow and do little to protect the coastline. (If the beaches were wider, the waves would break on the beaches reducing their erosive power).

5. The coastline is threatened further by **sea-level rise**, especially to the **east of the town**.

6. **Natural shingle beach** to **east** of the town **brought up from SW** is diminishing – **soft & hard engineering**

EFFECTS OF RETREAT:

- The coast is **receding up to 1 metre a year**.
- **10th Jan. 1999,** when up to **6 metres of cliff edge tumbled away, to a depth of 17 metres over a 70 metre long stretch** – rate of **erosion** expected to **increase** as **sea levels rise** due to **global warming**.
- 17th March 1999 in a remarkable feat of engineering work the **Belle Tout** was **moved** 17 metres (56 ft) away from the cliff face
- **The Sovereign harbour development** is at risk from future **sea level rise**
- Town has a **Coastal management & Flood Plan**

COASTAL MANAGEMENT:

- The **South Downs Coastal Group** (SDCG) and the **South East Coastal Group** (SECG) were set up in the mid **1990's** with the primary aim of producing Shoreline Management Plans.
- Eastbourne's **main defence** against the sea is the **shingle bank**. Much of the coastline consists of a **shingle upper beach** and a **sandy lower foreshore** -shingle absorbs wave energy & is kept in place by the **Greenheart wood groynes**. (Longshore Drift along Eastbourne's coastline is from west to east.
- **Storms in 1989 & 1990** removed much of the beach replenishment & damaged ageing groynes
- major scheme in the mid to late 1990's - total cost of the scheme was **£30m** and was **grant aided DEFRA**.
- The new groyne field consists of **94 timber**

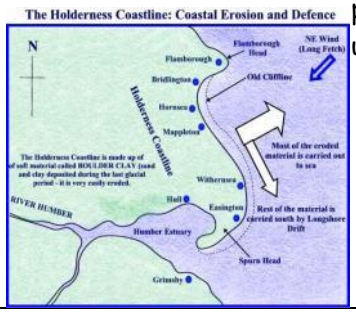
	groynes that run from **Holywell to Langney Point** – groynes are from sustainable sources in **Guyana, South America** • A **concrete seawall**, providing secondary protection, runs along the landward side of the beach from **Holywell to the Fishing Station**. In some areas **additional rock armour** have been installed to protect vulnerable sections • The **maintenance work** is currently carried out by **Pevensey Coastal Defence Ltd**, who are contracted to carry out this work until 2009. The work undertaken by them includes Beach re-profiling work (generally carried out in March/April) to retain the maximum volume of available beach material in each groyne bay.
EFFECTS OF COASTAL MANAGEMENT AT EASTBOURNE: • Those living **east of Eastbourne** have experienced the **'knock-on' effects** of the coastal management. • The **groynes & harbour mole have disturbed the natural longshore drift movement** • **Beaches** replenishment has to be moved from east to west – **Pevensey Coastal defence Company** contracted	**CONFLICT ON THE COAST:** • Issues over choice of **hardwoods** for **groynes** – due to pressure from **Friends of the Earth** the town ch**oose sustainably** produ**ced Greenheart** from **Guyana** • The construction of the **marina** has **increased erosion rates** further down the coast **at Pevensey Bay** • **Construction of Harbour** saw the destruction of a **SSI** – **local environmentalists** unhappy • Issues over money spent on flower gardens etc to attract tourists

HOLDERNESS COAST, N.E. ENGLAND

A Case Study of Coastal Erosion & Management

LOCATION:

- On the **North Sea** coast
- Between **Flamborough Head** (chalk headland) & **Spurn Head** (a spit)
- The coastline is mainly made up of **cliffs (20-30m high**), consisting of soft, easily eroded **glacial till**. Where the cliff line meets the **Humber Estuary**, a spit has formed due to the change in the direction of the coastline - **Spurn Head**.
- The **cliff line is retreating** at an alarming rate – av. **2m / yr** (fastest rate in Europe) - 4km of land have been lost since Roman Times, including many villages and farm buildings.
- **Easington Gas Station** (a North Sea Gas terminal) is situated on the cliffs top and its position is under threat.



CAUSES OF RETREAT:

1. The **cliffs are made up of soft glacial material** (glacial till - made up of sands and gravels). This is easily eroded by the waves and the cliffs are easily undermined & leads to widespread **slumping**

2. The Holderness Coast is **very exposed**, **approaching waves have a long fetch** over the North Sea.

3. **Beaches are narrow** & afford little protection from **waves are mainly destructive** - eroding the base of the cliffs (hydraulic action etc.)

4. Most of the Material eroded from the cliffs is washed out to sea, the rest is moved by longshore drift - the **beaches are therefore narrow and do little to protect the coastline**. (If the beaches were wider, the waves would break on the beaches reducing their erosive power).

5. The coastline is threatened further by **sea-level rise**.

EFFECTS OF RETREAT:

- **30 villages lost** since Roman times
- Campsites & farmland destroyed
- The **B1242 coast road** running through **Mappleton** is greatly threatened by cliff retreat – **high cost to replace**, **high economic value**
- **Local businesses threatened**
- **Loss of agricultural land**
- **Deposition** along **Spurm Head spit** & **Norfolk salt marshes**

COASTAL MANAGEMENT:

- **Cost £2million in 1991**
- use of **2 Norwegian rock groynes** to trap moving beach material and provide a protective beach in front of the cliff
- the construction of **sea walls and revetments** as wave-resistant structures at the **base of the cliffs**
- artificial **off-shore breakwaters like tyres and concrete blocks**, forcing waves to break off-shore.
- **sea wall used to protect Easington Gas Station (cost £4.5 million)**

NB: ***Due to extensive costs - only the most valuable areas of land are protected. Much of the area is farmland which is not protected.***

EFFECTS OF COASTAL MANAGEMENT AT MAPPLETON:	**CONFLICT ON THE COAST:**
• Those living **south of Mappleton** village have experienced the **'knock-on' effects** of the coastal management. • The **groynes at Mappleton have disturbed the natural longshore drift movement**, trapping the coastal material – no fresh sediment to replace eroded material • **Beaches** have become **even narrower to the south – erosion rates** increased to **between 10 & 20m. / year**	• **Farmers** to the south of Mappleton are experiencing **high rates of loss of land** to sea – their livelihood is under threat • **Academics** argue that the **loss of farmland produces sediment** to create **salt marshes on the Wash & Essex coast** thereby **protecting** important settlements – **Kings Lynn & London** • **Holderness Council** has an annual **budget of £4million** – Mappleton **defences cost £2million** & will need **constant maintenance** • From an **economic** point of view **farmland is of less value** than **infrastructure** – roads, gas terminals etc