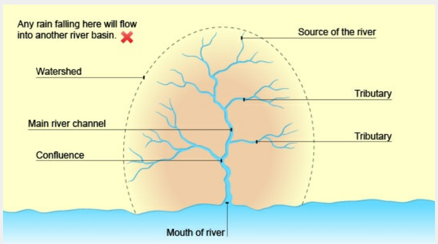
The Drainage Basin: A Component of the Water Cycle

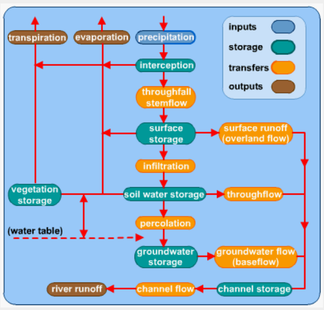
The Drainage Basin **

On the land, water is stored on the surface as *lakes* and *rivers*. Each river is contained within its own *drainage basin*. This is the area of land drained by a river, from its *source* to its *mouth* where it ends by meeting the *sea*, or *ocean* or *lake* and its *tributaries*. The boundary of a drainage basin follows a ridge of high land known as the *watershed*. A *confluence* is when a tributary meets a main river.

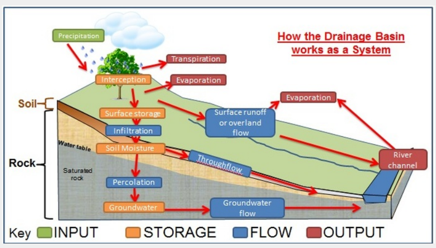
Diagram of a drainage basin.



The Drainage Basin System



The Drainage Basin System Diagram



'Hard' Engineering Strategies

Dams

Building a dam or reservoir in the upper course of the river can control the discharge in the river. They will reduce flooding and the resulting reservoir can be used for leisure and hydroelectricity. The disadvantages of building dams can be:

- high costs of construction and maintenance
- good farmland is flooded
- local people are displaced
- habitats are destroyed

Levees or Embankments

Building high embankments along the sides of the river increases the river's capacity to contain any floodwater. Levees do reduce flooding but they are expensive to strengthen and heighten (can be eroded easily). There will be catastrophic flooding if they are breached.

Floodwalls

These walls are built around settlements and important factories or roads. They are quite expensive and do not look very natural but are usually effective.

Straightening and Deepening River

Known as *channelising*. By straightening and deepening the river channel, the cross-sectional area of the river is increased allowing it to contain more water. The straighter channel makes the water move faster through that part of the river so it does not build up and is less likely to flood. This totally changes the ecosystem in the river and spoils the natural look of the area. Often further downstream where the river is not channelised, the water builds up and floods occur there.

Storage Areas

'Hard' Engineering Strategies (cont)

The water is pumped out of the river and stored in temporary lakes. Then it is pumped back in after the water in the river has returned to normal flow. This strategy is effective but a large amount of unused land is needed so it can be flooded.

'Soft' Engineering Strategies

These strategies are aimed at helping people cope with floods. They are generally sympathetic to the natural landscape, so tend not to damage the river for future generations, making them more sustainable than hard flood control methods.

Washlands

These are parts of the river floodplain in the lower course that are allowed to flood temporarily. They are one kind of flood storage area. They cannot be built on and are usually used for sports pitches or nature reserves.

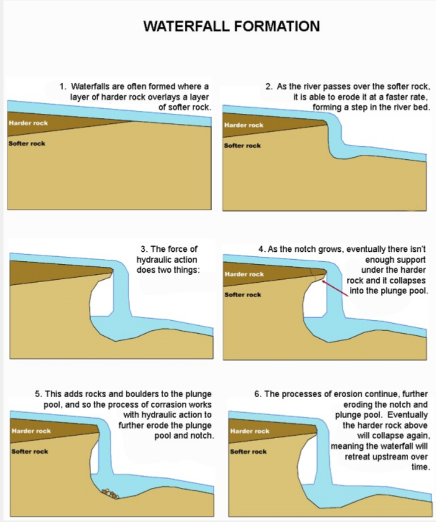
Land-Use Zoning

This is where land has different building controls depending on how far away from the river it is. Land next to the river is not allowed to be built on, the next land zone can be built on only for low risk housing and the last zone is for high risk buildings such as hospitals, retirement homes and dangerous factories.

Afforestation

This is re-planting trees in the upper course of the river.

Waterfalls



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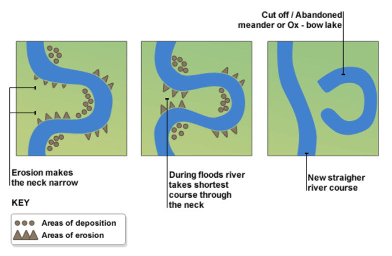
Ox-Bow Lakes



Keywords

Water Cycle
Drainage Basin
Precipitation
Interception
Surface Runoff/Overland Flow
Infiltration
Throughflow
Percolation
Groundwater Flow
Evapotranspiration
Watershed
Source
Tributary
Confluence
River Mouth
Gradient
Depth
Width
Load
Discharge
Erosion
Attrition
Abrasion/Corrasion
Hydraulic Action
Solution/Corrosion
Transportation
Solution
Suspension
Saltation
Traction

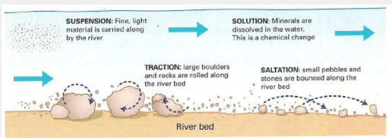
Keywords (cont)

Deposition
Waterfall
Meander
Slip-Off Slope
River Cliff
Floodplain
Levees
Flooding
River Managment Strategies
Hard and Soft Engineering Methods

River Processes and Landforms

	Near Source	Near Mouth
Gradient	Steep	Gentle
Depth	Shallow	Deep
Width	Narrow	Wide
Discharge	Low	High
Load	Large, Angular	Small, Rounded

Methods of Transportation Diagram



Why do channel width and depth increase?

1. Stream Ordering	2. Erosion
When a stream flows away from its source it is known as a *first order stream*. When two first order streams meet, the result is a *second order stream* and so on.	As a river flows downstream it erodes the channel bed and banks in two ways:

Why do channel width and depth increase? (cont)

As the diagram below shows, the river at point A is fed by only two streams whereas Point B is fed by the entire stream network. Whilst Point A has a narrow channel and is shallow in depth, Point B has a wider channel and deeper water.	(a) Hydraulic action - i.e. the force of the water itself. This will have the greatest effect when the river is full.
	(b) Abrasion - the bed load bumps along the river bed and banks causing erosion.
	When rivers have a large bed load made up of coarse material they scrape or rub against the channel bed, eventually lowering the level of the bed, creating steep valley sides. This is *vertical (downwards) erosion*

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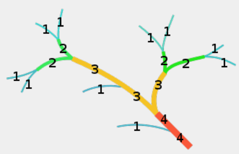
Why do channel width and depth increase? (cont)

In sections of the river channel where the river is flowing especially fast, the water itself has enough energy to wash away the bank of the river, leading to undercutting and collapse. As this is a sideways motion, it is called lateral erosion.

Stream Ordering Diagram



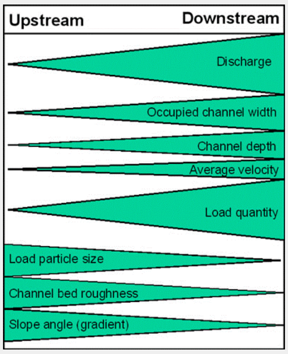
Why does discharge increase?

Discharge is calculated by multiplying cross sectional area by velocity. As width, depth and area increase downstream (due to erosion), discharge increases. Velocity increases downstream also due to a reduction in friction - as large angular rocks break down.

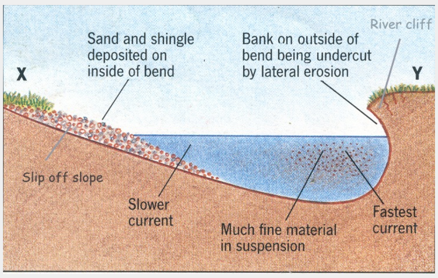
As more and more tributaries flow into the main river. By the time it reaches the mouth it will have gathered water from hundreds of smaller streams, increasing its volume of water.

The Bradshaw Model is another was to show how river characteristics gradually change upstream/downstream.

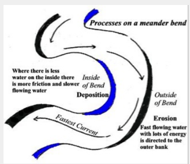
Bradshaw Model Diagram



Meander in a Cross-Section



Meander in a Plan View



Deposition

When the velocity of the river is reduced, its energy falls and it can no longer erode or transport material. Instead, the load is dropped, starting with the largest and therefore heaviest particles.

Conditions when deposition is likely

- River enters a lake or the sea, slowing its flow.
- The river floods onto its floodplain, where it flows very slowly.
- There is an area of shallow water, slowing the river flow
- The load is increased suddenly, eg. after a landslide.

Sustainable Management of Rivers

Why does river load become smaller?

1. Processes of erosion	2. Processes of transportation
Attrition - as the bed load moves downstream it bumps off itself. This reduces the size and makes the load more rounded with no sharp edges.	A river uses its energy to (a) erode and (b) transport its load.
Abrasion - this is when the bed load bumps along the river bed and banks.	Rivers move their load in 4 ways.
Solution occurs all the time, as rainwater and therefore river water, is slightly acidic. Water flowing along the channel constantly dissolves the surrounding rock. Some rocks eg. limestone and chalk are most prone to this type of river erosion.	Traction - the rolling of the large rocks along the river bed. This requires a lot of energy and the largest bed load will only be moved like this in times of severe flood.
	Saltation - the bouncing of medium-sized load along the river bed.

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Why does river load become smaller? (cont)

Suspension - the smallest load, like fine sand or clay, is held up continually within the river water. This makes the water appear opaque. Some rivers carry huge quantities of suspended material, eg. Yellow River in China.

Solution - soluble minerals dissolve in the water and are carried in solution. This may also colour the water, for example water in the rivers of the Mournes often appears yellow/brown as it is stained from iron coming off the surrounding peat bog.

Case Study - Somerset Levels 2014

Introduction & Spatial Context

The Somerset Levels are a low lying region in the *South West* of England. As it has a naturally high water table and poor drainage it is prone to flooding. The Winter of 2013-14 saw it experience prolonged flooding which was described as "the worst in over a century". Villages were stuck in polluted water for 6 weeks. Although the river was naturally supposed to flood twice every 100 years it flooded twice in the last 2 years.

Physical Causes

Case Study - Somerset Levels 2014 (cont)

- Combination of impermeable bedrock and low interception levels means land is naturally at risk of flooding.

- Southern England recieved 207mm of rainfall in January 2015 alone. 97% of rainfall fell in first 15 days of January; wettest winter of 2015.

- Series of severe winter storms in Southern England in 2013-14. One of the stormiest December's on record and one of the windiest since January 1993.

- High tides cause floodwater to back up along rivers across levels and moors. This was exacerbated by the river layers being higher than usual due to recent rains and because they had not been dredged.

Human Causes

- The rivers Tone and Parrett had not been properly dredged in 20 years, leaving farmland and homes without proper defence from floods. This resulted in hectares of land being left underwater from storms in December. Had the river been dredged this would have cleared them of slit, making them wider, deeper and easier to maintain. It would have also created more capacity to carry away flood waters; draining the floodplain more quickly.

- In addition, extra water was being sent to the levels from Taunton and Bridgewater as part of a scheme where water is pumped away from areas to protect new homes build on former floodplains. Pumping stations couldn't remove water fast enough. The environment agency brought in more pumps but it was 'too late'. Owen Paterson was slow to respond which made things worse.

Concluding Statement

Both human and physical reasons are to blame for the prolonged flooding experienced in the Somerset Levels from 2013-14.

Impacts of Flooding

Positive Impacts on People	Negative Impacts on People
- Replenishes drinking water supplies, especially wells.	- Spreads waterborn diseases such as chlorea.
- Provides sediment (or *slit* or *alluvium*) that naturally fertilises the soils of a floodplain.	- People and animals can be made homeless and even drown.
- Countries such as Bangladesh and Egypt rely on floods to help crops like rice grow.	- Buildings and infrastructures (roads and railways) can be damaged and destroyed.
- Can encourage innovative solutions in future building design. eg. houses on stilts, tilting floors and walls on groundfloor.	- Crops grown on fertile floodplains can be washed away in a flash flood.
Positive Impacts on Enviroment	- Can increase house insurance costs for house holders or make it impossible to insure home.
- Fish benefit as they can breed in the standing floodwater.	**Negative Impacts on Environment**
- In dry areas, floods bring relief from drought, providing drinking water for wild animals.	- Flooding can wash chemicals or sewage into local rivers and pollute them.

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Impacts of Flooding (cont)

- Wild animals may drown or lose their habitat during a flood.

Case Study - Mississippi River, USA

Background/Spatial Context

The Mississippi river is located in the South-East of the USA, with one of the largest drainage basins in America that drains water from a third of the USA and Canada.

The river is important as a shipping channel and is also important for recreation as it is a supply of hydroelectric power and a drinking water store.

Around 25,000 people were evacuated when it flooded in 2011, damage costs estimated at around 3 billion.

Management Response to Flooding - Hard

- Raised levees, levels raised to 15m and strengthened to enclose river for a stretch of 3000km.

- Straightened river channel - meanders were cut through over a stretch of 1750km, creating a fast flowing channel.

- Dams: the flow of the main tributaries, such as Ohio River, were controlled by over 100 dams.

Management Response to Flooding - Soft

- Afforestation in upper course, trees have been planted in areas such as Tennessee Valley to intercept some rainfall and stabilise soil.

- Safe flood zone; building has been restricted in many of the floodplain areas. Also, in areas like Rock Island, where houses have already been built on the floodplain, the housing has been bought by the county and demolished.

- Washlands; in 2011 the Maganza Spillway was opened to flood around 2000km squared of farmland in Louisiana, deliberately preventing that water from reaching the city of New Orleans.

Case Study - Mississippi River, USA (cont)

Evaluation of Management

- Mississippi River is very important to USA as 18million rely on it for water supply.

- Current hard engineering methods have been proven to be neither totally effective nor sustainable. The river still floods and recent flash floods are blamed on levees failing. Also, as river bed silts up alongside levees, river beds rise and the floodplain ends up below river level. eg. in New Orleans, some areas are 4.3m below river level.

- For current and future generations, the lack of silt reaching the land means that the fertility of the soil is no longer being naturally completed during the deposition of alluvium in the floods. Eventually more and more artificial fertilisers will have to be added to the soil.

- For wildlife, the draining of wetland and lack of silt to maintain the delta are destroying valuable habitats. In the last 75 years, Illinois, Indiana, Iowa, Missouri and Ohio have each lost more than 85 per cent of their wetlands.

- The soft engineering strategy of afforestation is ineffective as not applied over wide enough area and takes too long for trees to become large enough for noticeable runoff difference.

- Use of washlands should only be an emergency measure as it takes up a large area of spaces near cities. The 2011 flooding showed there was a lack of these floodlands, as in response the Army Corps of engineers took the decision to explode the levee at Birds Point to create a makeshift washland that destroyed dozens of farmsteads with their crops.

Conclusion

In conclusion, it seems management of the Mississippi is currently not sustainable.

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