

London under water

Fact Sheet

Lesson 1: River basin floods, climate change & London

Starter

Four types of common river basin flooding

1. Fluvial (river) flooding

A flood occurs when the discharge of a river exceeds the capacity of the river channel to contain it. Once bankfull discharge is exceeded, inundation of the river valley flood plain must follow. An extremely flashy storm hydrograph can indicate that a flood is imminent. Flood conditions are often associated with precipitation moving through a drainage basin via the process of overland flow as part of the hydrological cycle. Water flows directly over the land surface as result of two possible rainfall scenarios:

- Soils are saturated, perhaps due to long rainfall duration, with a large volume of rain having fallen previously.
- Extremely high intensity rainfall immediately outstrips the infiltration capacity of soil that may even be dry (also called Horton overland flow)

Specification advice

AQA and OCR centres studying rivers & floods must emphasise to students that fluvial flooding is their central exam concern. However, pluvial and groundwater flooding are also highly relevant to these courses, as they are temporary hydrological stores. WJEC and Edexcel centres can link all types of flooding to their AS climate change courses.

Both conditions result in overland flow, although the latter is more likely to produce the most dramatic effects. Overland flow – and the potential for flooding – is also exacerbated by steep slopes, thin soils, impermeable bedrock (or concrete) and a lack of vegetation which would otherwise intercept some of the rainfall (this can reduce or slow the transmission of water through the system, thereby alleviating flood risk).

2. Coastal flooding

This can sometimes happen when there is a high tide and a storm is blowing at the same time. Winds drive the high tide further inland than usual. The Thames Flood Barrier protects London from coastal flooding (driven by storm surges).

Teaching tip

This Starter is supported with a series of "[60 second](#)" online guides – if you use the 'guide to fluvial flooding', you could challenge the students to write down all they can in just 60 seconds while each type of flooding is displayed. Spend a couple of minutes afterwards summing up what has been learned. Ensure the starter takes no longer than 6 minutes in total.

3. Pluvial (surface water) flooding

Pluvial flooding is defined as flooding that results from rainfall-generated overland flow, before the runoff enters any watercourse or sewer. It is usually associated with high intensity rainfall events (typically >30mm/h) but can also occur with lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or otherwise has low permeability resulting in overland flow and ponding in depressions in the topography. Urban pluvial flooding arises from high intensity 'extreme' rainfall events. In such situations, urban underground sewerage/drainage systems and surface watercourses may be completely overwhelmed.

4. Groundwater flooding

Groundwater flooding is caused by groundwater escaping from the ground when the water table rises to or above ground level. It occurs from water rising up from the underlying rocks or from water flowing from abnormal springs. This usually happens after long periods of sustained high rainfall. Groundwater flooding takes longer to dissipate because groundwater moves much slower than surface water and will take time to flow away underground

Main activity

(1) Decreasing urban permeability and the hydrological cycle - the local human causes of increasing flood risk in London

Specification advice

AQA and OCR centres studying rivers & floods should focus on the role that paved-over London gardens play in increased fluvial flooding, especially along tributaries such as the River Wandle. Pluvial flooding is also relevant to the AQA and OCR courses but in the more general context of the hydrological cycle and its flows and stores.

The main activity now focuses on the reasons why fluvial and pluvial flooding are on the rise in the Thames basin.

The key issue is the loss of **impermeable** surfaces. Fifty years ago, more than a third of London's green space, and one-fifth of the city's total land area, was made up of private gardens. Together, London's private gardens still cover an area just slightly smaller than the combined size of the inner London boroughs - 319 square kilometres (or 123 square miles). An estimated two-thirds of London's trees – a crucial **interception** store - are growing in domestic gardens.

Private gardens have always been a crucial component of London's ecosystem the city's ability to absorb rainfall.

However, this huge area of land - around 22 times the size of Hyde Park – is progressively being transformed from grass cover into concrete and hard timber decking.

Urbanisation will always radically alter the flows of the hydrological cycle by speeding up the rate at which water can reach the main river channel, greatly reducing lag-time and increasing peak discharge for the storm hydrograph. This happens because urban design makes previously permeable soil surfaces impermeable, thereby increasing surface run-off and decreasing the effectiveness of soil storage. Ground is covered by impermeable hard surfaces such as concrete or paving slabs. As a result, rainfall cannot **infiltrate** and quickly runs over the ground, directly into London's drains.

Teaching tip

Find out more about the issues behind paved-over London by reading the RGS-IBG Geography in the News article [Crazy paving](#).

According to the Royal Horticultural Society, an average suburban garden on a typical rainy day will absorb about 10 litres of rainwater a minute, representing around 10 per cent of the water that will fall in a storm. The loss of this vital water store in recent years now makes pluvial, fluvial and groundwater flooding much more likely to happen in cities like London.

Main activity

(2) Extreme rainfall events and storm surges – investigating how global climate change is increasing London's flood risk

The majority of experts now agree that climate change means that all four of London's different flood risks are increasing. In each case, the main culprit is usually the same: **depressions**. Depressions are formed when tropical and polar air masses converge at the polar front (between 40N and 60N), often close to the UK. Under conditions of divergent flow in the jet stream (a meandering belt of air moving 12 km above ground level), cyclogenesis (depression formation) takes place and a wave form is produced with a warm front leading a cold front.

The UK has been reported as becoming twice as stormy in the past 50 years. According to new Hadley Centre research, climate change has modified the North Atlantic oscillation (NAO) and forced deep depressions further south, causing more of them to pass close to, or directly over, southern parts of the UK and the North Sea.

Depressions often bring intense bursts of heavy rain. Fluvial, pluvial and groundwater flood risks can all be expected to increase if there is greater depression activity. Experts also predict that London may see greater seasonality in its rainfall pattern. The annual total is likely to stay the same, but Londoners can expect to see heavier winter rain from depressions but may experience less in summer. Generally, rain is likely to arrive in higher-

intensity bursts, leading to the monsoon-type downpour conditions that trigger Horton overland flow, surface ponding and the overcoming of drainage systems. One estimate suggests there will be a 30% increase in winter rainfall.

Specification advice

Edexcel students can explore how risk and vulnerability are growing in London for a variety of reasons. Climate change is one reason for an increase in the frequency of global hydro-meteorological hazards. However, another important reason is that land use changes in cities like London are altering the local catchment hydrology, by removing gardens (which are semi-natural permeable surfaces that slow down the transmission of rainwater to the Thames).

The other major climate change concern is a projected increase in storm surges from the North sea, resulting in greater coastal flooding of the Thames Estuary and a forcing of tidal water towards the city. The Thames Flood Barrier will need to be raised even more frequently to prevent storm surge waters reaching London.

Plenary

Recent events: is Britain getting wetter?

To conclude this lesson, quickly review the evidence that the UK is experiencing more extreme weather events

leading to flooding.

1. Fluvial flooding The Boscastle flood of 2004 may be part of a "bigger picture" that suggests Britain's weather is changing. The summer of 2004 as a whole was the wettest in the UK since 1956. In fact, more than double the normal amount of rain fell in England and Wales during June, July and August 2004. It is also notable that it followed on more or less directly from the widespread European floods of 2002 (when 600,000 people experienced economic losses topping £10 billion and over 100 died). Major fluvial floods were also reported in the UK in 2000 and 2008.

2. Pluvial flooding Unprecedented insurance losses were brought by the June and July 2007 pluvial floods to England. Total losses of £3bn meant that many of the UK's major insurers struggled to post any profit for the financial year. "The floods during June and July 2007 were a wake-up call. The three months from May to July were the wettest since records began and the events that followed have been linked to the deaths of 13 people. They also resulted in damage to 48,000 homes and 7,000 businesses. Power and water supplies were lost, railway lines, eight motorways and many other roads were closed and large parts of five counties and four cities were brought to a standstill. The flooding triggered a series of emergencies which stretched local resources to the limit."(Sir Michael Pitt)

3. Coastal flooding In November 2007, a major storm surge threatened London and the East Anglian coast. In parts of the region, waters rose by 9m – the highest mark since the 1953 floods that killed 300 people. 100s of kilometres of coastline looked to be under threat, including the settlements of Great Yarmouth, Lowestoft, Southwold, Ipswich and Felixstowe. In the event, none of the area's major defences were breached. However, minor flooding occurred in some low population density regions. The village of Walcott on Norfolk experienced 4m waves that breached the sea wall.

Teaching tip

Find out more about the [2007 storm surge](#) by reading the RGS-IBG Geography in the News article