Department for Transport

Met Office

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Transport hazard summary series

Groundwater flooding

Groundwater flooding happens when water beneath the ground rises to the surface and can severely disrupt transport infrastructure, particularly underground assets like tunnels, underpasses and underground railway lines. Climate change is projected to lead to wetter winters, leading to an increase in the frequency and severity of groundwater flooding. In response, the transport sector must become more resilient to deal with these challenges.

The Department for Transport, Met Office and partners have created this series of **transport hazard summaries** to explain natural hazards and other hazards that are not the result of malicious acts, their impacts and how they may change in the future. This summary will introduce what is meant by groundwater flooding and how it can impact transport, and offers further information to help decision makers manage and adapt to these risks.

The devastating floods of winter 2013 to 2014 persisted for 4 months. Groundwater flooding lasted the longest after other forms of flooding subsided. Many areas of southern England were affected with damages to the transport sector estimated at £295 million.*

* GOV.UK, 'The costs and impacts of the winter 2013 to 2014 floods', available at: **https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/the-costs-and-impacts-of-the-winter-2013-to-2014-floods**

What is groundwater flooding?

Groundwater flooding is when water stored beneath the ground, known as the water table, rises to the surface and can submerge roads and railways and seep into tunnels and underground transport systems. Unlike other types of flooding, groundwater levels typically build gradually due to prolonged wet weather, with impacts over weeks to months.*

Flooding can have different natural causes that can happen at the same time but are distinct. We have created separate **transport hazard summaries** focusing on surface water flooding, river flooding and coastal flooding and erosion.

Figure 1:
Rain gradually fills underground spaces and soils with water. The water table rises and causes groundwater flooding.

Where does it occur?

It is common in areas with porous rock such as chalk or limestone like the Chilterns, in river valleys such as Oxford, or in cities with significant underground infrastructure such as London.

When does it happen?

In spring and summer, groundwater levels drop as evaporation increases, and water use rises. During autumn and winter, rainfall refills them, so groundwater flooding is most likely in late winter or early spring and is rare in summer or early autumn.

How long does it last?

High groundwater levels and flooding can persist for weeks, often requiring continuous pumping to keep water out of sub-surface infrastructure.

* Environment Agency, 'Rapid evidence assessment and overview of groundwater flood risk management in England', 2021, available at: **https://assets.publishing.service.gov.uk/media/60ca0dc88fa8f57cef61fc6e/Groundwater_flood_risk_management_in_England_-_report.pdf**

What increases groundwater flood risk?

- Heavy or prolonged rainfall when groundwater levels are already high.
- Blocked or inadequate natural drainage channels.
- In some areas, there has been a reduction in groundwater use for industry, leading to a gradual increase in the level of the water table.*

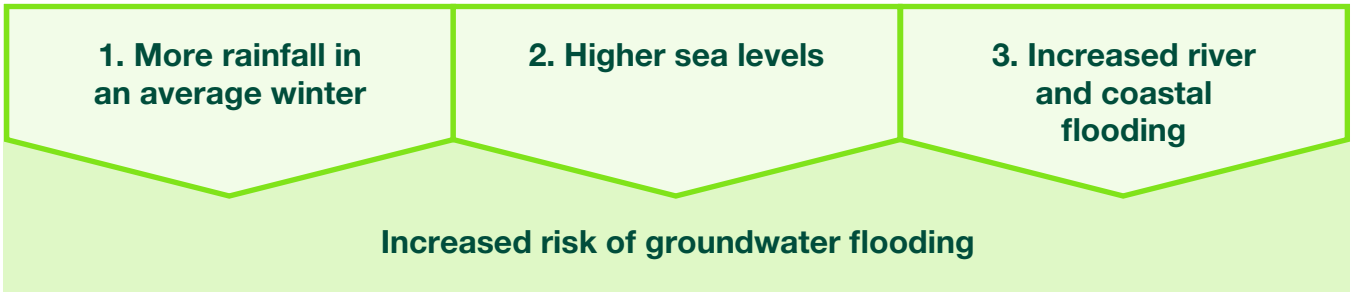
How are groundwater flooding events changing due to climate change?

1. Groundwater flooding can happen in response to unusually long or intense periods of rainfall, often combined with already-high groundwater levels.† Climate change is projected to significantly alter rainfall in the UK.‡ Winters are projected to become wetter overall, even under a low emissions scenario.§ This means that winter groundwater levels could become even higher, potentially making groundwater flooding events worse.

2. Low lying coastal areas are projected to see a higher risk of groundwater flooding due to rising sea levels, which will raise the water table.¶ Less rainfall will be needed to cause groundwater flooding.† See the transport hazard summary on coastal flooding and erosion for more information on sea level rise.

3. Groundwater flooding is influenced by other forms of flooding that are also projected to increase with climate change.† If water from river or coastal flooding runs onto ground that is already saturated by rainfall, then groundwater flooding can be made worse and continue for longer.

Figure 2: Climate-related factors that can contribute to an increased risk of groundwater flooding



* British Geological Survey, 'Groundwater rebound in urban centres', available at: **https://www2.bgs.ac.uk/groundwater/flooding/urban.html**

† Environment Agency, 'Rapid evidence assessment and overview of groundwater flood risk management in England', 2021, available at: **https://assets.publishing.service.gov.uk/media/60ca0dc88fa8f57cef61fc6e/Groundwater_flood_risk_management_in_England_-_report.pdf**

‡ Met Office, 'UKCP18 Climate Change Overland', available at: **https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-infographic-headline-findings-land.pdf**

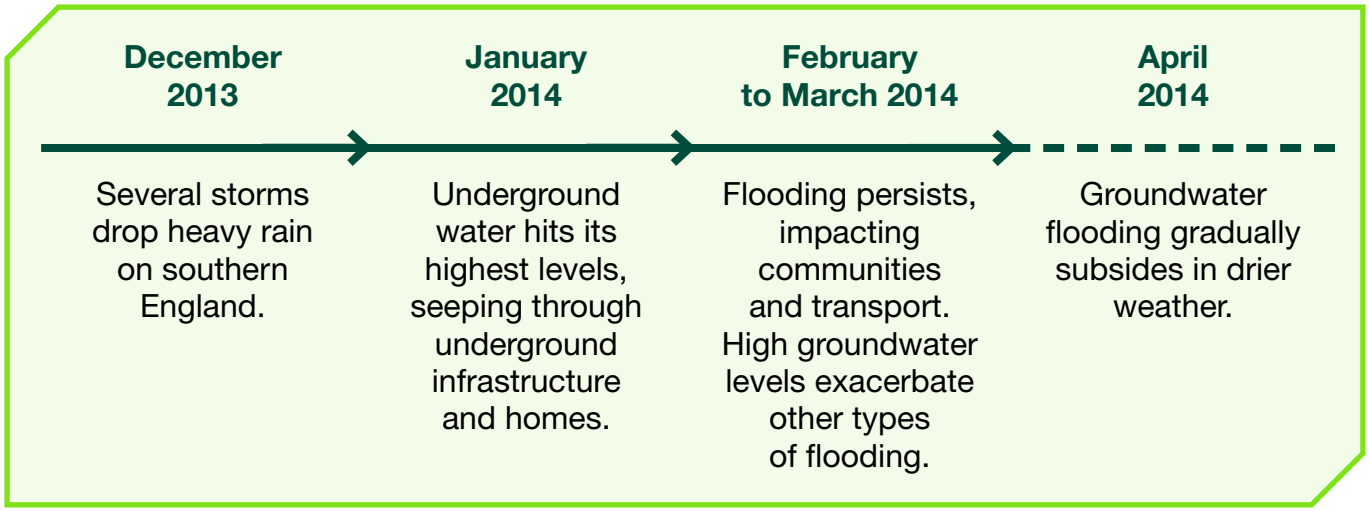
§ Slingo, J. and others, 'Latest scientific evidence for observed and projected climate change, in The Third UK Climate Change Risk Assessment Technical Report', 2021, available at: **https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Chapter-1-FINAL.pdf**

¶ Palmer, M., Howard, T., Tinker, J. and others, 'UK Climate Projections Science Report: UKCP18 Marine report', 2018, available at: **https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Marine-report.pdf**

Case studies

The winter of 2013 to 2014 was exceptionally stormy and experienced persistent heavy rainfall, making it the wettest winter for England and Wales since national records began. This prolonged period of high rainfall led to significantly elevated groundwater levels across southern England. The longevity of the wet weather, combined with other types of flooding, led to significant transport impacts.*

Figure 3: Timeline of groundwater flooding in 2013 to 2014



In January 2014, the A303 at Deptford (Wiltshire) had to be closed when groundwater rose up through the road, overwhelming drainage systems and submerging the eastbound carriageway. The A303 remained affected for 12 days until the floodwater receded.†

From late January to mid-February 2014, groundwater flooding infiltrated rail infrastructure across the Thames Valley. In Berkshire, high groundwater levels flooded trackside equipment and damaged signalling on the Great Western Main Line, dramatically reducing capacity between Reading and London for several days.‡

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* GOV.UK, 'The costs and impacts of the winter 2013 to 2014 floods', available at: **https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/the-costs-and-impacts-of-the-winter-2013-to-2014-floods**

† UK Parliament debates, 'A303', 4 March 2014, available at: **https://hansard.parliament.uk/Commons/2014-03-04/debates/14030456000001/A303**

‡ Network Rail, 'Media Update: Thames Valley flooding brings disruption to main line', 11 February 2014, available at: **https://www.networkrailmediacentre.co.uk/news/media-update-thames-valley-flooding-brings-disruption-to-main-line**

Direct transport impacts due to groundwater flooding

Human health and safety

- Where groundwater flooding leads to flooding of underground structures, for example tunnels, rail lines, underpasses and underground car parks, access can be blocked, potentially hindering evacuation and rescue of anyone who is trapped.
- Groundwater flooding events tend to last longer than other types of flooding, which can cause extended periods of disruption and more stress for passengers and workers.
- Workers and passengers may come into contact with dirty, contaminated water and become ill.

Vehicle and service operations

- High groundwater levels can flood crucial road and rail links, cutting off access to major transport hubs such as ports.
- Rising groundwater can require constant pumping of water to maintain operations in underground infrastructure. If pumping fails, tunnels or underground services may have to close for days to weeks.

Infrastructure

- Long-term water saturation of the ground can weaken tunnel linings, walls and foundations, making them more likely to collapse.
- Large differences in the amount of groundwater between summer and winter can cause subsidence, which can damage railways and roads.
- Flooded underground stations and car parks may stay shut for weeks while water is pumped out and repairs made.

Interdependencies: Power outages from flooded substations can halt electric trains, disable signalling and darken roads by knocking out streetlights.

Hazards associated with groundwater flooding

Coastal flooding and erosion

High groundwater levels can contribute to the instability of coastal cliffs and increase the risk of coastal erosion.

Landslides and earthwork failures

Rapid changes in groundwater levels and increased saturation can cause instability of soils in slopes and embankments making them susceptible to fail.

River flooding

High groundwater levels mean that less rainwater can seep into the ground. More water flows into rivers or groundwater enters rivers from below, raising river levels and increasing river flood risk.

Storms

Heavy rainfall associated with storms often occurs in winter when groundwater levels are highest. This additional rain can lead to groundwater flooding.

Subsidence, soil degradation and sinkholes

Variations in soil moisture can lead to shrinkage and de-stabilisation of the ground, especially after repeated severe drying and wetting cycles.

Surface water flooding

High groundwater levels reduce the capacity of drainage into the natural environment, worsening surface water flooding.

Further information on these hazards can be found in our series of Transport hazard summaries: **https://www.gov.uk/government/collections/transport-hazard-summaries**

Risk mitigation and adaptation

Some methods to mitigate the risk of groundwater flooding to transport in the UK are well established. However, as more areas of the transport network become exposed to groundwater flooding, co-ordination with other agencies and organisations is required to mitigate and adapt to the risk. Examples include:

- building or upgrading dedicated water pumping stations to remove groundwater
- upgrading drainage in at-risk infrastructure such as tunnels
- deploying groundwater sensors near critical assets to provide early warnings
- routinely using groundwater flooding forecasts in daily operations to act early and minimise transport disruptions*

Questions for decision makers

- Which of your transport infrastructure is at risk of groundwater flooding and do you have preventative or emergency pumping plans or other measures in place?
- How can groundwater flood risk considerations be effectively integrated into infrastructure design, operation and maintenance practices?
- Do you know which of your local transport routes, that may be at risk of groundwater flooding, are critical for other sectors?
- What personnel and equipment will you need, and are responsibilities and lines of communication well defined during a groundwater flooding event?
- Do you have plans in place to communicate disruption due to groundwater flooding to keep the travelling public safe and avoid congestion?

* British Geological Survey, 'Groundwater level forecasting', available at: **https://www.bgs.ac.uk/geology-projects/environmental-modelling/groundwater-level-forecasting/**

Further reading

Groundwater flooding – GOV.UK

Groundwater rebound in urban centres – British Geological Survey

National assessment of flood and coastal erosion risk in England 2024 – GOV.UK

Review of groundwater flood risk management in England – GOV.UK

Climate information and risk assessment

See ‘The changing climate’ and ‘Transport hazards, risks and resilience’ transport hazard summaries for more information on identifying and planning for risks to transport and where to find climate data, including more detail on projected changes on a regional level.