



Network
Resilience

Resilience & Climate Adaptation

Moving towards an *All-Hazards Resilience*?

John A. Lamb FCIHT

**APSE Highways Winter Forum
Severe weather and flood resilience in a
changing climate**



Objectives of the session

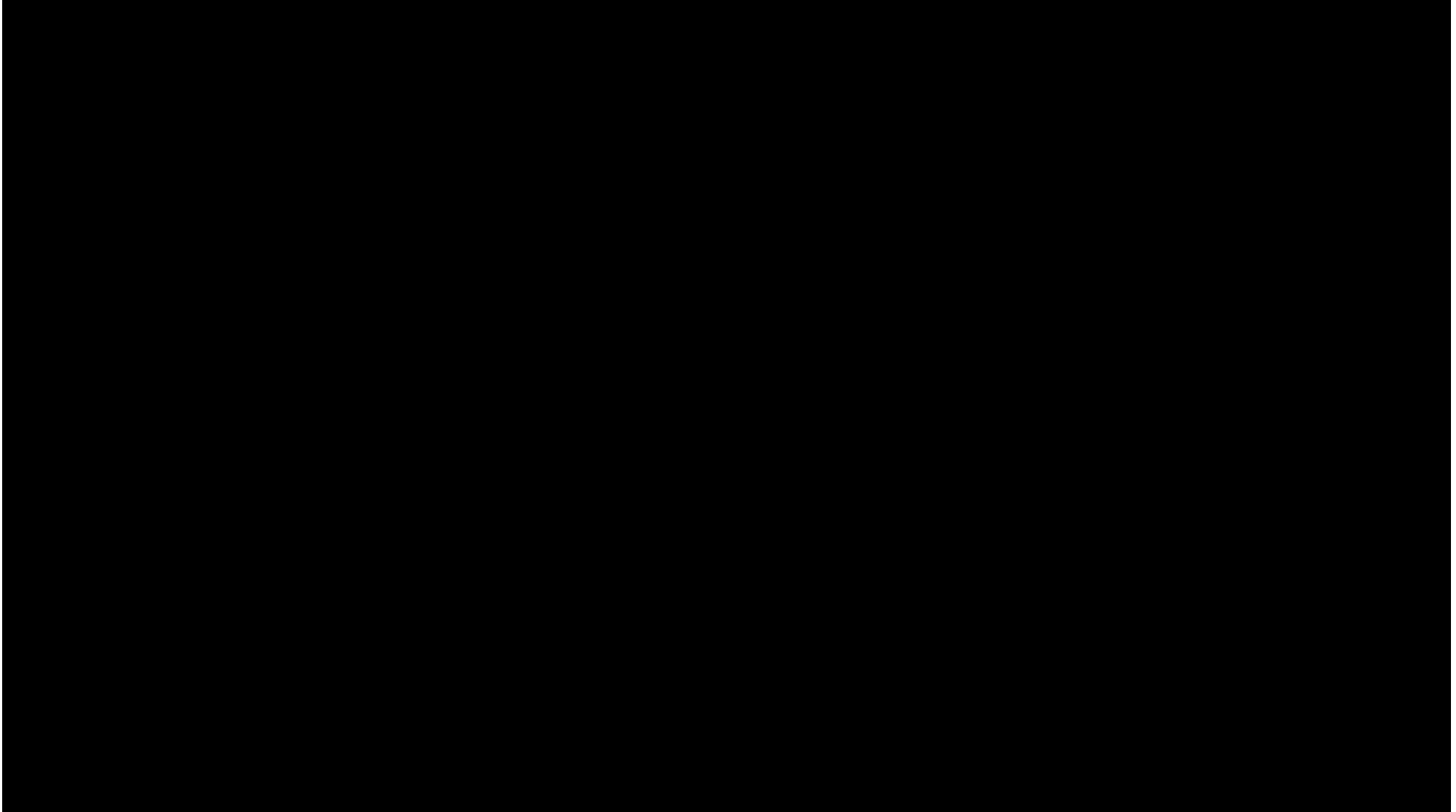
- 1** Extreme Events are baked into Current Climate
Not a 'far off average' clear and present hazard
- 2** A new Reality
Intense events – exceeding all previous records
- 3** More Frequent & Concurrent Hazards
More frequent, and often multiple hazards (floods and gritters)
- 4** Cascading Failures
Rail, Road, Bus and asset loss
- 5** Preparing for your worst day
Not a far-off climate average – but an operational reality for our teams, services and the communities we serve.
- 6** Reasonable worst-case scenario
London did not cope with 100mm in 2021. Belgium / Germany (2021) was 150mm – unfreeze sector minds and siren call to Government.



Ministerial Video to English Workshops (DA's have their own version)



Extreme Weather already impacting UK

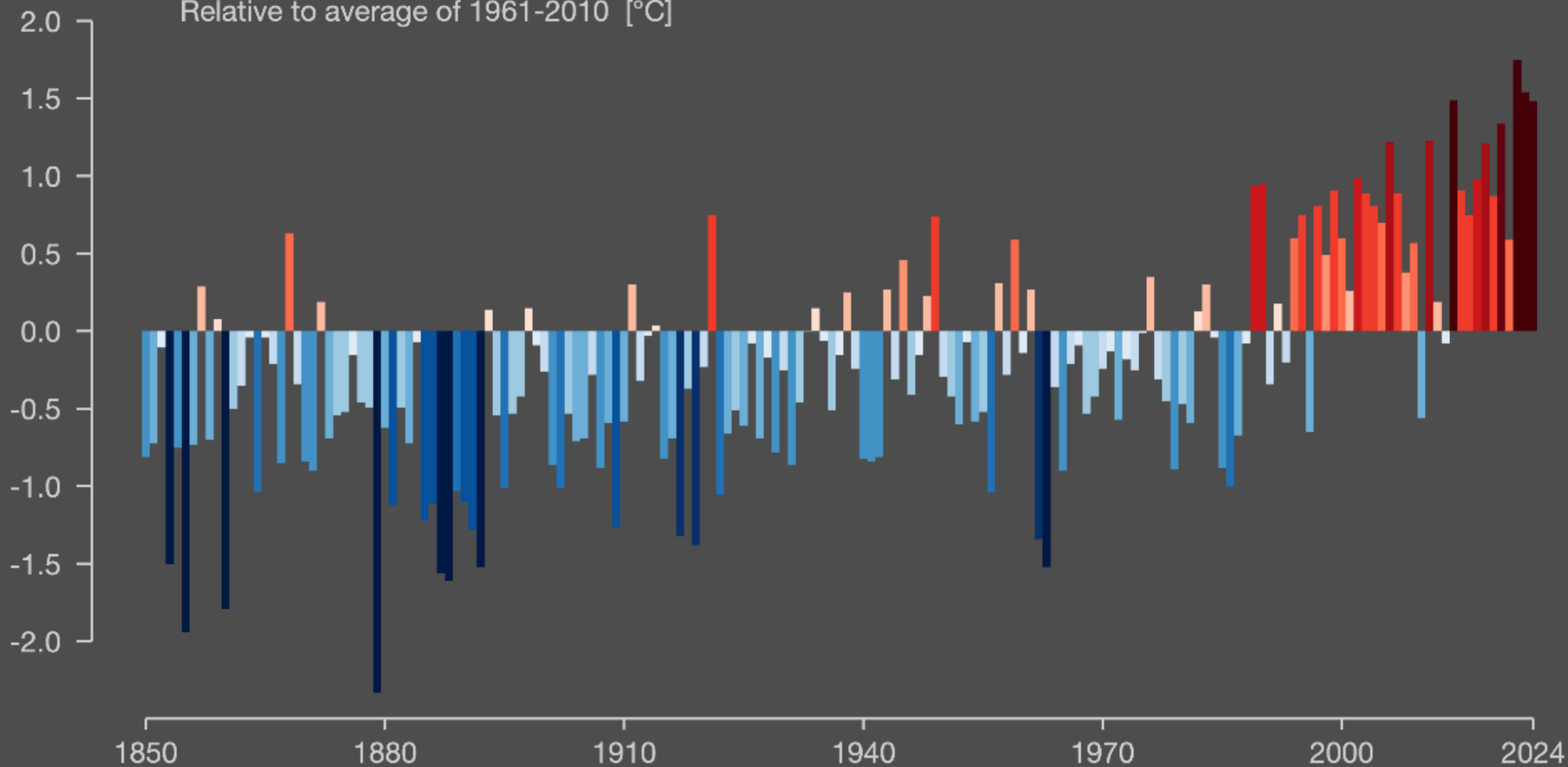


UKRLG Regional Workshops

- Over 200 UK Highways Authorities
 - 33 London, 32 Scotland, 22 Wales, 150+ in England
- 12 Regional events
 - Funded by DfT, leveraging input from Met Office, BGS/ Local Partnerships, Mining, Ringway & PIARC (UK)
 - Invite only for Highway Authority Directors *invited by/with DfT / D.A.'s*
- Led by UKRLG The UK ABC Board - ***Adaptation, Biodiversity & Climate Resilience***

Temperature change in London

Relative to average of 1961-2010 [°C]

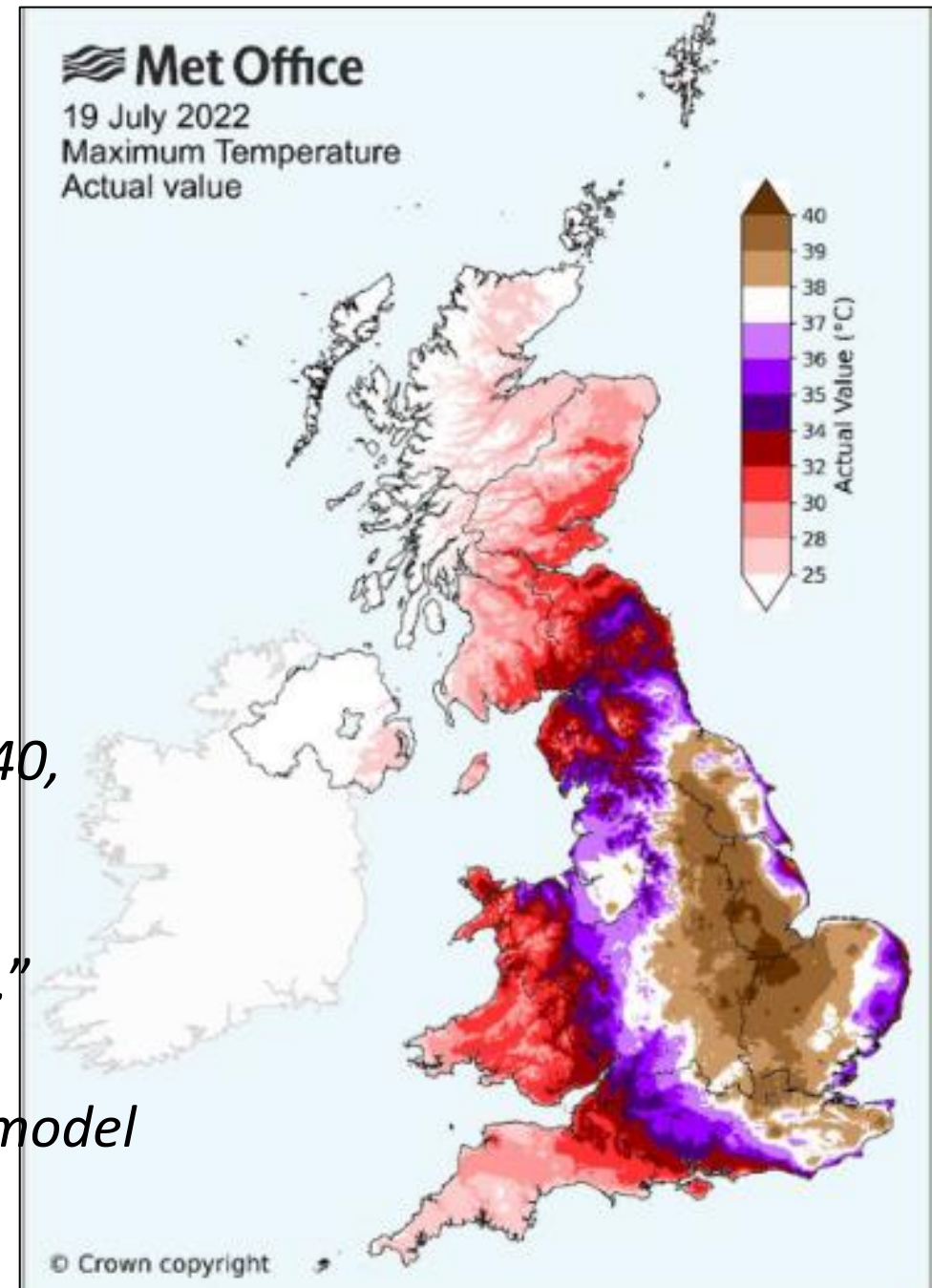




- “There is a **very small chance** of exceeding 40°C by 2040,
- but by 2080 on a pathway to 4°C global warming at the end of the century, the frequency of exceeding 40°C
 - is similar to the frequency of exceeding 32°C today.”

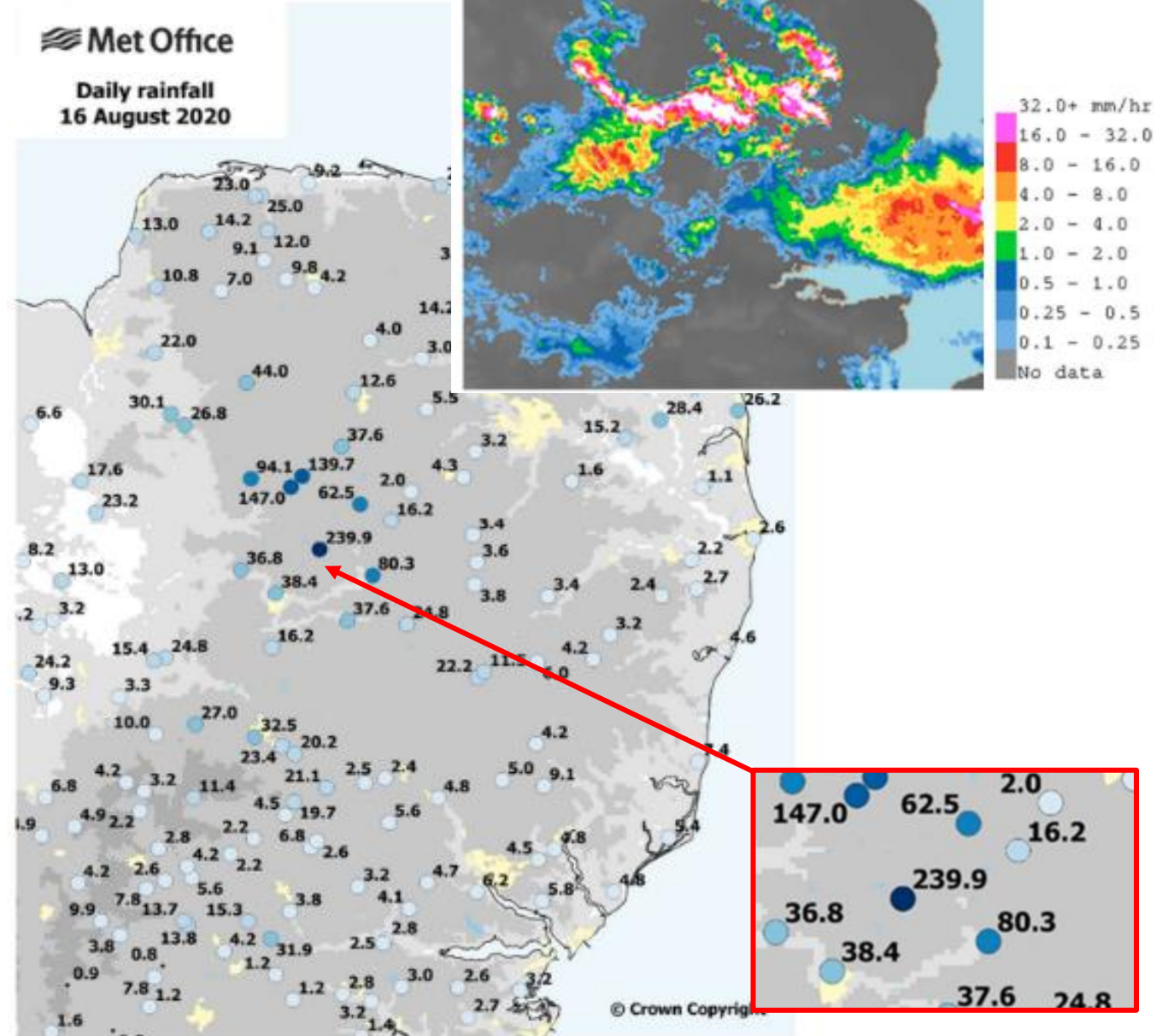
CCRA3 (2021: p.64)

- And more recent (2025) probably 45°C in our climate model



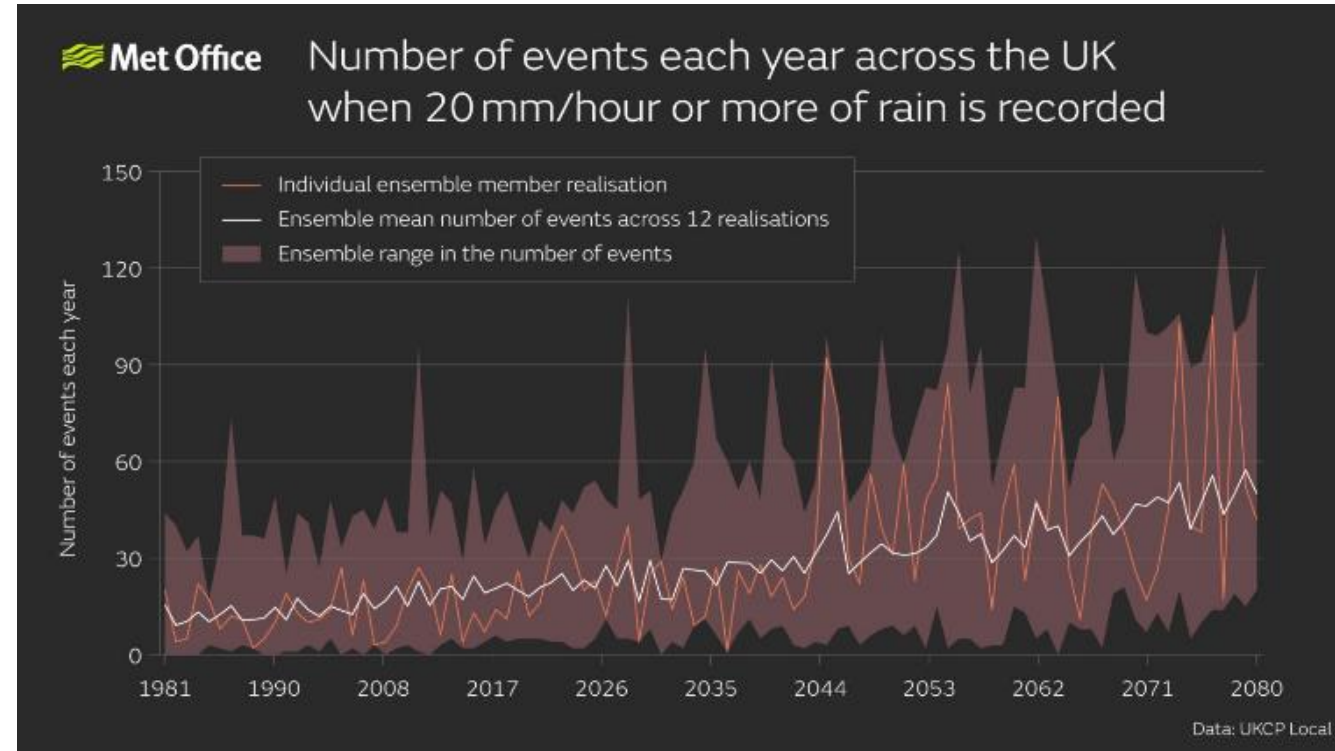
Extreme Rainfall:

- 5th Dec 2015: **341mm** Honister, Cumbria (standing UK 24hr record)
- 16th Aug 2020: **240mm** in just a few hours, East Wretham, Norfolk
- Jul 2021: **271.5mm** in 48hr Jalhay, Belgium (record)
- Oct 2024 Valencia, Spain: **771.8mm** in 24hrs (DANA)

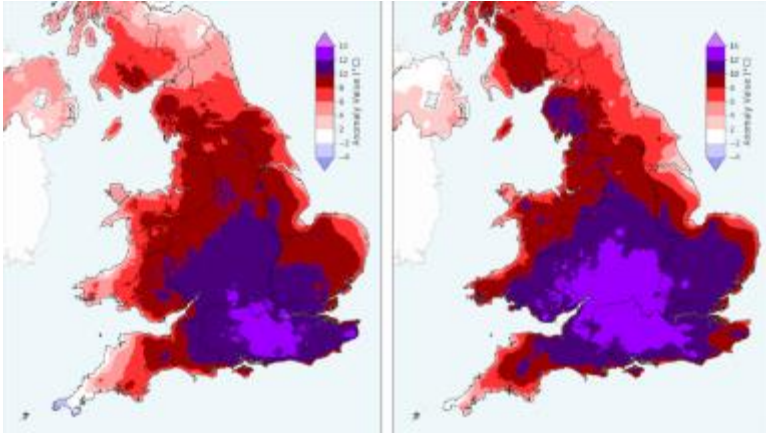


Variability conceals emerging trend in local hourly precipitation extremes

- Local extreme hourly precipitation **does not intensify *gradually*** with warming....
- ...but through periods of **rapid intensification**, followed by pauses.
- Extreme years with lots of extreme rainfall events tend to cluster and this poses challenges for adaptation.
- **Extreme downpours about 4x more frequent** by 2070s, under RCP8.5.
- These increases are greatest in the north of the UK (up to 10x)



Climatic Trends - More frequent , *more extreme*, extremes



• Heatwaves

- **July 2022** UK exceeded 40°C for the first time on record in the UK.
- Recent summer heatwaves have been amongst the most severe on record, and each typically causes several thousand deaths.
- By **2050** hot summers could happen **every other year**



Heavy rainfall

- **Storm Babet** brought
 - the wettest day on record in Angus
 - the wettest 3-day period on record in the Midlands
- By **2070**, winter rainfall events, similar to these, are expected to **increase by up to 25%**
- Summer thunderstorm rainfall is becoming more intense



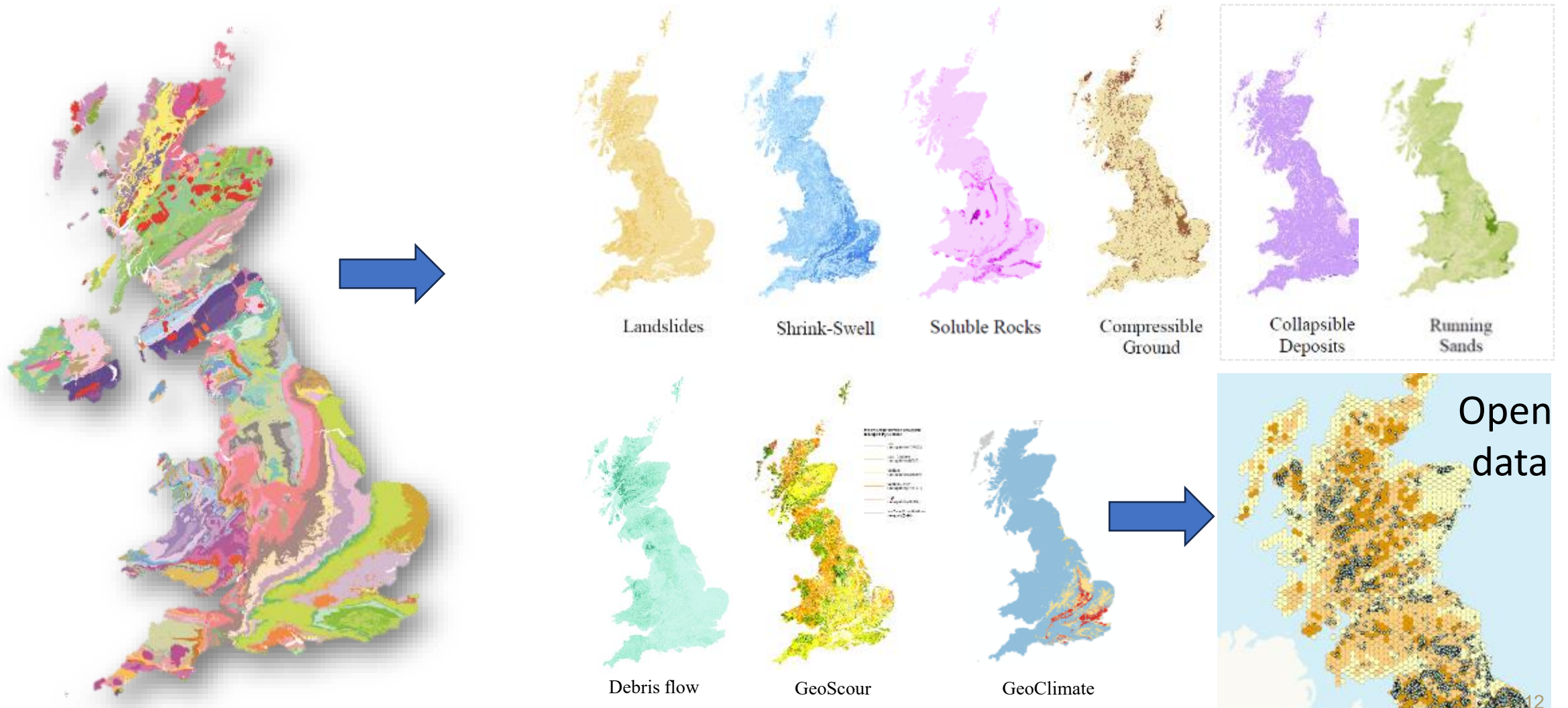
Wildfires

- **UK wildfires** has been **increasing** in recent years
- **5 times more likely** by 2100 due to increases in high temperatures and low summer rainfall; conditions highly conducive to wildfires

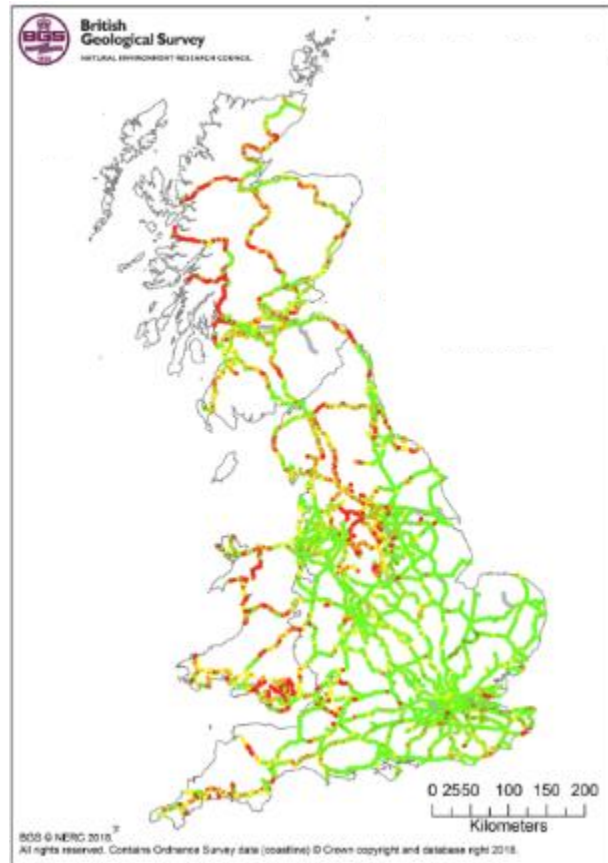
GEOLOGICAL HAZARDS AND THE INFRASTRUCTURE NETWORK



Mapping susceptibility to geological hazards

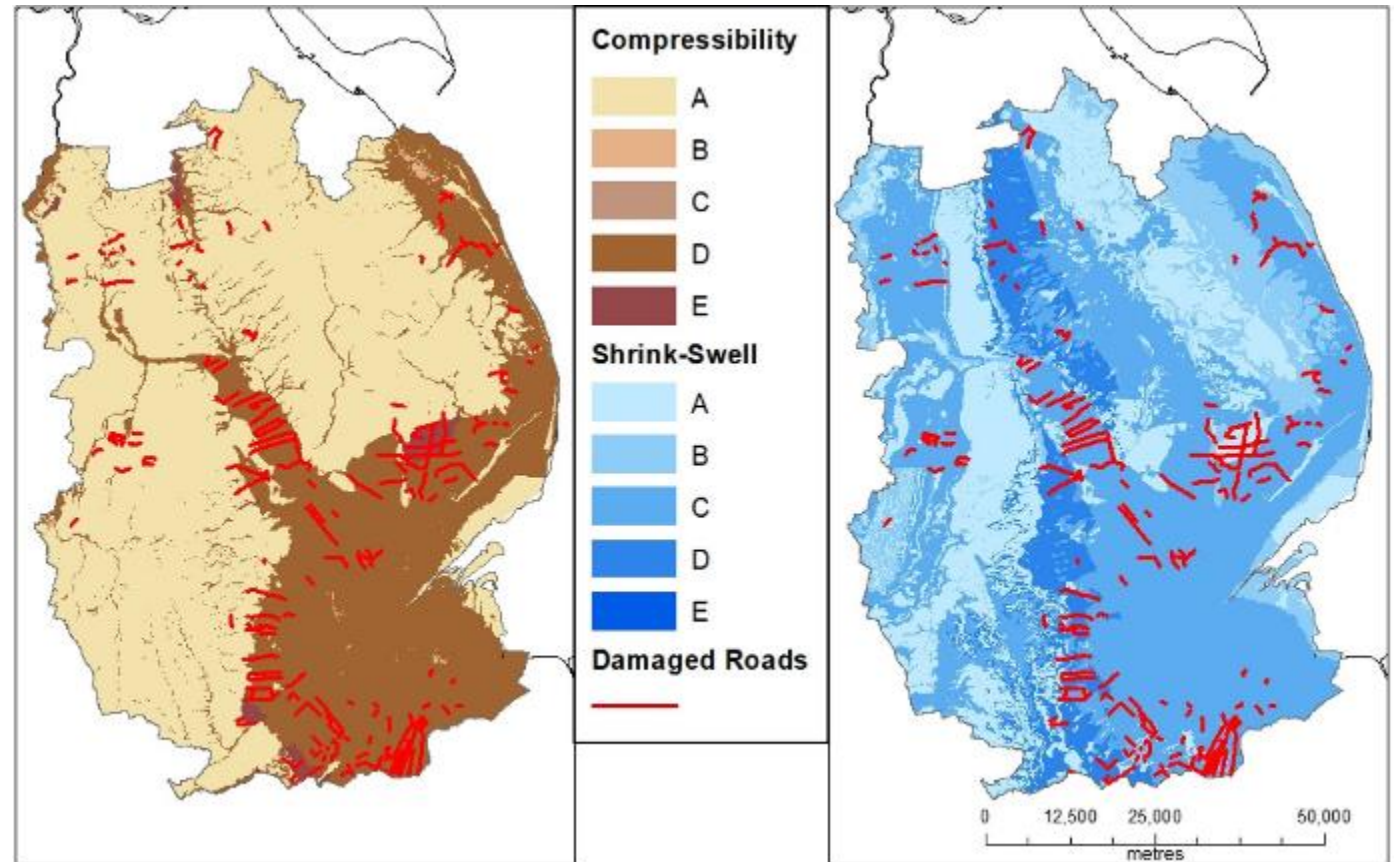


MAPPING SUSCEPTIBILITY TO GEOLOGICAL HAZARDS - EXAMPLES



Outside Party Slope landslide susceptibility for the rail network

© Crown copyright and database right [2019]. *Freeborough et al 2019*



Sites recorded (red lines) by Lincolnshire County Council as requiring remedial work due to **drought damage** during 2011–2012.

© Lincolnshire County Council. Contains Ordnance Survey data
© Crown copyright and database right [2022]. *Harrison et al 2023*

Key recommendations from extreme-weather reviews

- The critical importance of **Suitably Qualified, Experienced and Empowered People** in delivering Highways emergency management.
- The need for consistent **Rapid Impact Assessment**
- The need for **Mutual Aid** contingencies to be developed **on a regional / national basis**, and in conjunction with the **private sector**.

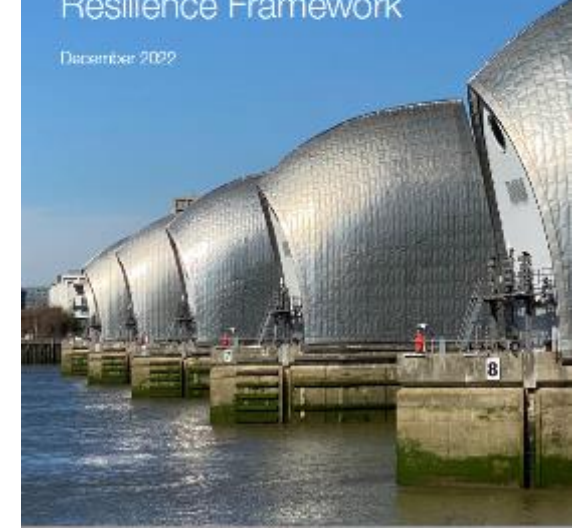






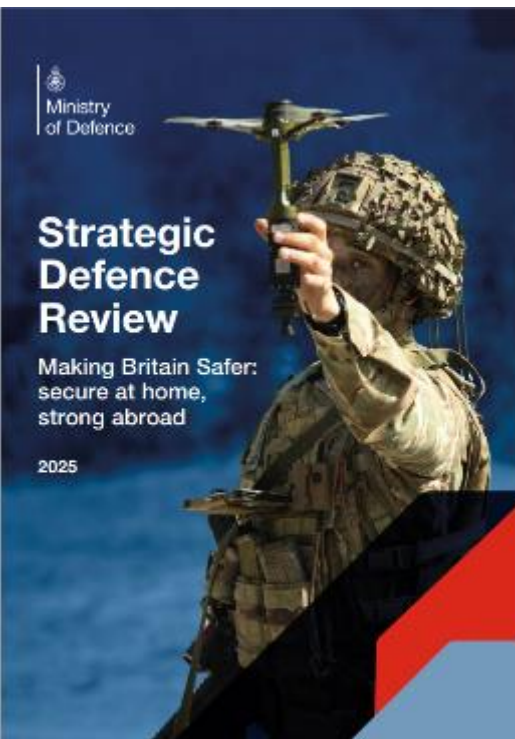
“...the ability to anticipate, assess, prevent, mitigate, respond to, and recover from natural hazards, deliberate attacks, geopolitical instability, disease outbreaks, and other disruptive events, civil emergencies or threats to our way of life.”

Resilience



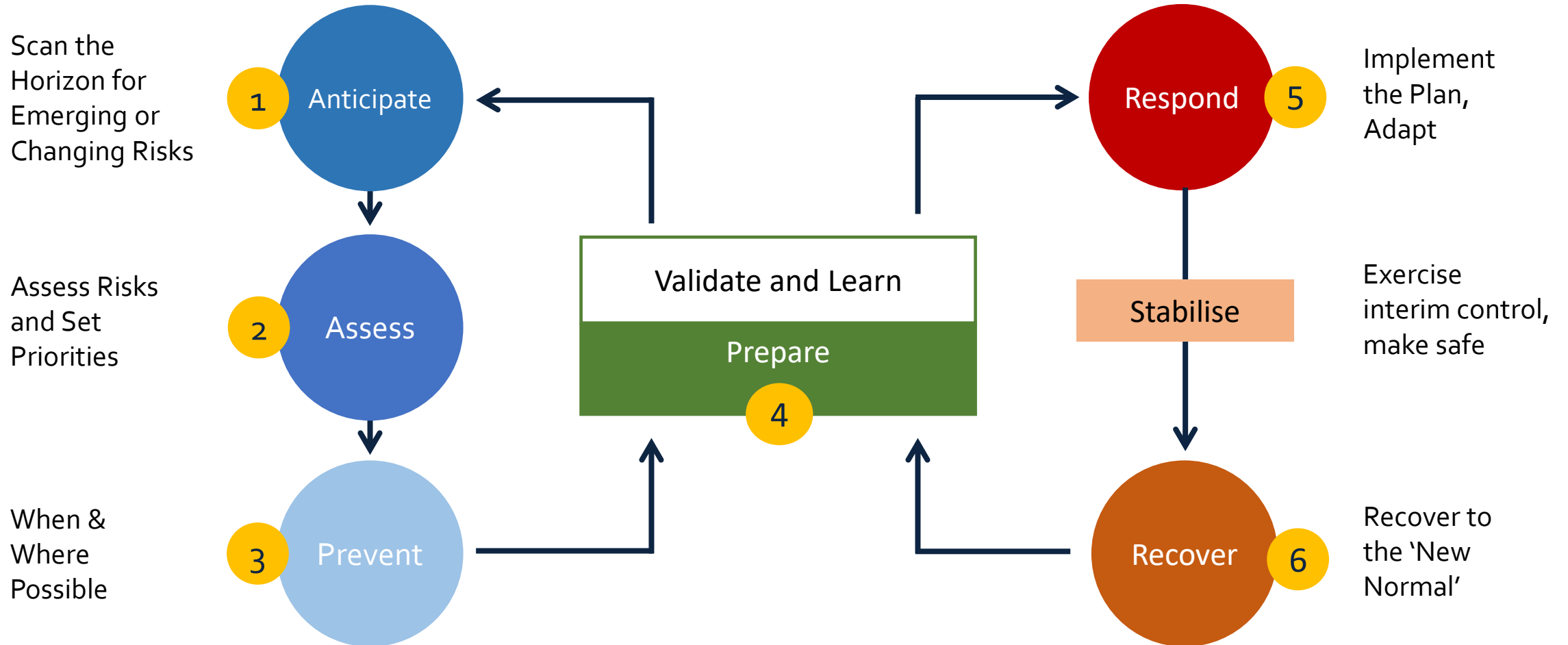
Resilience

“Resilience is a ‘**whole of society**’ endeavour, so we must be more transparent and empower everyone to make a contribution.”



“With multiple threats and challenges facing us now, and in the future, a **whole-of-society** approach is essential.

The Resilience Cycle



Domains of Resilience

- 1 Robustness**
physical resistance, up to design standard (e.g. high-spec materials)
- 2 Reliability**
continuity under a variety of conditions
- 3 Redundancy**
substitution (e.g. safe diversion routes, fall-back options)
- 4 Resourcefulness**
the ability to apply material (i.e., monetary, physical, technological, and informational) and human resources to meet established priorities and achieve goals
- 5 Rapidity**
meet priorities and achieve goals in a timely manner
- 6 Recovery**
recover from disruption, 'build back better'





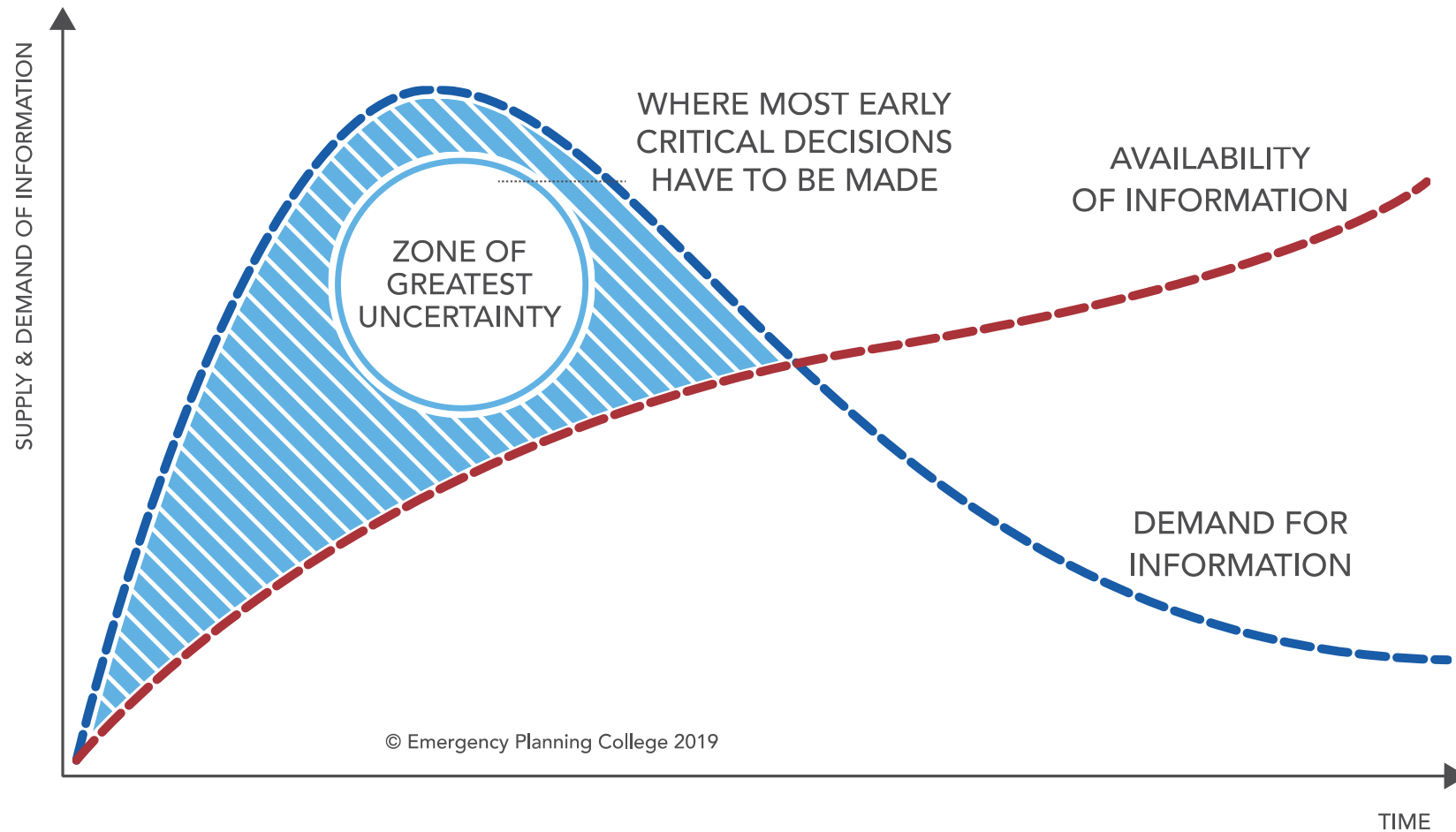
FEMA

Highways as 'Lifelines'



- “Lifelines are the most **fundamental services** in the community that, **when stabilized**, enable all other aspects of society to function
- Lifelines are the **integrated network** of assets, services, and capabilities that are used day-to-day to support the recurring needs of the community
- When disrupted, **decisive intervention** is required to stabilize the incident”

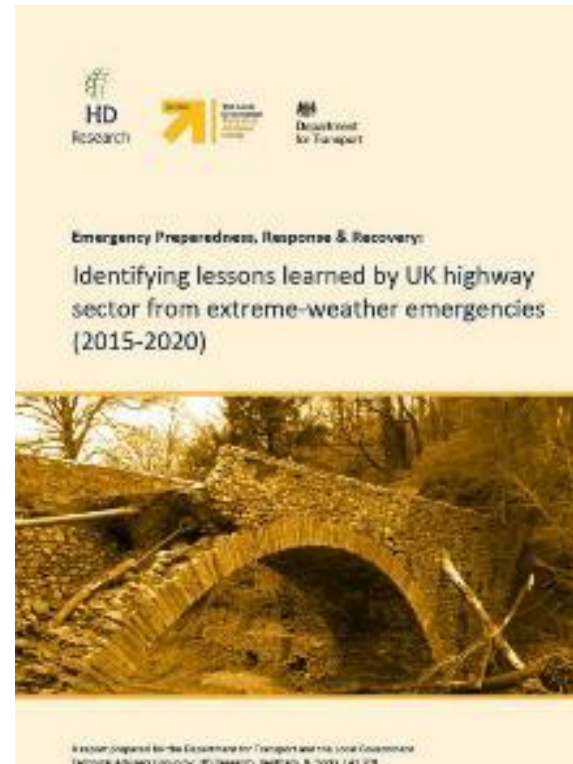
Situational Awareness





Key recommendations from extreme-weather reviews

- The critical importance of **Suitably Qualified, Experienced and Empowered People** in delivering Highways emergency management.
- The need for consistent **Rapid Impact Assessment**
- The need for **Mutual Aid** contingencies to be developed **on a regional / national basis**, and in conjunction with the **private sector**.



Impact =

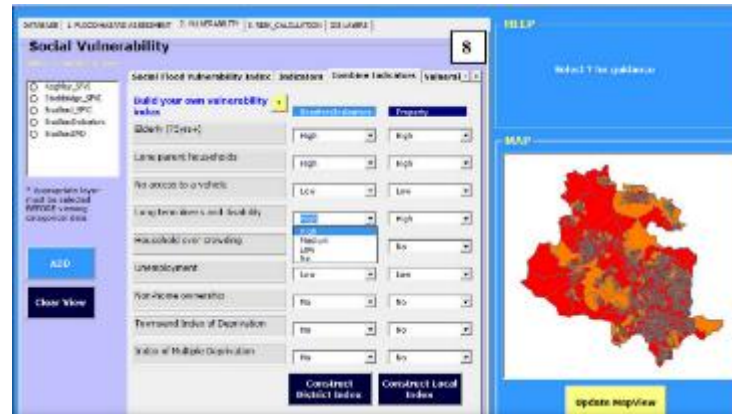


Damage

x



+



Consequences

x



Duration

StormchainRIA Summary Report - Local Highway Authority



Time/Date Report Created: 12 Jun 2025 08:49 (GMT)
 Incident Name: Storm Zinder - Test
 Reporting Authority: United Kingdom
 Report printed by: Hugh Deering
 Current Cost Estimate: £ 372,490

Assets to be assessed (provisional): 18

* Provisional number of inventoried assets, plus number of assets found and/or reported at this time as damaged for which RIA has been activated.

Highways Operating Picture at Time of Report:

Local Summary

Incident storm zander - test has occurred in United Kingdom

As a result of this event 18 assets have been identified for inspection and RIA tests have been issued. So far 18 RIAs have been fully issued, and from the assessments undertaken 2 total failures of an asset have been identified. Further details are included below in this report and links to individual asset reports (which include images and a more precise map location) are also provided.

Access to the StormchainRIA website (registered account and password required) is provided here: [Launch StormchainRIA](#)

WARNING: If you are viewing this report as a PDF in a web browser, launching StormchainRIA from this link will close the report.

Note: An overview map is provided below, however accessing storm chainria will allow users full (read only) map search functionality and access to additional data layers.

Location Overview of Incident Area and Assessments



Asset VDR Key:
 Total Failure
 Severe
 Limited and Moderate
 None
 Not Assessed: Inaccessible
 Damage not rated but noted

12 Jun 2025 08:49

Visible Damage Rating (VDR)		
Rating	Total	Damage Status
Total Failure	2	Complete loss of structural integrity (collapse) and/or danger from damaged aligned services
Severe	4	Structure badly damaged, with impact on structural integrity
Moderate	3	Structure is damaged, but retains integrity
Limited	8	Minor damage only
None visible or suspected	1	No damage visible or suspected
Suspected, but not visible	0	Damage is reasonably suspected but not currently visible (e.g. possible bridge scour obscured by high river flow)
Awaited	0	RIA has been assigned but inspector has not yet completed assessment

Consequences Rating		
Rating	Total	Repair Priority
Extreme	2	Significant to extreme immediate impact on community. Expedited repair of asset is critical for community functioning
Significant	3	Repair of asset is critical for community recovery (requires expedited repair and focused management and community support)
Moderate	4	Repair is important for community recovery, but managed temporary options are acceptable in short/medium term.
Limited	0	Repair can be dependent on broader recovery programme
Minor	9	This asset repair should not be prioritised above business as usual
Awaited	0	Assets awaiting consequence assessment

Impact Rating Matrix											
Consequences for the Community	5 - Extreme	4 - Significant	3 - Moderate	2 - Limited	1 - Minor	1 - None visible or suspected	2 - Limited	3 - Moderate	4 - Severe	5 - Total Failure	6 - Damage suspected but not visible (e.g. bridge scour)
	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10
	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10
	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10
	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10
	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10	0 x10

NB: The top left cell is Red listed, even though there is no visible damage reported. This covers possible occasions when a blanket closure has been placed (e.g. all bridges closed until inspected). Having the Red Rating here draws the RIA Manager's attention to the fact that this asset needs to be reopened ASAP.

Warning: Only assets with both a damage and consequence ratings are included in the matrix asset counts and only rated assets can contribute to the Total Impact Score.

Total Assets Identified for Assessment: 18
 Damage Rated but No Consequence Rating: 0
 Consequence Rated but Damage Not Rated: 0
 Neither Damage nor Consequence Rated: 0
 Total Fully Rated Assets: 18
 Total Impact Score (for Rated Assets): 299

Damage rating 6 applied where damage is reasonably suspected but a substantive visual inspection is not possible at this time (e.g. inspection of bridge foundations during high flow).

12 Jun 2025 08:49



Stormchain
 Restoring Community Lifelines

Asset Type	Visible Damage Rating	Impact Score	Location	Asset Status	Diversion Required	Current Cost Est.	UID - Click for Site Report
Road Structure	Total Failure	50	54.5041262N -3.0455740W	Closed To All Traffic	Yes	£100,000	3733
Road Structure	Total Failure	50	54.5508596N -2.5420138W	Closed To All Traffic	None Av.	£100,000	2802
Bridge	Severe	40	54.4285209N -2.8367883W	Closed to all traffic pending safety/stabilisation measures	None Av.	£25,000	1432
Embankment	Severe	40	54.4544881N -2.8021642W	Closed To All Traffic	Yes	£9,000	1280
Bridge	Severe	40	54.5467048N -3.1542269W	Closed To All Traffic	Yes	£18,500	1245
Road Structure	Severe	25	54.5605802N -3.1543386W	Open To Public With Restrictions	No	£100,000	3793
Wall/Retaining wall - public	Limited	15	54.5157856N -3.1828042W	Open To Public With Restrictions	No	£4,000	1450
Bridge	Moderate	15	54.6780312N -2.8093972W	Open To Public With Restrictions	No	£3,000	2332
Road Structure	Moderate	15	54.4884454N -3.0238164W	Open To Public With Restrictions	No	£5,000	1462
Culvert greater than 0.9m in diameter	Limited	1	54.2688383N -2.8042107W	Open To Public With Restrictions	Unknown	£450	1233
Trees	Limited	1	54.2736281N -2.8505862W	Open To Public With Restrictions	No	£840	1235
Wall/Retaining wall - private	Limited	1	54.5024701N -2.7114432W	Open To All Permitted Traffic	Unknown	£0	1482
Wall/Retaining Wall - public	Limited	1	54.37780310N -2.8178523W	Open To Public With Restrictions	No	£1,700	1238
Wall/Retaining Wall - public	Limited	1	54.6756310N -2.9222060W	Open To Public With Restrictions	No	£1,200	1243
Bridge	Limited	1	54.5168974N -3.2084219W	Open To Public With Restrictions	No	£400	2732
Bridge	Moderate	1	54.5226326N -3.2213577W	Closed To All Traffic	Yes	£2,400	1251
Culvert less than 0.9m in diameter	Limited	1	54.5315334N -3.2580039W	Open To Public With Restrictions	No	£1,000	1252
Bridge	None-visible or suspected	1	54.6015027N -3.1912587W	Open To All Permitted Traffic	Unknown	£0	1231

12 Jun 2025 08:49

Individual Asset Damage Report.



Time/date report created (GMT): 31 Jul 2023 15:38
Incident Name: Storm Zander - Test
Reporting Authority: United Kingdom
Asset URN: 3810
Stormchain internal URN: 3811
Stormchain version ID: 3884

Report created by: Hugh Downing
Report printed by: Hugh Downing
Visible (Internal Only): Total Failure
Consequence Rating: Extreme
Impact Score: 50
Current Cost Estimate: £ 100,000



Live link to StormchainRIA (registration and password required): <https://uk.stormchain.org/oms/>
Note: accessing StormchainRIA will allow users full map search functionality (Read-only)



Stormchain Internal URN:

2902



Stormchain

Restoring Community Lifelines

Stormchain Internal URN: 3810
Stormchain Version ID: 3811

Asset Location: OSGR: 51.2508203, -0.0666884
Lat/Long: 51.2508203, -0.0666884
WVR: Near the junction of Salisbury

Location Description: Class: A
Number: 25
Name: Godstone High street
Resilient Network: Yes

Road Details: Class: A
Number: 25
Name: Godstone High street
Resilient Network: Yes

Safe to Proceed: Yes

Asset Type: Road Structure
Asset Description: Road structure compromised
Asset URN (JA Inventory): Collapse (Sinkhole) - Carriageway
Damage Assessment: Total failure
Damage Description: Total failure
Visible Damage Rating: Total failure

Damage to Networks: "Gas - No Smell", "Electric - Buried", "Water - Main", "Water - Foul", "Water - Surface", "Telecom/Fibre - Buried"

Detail of "Other" Damage to Networks: Total collapse 2 visible holes one in the carriageway and another in a private drive. Approx size first hole 25m x 8m second hole 8m x 8m depth of both is roughly 5m. Both of the holes are actually connected and the only thing holding the tarmac up is a large gas main

Specialist Assessment: Detail of "Other" Specialist Inspections: "Full Carriageway Closure", "Footway Closure", "Safety Barrier / Cones"

Traffic Measures Required: Here's fencing has been installed to cover the whole area off. Gatemen on both sides of the closures. Diversion put out and other smaller cut through roads have been shut to stop diverted traffic using it as road is unsuitable

Traffic Measures Description: Yes, medium diversion (greater than 2km - less than 10km)
No

Diversion Route Required: Yes, medium diversion (greater than 2km - less than 10km)
No

Approved Diversion Route Operating: No

Consequence Rating: Extreme
Consequence Rating Reason: multi agency disruption and assets affected. Residents have been evacuated from three homes within a certain radius. Main A road will be shut for the foreseeable future. Costs unknown at this present time awaiting survey of complete damage

Impact Score: 50
Repair Task: Complex repair project
Current Cost Estimate: £ 0

Current Status of Asset: Closed To All Traffic
Safe for Users: No
Actions Required to Reopen: Complete investigation of the sinkhole. Repair all utility assets that are damaged as well as complete reconstruction of the road once the sinkhole has been backfilled

Current Comment/Message: SGH, UKFR, SES water on site

Impact Rating Matrix

Consequences for the Community	5	Extreme	x16	x25	x25	x45	x50	x45
	4	Significant	x16	x25	x25	x45	x45	x45
	3	Moderate	x7	x15	x15	x25	x20	x25
	2	Limited	x7	x15	x15	x15	x15	x15
	1	Minor	x7	x7	x7	x7	x7	x7
Damage to Asset								
1 - None visible or suspected								
2 - Limited								
3 - Moderate								
4 - Severe								
5 - Total Failure								
6 - Damage suspected but not visible (e.g. bridge scour)								

NB: The top left cell is Red Rated, even though there is no visible damage reported. This covers possible occasions where a blanket closure has been placed (e.g. all bridges closed until inspected). Having the Red Rating here draws the RIA Manager's attention to the fact that this asset needs to be reopened ASAP.

Impact Score: 50

Damage rating 6 applies where damage is reasonably suspected but a substantive visual inspection is not possible at this time (e.g. inspection of bridge foundations during high flow).

From UKRLG to PIARC

Strategic Theme 1 Road Administration 	Strategic Theme 2 Road Mobility 	Strategic Theme 3 Safety and Sustainability 	Strategic Theme 4 Resilient Infrastructure 
Technical Committees			
TC 1.1 Performance of Transport Administrations	TC 2.1 Roads for Accessibility and Mobility in Urban and Peri-urban Areas	TC 3.1 Road Safety	TC 4.1 Pavements
TC 1.2 Contribution of Roads to Economic and Social Development	TC 2.2 Roads for Equity, Accessibility and Mobility in Rural and Interurban Areas	TC 3.2 Winter Service	TC 4.2 Bridges
TC 1.3 Finance and Procurement	TC 2.3 Sustainable Freight	TC 3.3 Asset Management	TC 4.3 Earthworks
TC 1.4 Planning the Resilience of Road Networks - Climate Change and other Hazards	TC 2.4 Road Network Operations and ITS for Sustainability	TC 3.4 Environmental Impacts of Road Infrastructure and Transport	TC 4.4 Tunnels
TC 1.5 Disaster management	TC 2.5 Road infrastructure for Connected and Automated Mobility	TC 3.5 Road infrastructure for road transport decarbonization	TC 4.5 Decarbonization of road Construction and Road Maintenance
			TC 4.6 Road Design Standards

Moving from Decarb to Adaptation

- Considerable focus on Decarbonisation – Nationally
- £30m DfT Live Labs2 to decarbonise how we maintain our roads
 - Projects include
 - bio-ethanol from verge grass
 - Place based decarbonisation
 - A Net Zero carbon road
 - Rethinking street lights whilst enhancing visual acuity
- Where is the Adaptation
 - Funding right now for supporting learning & training – multi hazard
 - Rapid Impact Assessment as the basis of Shared Situational Awareness
 - Building the longer-term business case
 - What assets and where according to different hazards?
 - Where are the most hazard prone locations?
- The drivers to act are already here – where is the action? Who leads on this? What is the consequence

One Last Thing

Support APSE

Engage with UKRLG

Get Connected with PIARC

Thank you