Resilient Network Management Plan

Revision 2.2 - July 2022

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Change Control

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Reviewer List

Name	Role	First Issue	Revision 1	Revision 2	Revision 2.1
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Approvals

Name	Role	Date	Version
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LB	Acting Head of Highways	29/12/2021	Revision 2
LB	Acting Head of Highways	23/02/2022	Revision 2.1
JM	Principal Engineer (Highways Operations	20/07/2022	Revision 2.2

Revision History

Version	Date	Description	Author
First Issue	February 2018	Initial compilation and publication	JM
Revision 1	September 2020	Biennial Review	CS
Revision 2	December 2021	Map update following consultation	LB
Revision 2.1	February 2022	Table from map added as appendix to report. Organisation names updated.	AA
Revision 2.2	July 2022	Exceptional Heal Plan appended	AA

Contents

1 Introduction

1.1 Purpose

The UK's road network is an important part of our national infrastructure, enabling the successful operation of many social and economic activities and the continued availability and operation of these routes is a vital part of keeping our towns, cities and regions running.

Resilience is defined by the Cabinet Office as the 'ability of the community, services, area or infrastructure to detect, prevent, and, if necessary to withstand, handle and recover from disruptive challenges.' There are four components to resilience and Highway Authorities are likely to draw on a combination of these in reducing risk of failure, especially on their Resilient Networks:

- resistance – preventing damage;
- reliability – operation under a range of conditions;
- redundancy – availability of backups or spare capacity;
- recovery – enabling a fast response and recovery.

In accordance with the recommendations in Well Managed Highway Infrastructure: A Code of Practice (2016), Medway Council has identified a Resilient Network within the highway network 'to which priority is given through maintenance and other measures to maintain economic activity and access to key services during extreme weather' and other disruptive events.

This document sets out our approach to the definition and management of the Resilient Network in Medway and our response to managing disruptive events.

1.2 Aims of the Resilient Network

The aim of the Resilient Network is to maintain economic activity and access to key services during extreme weather and other disruptive events:

1.3 Scope

This document covers the following activities:

- Network improvements;
- Planned, cyclical and reactive maintenance;
- Network management;
- Highway operations.

This covers all assets on the Resilient Network, including:

- Carriageways and Footways;
- Highway Structures;
- Highway Drainage systems;
- Street Lighting;
- Traffic Signals.

1.4 Relationship to other documents

This document describes our approach to managing the Resilient Network and, wherever possible, references other external documents that cover the detailed response to particular disruptive events.

- Drainage Improvement Plan;
- Exceptional Heat Plan (included as an Appendix to this document);
- Local Flood Risk Management Strategy;
- Highway Asset Management Plan;
- Major Emergency Plan;
- Medway Tunnel Emergency Plan;
- Surface Water Management Plans;
- Winter Service Policy and Plan.

This is illustrated below:

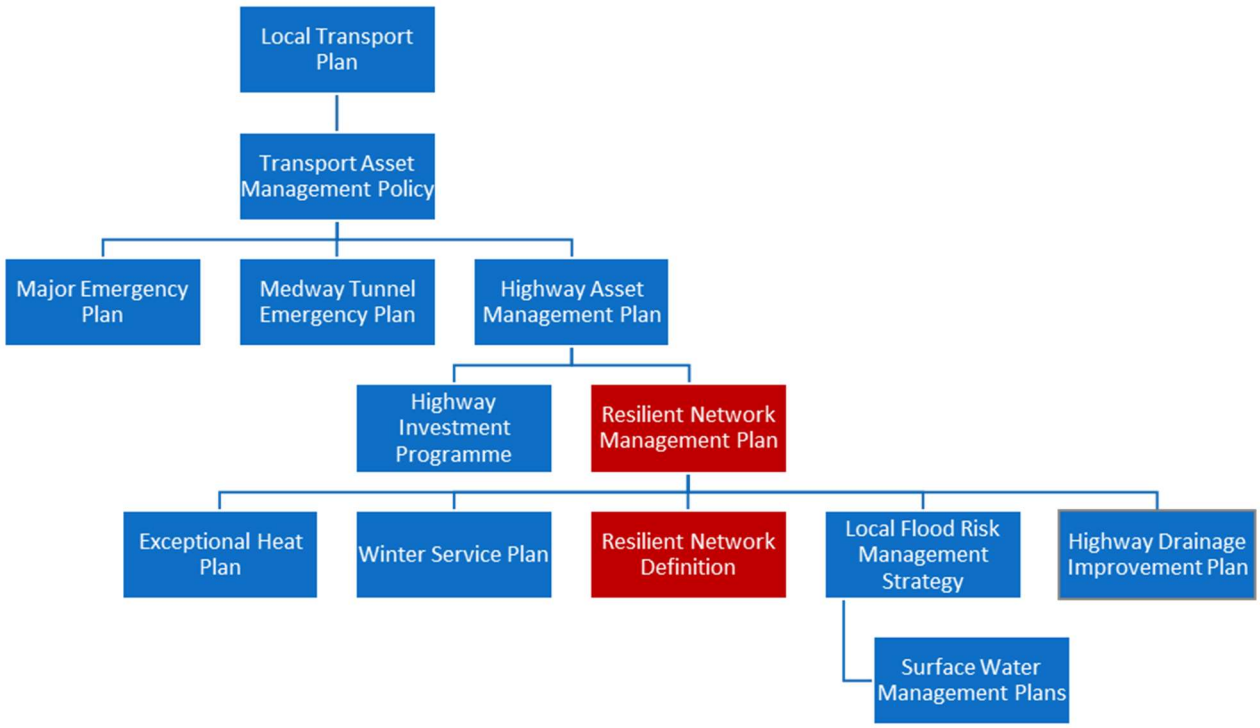

Figure 1 - Network Resilience Related Documents.

2 Governance

2.1 Ownership and responsibilities

Overall ownership for this document rests with the Head of Highways. Responsibility for undertaking reviews and developing the resilient network management plan sits with the Principal Engineer (Asset Management), and Principal Engineer (Highways Operations).

The plan has been produced by the Asset Management team with input from the other highway functions as illustrated in the RACI chart below:

	Definition of Resilient Network	Resilient Network Management	Implementation of Resilient Network
Assistant Director - Frontline Services	A	A	A
Head of Environmental Services	C	C	I
Head of Regulatory Services	C	C	I
Head of Highways	A/R	A/R	A/R
Head of Transport & Parking	C	C	I
Strategic Environmental Protection Manager	C	C	I
Emergency Planning Manager	C	C	I
Community Safety & Enforcement Manager	C	C	I
Sustainable Transport Manager	C	C	I
Traffic Engineering Manager	C	C	I
Principal Engineer (Asset Management)	R	R	R
Principal Engineer (Highways Operations)	R	R	R
Principal Engineer (Network Management & Street Lighting)	C	C	R
Principal Engineer (Capital Projects)	C	C	R
Principal Engineer (Road Safety)	C	C	R
Senior Engineer (Traffic Signals)	C	C	R
Flood Drainage and Special Projects Officer	C	C	R
Smart Cities Project Officer	C	C	R
Other Highways Staff	I	I	R
Other Council Staff	I	I	I
Rochester Bridge Trust	C	I	I
Other External Stakeholders (as required)	C	I	I

R - Responsible, A – Accountable, C – Consulted, I – Informed

Table 1 – Medway's Responsibility Assignment Matrix.

2.2 Funding

While there is currently no separate capital or revenue budget allocated to the management and maintenance of the Resilient Network, the costs needed to provide the required level of

service and preparedness of the Resilient Network effectively represents a 'do minimum' funding scenario when budget planning takes place. However, it is recognised that the enhanced level of service on the Resilient Network must be affordable.

3 Definition of Resilient Network

3.1 Criteria for inclusion in the network

Criteria for inclusion in the Resilient Network are as follows:

- Link major routes to Town Centres;
- Roads connecting main areas with the National Highways Strategic Road Network, including M2 Diversion Route, or Kent County Council's Strategic Road Network;
- High employment sites (including commercial, industrial sites);
- Emergency Hub Points (including Fire, Police and Ambulance Stations and Hospitals);
- Roads connecting to key infrastructure (including Power Stations);
- Links to bus and railway stations;
- It forms a connected network.

The total length of the overall Resilient Network based on these criteria is 126 km or 15% or Medway's 835km highway network. Despite comprising a relatively small proportion of the overall highway network, 95% of automatic traffic counters, 100% of CCTV cameras, 100% of variable message signs and 84% of traffic signals are situated on the Resilient Network.

Within the overall Resilient Network, Medway has identified Tier 1 and Tier 2 Resilient Networks as described below.

Tier 1 Resilient Network

Medway has identified, within the overall Resilient Network, routes where disruptive events will have a particularly high impact on traffic flow in Medway and surrounding network. This Tier 1 Resilient Network will be kept open and accessible in all but the most extreme circumstances with the aim of providing a minimum essential service to the public, including links to the strategic network and bordering authorities' networks, significant through routes, access to key facilities and local communities, and other transport needs. The length of the Tier 1 Resilient Network is 85 km or 10% of the total highway network.

Tier 2 Resilient Network

The Tier 2 Resilient Network is that part of the overall Resilient Network which isn't considered Tier 1. It includes roads that are locally important but that do not provide links to the Strategic Road Network or are significant through routes. The Tier 2 Resilient Network will be kept open and accessible with the aim of maintaining economic activity and access to key services during extreme weather and other disruptive events. The length of the Tier 2 Resilient Network is 41 km or 5% of the over Highway Network.

Publication of Network Maps

A map of Medway's Resilient Highway Network can be found at the following location: Resilient Network Map. It is the longer-term intention to build the resilient network into

Medway's Highway Asset Management system, should this be considered to provide a benefit in future.

3.2 Critical assets

Critical assets are those individual assets that are essential for supporting the social and business needs of both the local and national economy. They will have a high consequence of failure, but not necessarily a high likelihood of failure. These assets should be identified separately and assessed in greater detail as part of the asset management planning process.

The only critical asset managed by Medway Council is the Medway Tunnel. Any response to an incident is described in the Medway Tunnel Emergency Plan.

The Medway Tunnel Emergency Plan is intended to aid emergency responders in understanding the technical and safety facilities of the Medway Tunnel and to supplement the Medway Council Major Emergency Plan. The plan sets out the tactical principles for incident response and describes the tunnel infrastructure. It is intended that each responding agent will utilise this information in the preparation of their own response plans for an incident at or in the tunnel.

The other critical asset in Medway is Rochester Bridge which serves as one of the only alternative diversion routes across the River Medway if the Medway Tunnel is not operational. The bridge is maintained by the Rochester Bridge Trust who are one of our key stakeholders.

3.3 Stakeholder consultation

In addition to the internal stakeholders identified in the above RACI chart, the external stakeholders for the Resilient Network include:

- National Highways;
- Kent County Council;
- Kent Fire and Rescue Service;
- Kent Police;
- Kent Resilience Forum;
- Major employers;
- Network Rail;
- Royal Engineers;
- South East Coast Ambulance Service;
- Utility companies.

This list will be reviewed before the Resilient Network is updated.

Stakeholders will be consulted on the initial definition of the Resilient Network and the Resilient Network Management Plan to ensure that:

- They are aware that Medway maintains a Resilient Network and how it is intended to be managed;

- As far as possible, the network provides a level of service that meets their ongoing needs and enables them to provide their own resilience (for example they may need guaranteed access to certain locations);
- The network reflects any planned changes.

As far as possible, this consultation will make use of existing forums and channels such as Kent Highway Authority Utilities Committee (HAUC), and Kent's Local Resilience Forum (LRF) meetings.

3.4 Communication and Awareness

The Resilient Network will be published on www.medway.gov.uk and will be communicated through the normal council communication channels. Internally, relevant staff will be made aware of the Resilient Network management plan through training events as well as through normal management communications.

3.5 Ongoing review and update

The Resilient Network definition will be reviewed biannually to ensure that it reflects any changes to the network or any significant developments within Medway, such as those associated with the Housing Infrastructure Fund or the long-term ambition of becoming a 'Waterfront University City', that have occurred since the previous version. Considerations will also be made to review the resilient network after any major disruptive event as part of any lessons learned.

4 Management of the Resilient Network

This section describes how we intend to provide resilience through our normal maintenance and operations on the Resilient Network. Section 5 describes how we manage particular disruptive events including flooding, winter and severe weather and other major disruptive events.

4.1 Planning

Resources and competencies

Through Medway Council's staff and its service providers, we will provide the resources and competencies required to manage the Resilient Network as described in this plan. This will be subject to ongoing review and, where there are competing resource demands, the Resilient Network management will be prioritised.

Data and systems

We will maintain good information about the Resilient Network, including its age, condition and performance, and will use our information management systems to assess risks and manage our response.

4.2 Maintenance and Operations

Design for resilience

We will consider how to provide resilience in the design and construction of any new assets on the Resilient Network, including:

- Choosing materials and equipment that has a long-life or considering how future maintenance can be carried out while minimising disruption on the network;
- Considering how disruptive events, such as flooding or extreme heat, could be mitigated through the design of the solution for example through the use of smart drainage technology or surface materials that are resilient to extreme heat.

We will also seek to future-proof the maintenance of any new assets as far as possible by considering ongoing availability of materials, compatibility and technology obsolescence. In future, these will be described in specific Resilient Network design standards covering all asset types.

Planned maintenance

The condition of the Resilient Network and its assets will be surveyed and inspected, and maintenance needs identified in line with the rest of the network. However, any potential highway schemes on the Resilient Network will be given a higher weighting when these schemes are prioritised each year using our multi-criteria scheme prioritisation matrix.

As far as possible, we will carry out preventative maintenance to avoid more disruptive maintenance in future and maintenance schemes will be designed to provide resilience as described above. In future, these will be described in specific Resilient Network design standards covering all asset types.

Cyclical maintenance

In terms of routine or cyclical maintenance activities, we will carry out gully cleansing operations on the Resilient Network every year along with those on other A and B roads, compared with every other year on the rest of the network, to help mitigate the risk of flooding.

In future, we will consider the frequency of other routine maintenance activities on the Resilient Network including, but not limited to:

- Targeting gully cleansing operations based on information about flood risks, in line with the Local Flood Risk Management Strategy (LFRMS);
- Tensioning and repair of barriers;
- Cleansing and repair of traffic signs and bollards;
- Replacement of road markings and studs;
- Management of trees.

Responsive maintenance

Currently we make no distinction between the Resilient Network and the rest of the network in terms of safety inspections frequencies, but this may be reviewed in the future.

If any defects are found on the Resilient Network, then they may trigger a faster response time than the standard 28 working day response depending on the specific level of risk. In terms of repair, the focus is on ensuring the network is safe, reopened quickly and future disruption due to follow-up maintenance minimised.

Network management

We will consider whether there would be any benefit in terms of network resilience if all streets on the Resilient Network were designated Traffic Sensitive Streets under section 64 of the New Roads and Street Works Act. This would require works promoters to give greater advanced warning of proposed works or activities which may help co-ordinate activities and reduce disruption.

Incident management

Any incidents occurring on the Resilient Network, such as vehicle impact, cable damage, vandalism, storm damage, may trigger a faster response time depending on the specific level of risk, including Emergency Call Outs (ECOs).

Ongoing and Post Event review

Our maintenance and operational activities on the Resilient Network will be reviewed on a regular basis to ensure that they are effective, affordable and provide the level of resilience required. They will also be considered for review along with lessons learned, following any disruptive event that may occur on the network.

Any necessary changes will be considered in the next update of the Network Resilient Management Plan unless, and by exception, they need to be implemented more urgently. In this instance any urgent changes required to operational procedures will be made as soon as reasonably possible.

Currently, no distinction is made between the assessment criteria, or response times for Tier 1 and Tier 2 Resilient Network routes. This currently applies to all areas of highway maintenance and operations, however it is our intention for this to be reviewed and developed in the future.

5 Managing Disruptive Events

The following table shows the potential events leading to disruption on the Resilient Network, mitigating actions, response and recovery actions, and also references external documents where relevant.

Disruptive Event	Mitigating Actions	Planning	Response	Recovery
Flooding	• Carry out targeted gully cleansing at flood sites; • Prioritise drainage improvement schemes on Resilient Network. • Secure investment into remote monitoring systems at known flooding sites to enable a more effective response.	• Maintain detailed records of all flood incidents; • Local Flood Risk Management Strategy; • Surface Water Management Plans.	• Drainage Service Standards review as part of the biennial review of the Drainage Improvement Plan in 2021; • Secure capital investment into Drainage Infrastructure to improve resilience performance.	• Biennial Review of the Drainage Improvement Plan in 2021.
Winter and severe weather	• Designing for resilience; • Develop response to exceptional heat.	• Winter Service Plan; • Develop response to exceptional heat.	• Prioritise incident; response (e.g. storm damage) on Resilient Network; • Post event review; • Winter Service Plan; • Develop response to exceptional heat.	• Winter Service Plan; • Develop response to exceptional heat; • Post event review.
Asset deterioration or failure	• Carry out regular inspections and surveys; • Prioritised planned maintenance on Resilient Network;	• Maintain accurate and up to data asset information; • Carry out regular inspections and surveys.	• Prioritised reactive responses on Resilient Network; • Post event review.	• N/A.

Disruptive Event	Mitigating Actions	Planning	Response	Recovery
	• Designing for resilience.			
Medway Tunnel availability	• Review of Medway Tunnel Emergency Plan.	• Medway Tunnel Emergency Plan.	• Medway Tunnel Emergency Plan.	• Medway Tunnel Emergency Plan.
Rochester Bridge Trust availability	• Pending further development and engagement with RBT.	• Pending further development and engagement with RBT.	• Pending further development and engagement with RBT.	• Pending further development and engagement with RBT.
National Highways Diversion on M2 in effect	• Pending further development.	• Pending further development.	• Pending further development.	• Pending further development.
Other major disruptive event	• Designing for resilience.	• Major Emergency Plan.	• Prioritising street works management on Resilient Network; • Prioritising incident management on Resilient Network; • Major Emergency Plan.	• Major Emergency Plan; • Post event review.

Table 2 Disruptive Event Management.

6 Improvement Actions

The following potential improvement actions have been identified for consideration in the next version of the resilient network management plan:

- Ensure exceptional heat, industrial action, major incidents, and other local risks are built into the resilient network management plan;
- Identify Tier 1 and Tier 2 resilient networks in asset information systems;
- Organise internal communication and awareness activities, including establishing an Internal Resilience Forum;
- Ensure relevant policy documents refer to the Resilient Network Management Plan;
- Instigate ‘lessons learned’ capture and review processes;
- Investigate other cyclical activities on Resilient Network;
- Consider Traffic Sensitive Streets categorisation for streetworks management on Resilient Network;
- Create a resilient network layer within streetworks gazetteer to help with managing diversion routes in future;
- Consider producing design standards for network resilience;
- Define response standards for National Highways M2 diversion route;
- Review whether to distinguish between Tier 1 and Tier 2 for reactive, cyclic and planned maintenance plus incidents including viability of different service response standards towards both tiers;
- Consider ways of improving traffic management on the resilient network, such as innovative technology methods;
- Consider ways of using technology to better co-ordinate inspectors and other operational staff while on the network;
- Resilient Network needs to include condition data analysis;
- Explore viability of a ring-fenced maintenance budget for the Resilient Network;
- Engage with Rochester Bridge Trust regarding the coordination of response for Rochester Bridge emergency;
- Include operational response to flooding incidents on the resilient network in the forthcoming review of the Drainage Improvement Plan.

Appendix – Roads on the Resilient Network and their criteria for inclusion (table also shown on Map in tick box format)

Road Class	Road Name or Section	Area	Length (m)	Criteria for Inclusion in resilient network	Resilient Network Tier
A2		Strood	3,380 m	Significant road connecting to economic centres, major superstores and providing important connection for Kent or National Highways network	Tier 1
A2	in	Rochester	2,706 m	Significant road connecting to economic centres	Tier 1
A2		Chatham	2,622 m	Significant road connecting to economic centres	Tier 1
A2	in	Gillingham	6,173 m	Significant road connecting to economic centres and to fire station or emergency R.V.P.	Tier 1
A2		Rainham	2,681 m	Significant road connecting to economic centres and providing important connection for Kent or National Highways network	Tier 1
A226	Gravesend Road	Strood	1,451 m	Significant road connecting to fire station or emergency R.V.P. and providing important connection for Kent or National Highways network	Tier 2
A228	Grain to A289	Peninsula	17,920 m	Significant road connecting to economic centres, isolated community and significant power and gas supply infrastructure	Tier 1
A228	A289 to Strood Centre	Strood	1,687 m	Significant road connecting to economic centres	Tiers 1 & 2
A228	Strood Centre to M2	Strood	3,204 m	Significant road connecting to economic centres and major superstores	Tiers 1 & 2
A228	South of M2	Cuxton & Halling	5,701 m	Significant road connecting to economic centres	Tier 1
A229	City Way	Rochester	2,890 m	Significant road	Tier 1
A229	Maidstone Road	Chatham	2,770 m	Significant road connecting to economic centres, major superstores, fire station or emergency R.V.P. and providing important connection for Kent or National Highways network	Tier 1
A230	Horsted Way	Chatham	499 m	Significant road	Tier 2
A230	Maidstone Road	Chatham	2,628 m	Significant road	Tier 2
A231		Chatham	3,378 m	Significant road connecting to economic centres and Royal Engineers	Tier 2
A231	in	Gillingham	3,112 m	Significant road connecting to economic centres and railway station	Tier 2
A278	Hoath Way	Gillingham	7,765 m	Significant road providing important connection for Kent or National Highways network	Tier 1
A289	in	Strood & Tunnel	13,240 m	Significant road providing important connection for Kent or National Highways network	Tier 1
A289		Chatham & Gillingham	11,367 m	Significant road connecting to major superstores, police station and highways or waste depot	Tier 1
B2001	Grain Road	Peninsula	2,880 m	Significant road connecting to economic centres, isolated community, fire station or emergency R.V.P and significant power and gas supply infrastructure	Tiers 1 & 2
B2004	Station Road	Rainham	451 m	Road connecting to railway station and fire station or emergency R.V.P.	Tier 2
B2017	North Street	Strood	245 m	Significant road	Tier 1
C32	Walderslade Road	Chatham	122 m	Significant road providing important connection for Kent or National Highways network	Tier 2
C32	Walderslade Road by-pass	Chatham	281 m	Significant road providing important connection for Kent or National Highways network	Tier 2
C32	Robin Hood Lane	Chatham	275 m	Significant road providing important connection for Kent or National Highways network	Tier 2
C372	Dock Road	Chatham	837 m	Significant road	Tier 2
C372	Maritime Way	Chatham	703 m	Significant road	Tier 2
C490	High Street	Halling	1,125 m	Road connecting to railway station	Tier 2
C490	Kent Road	Halling	482 m	Road connecting to railway station	Tier 2
C8	Main Road	Hoo	2,958 m	Road connecting to fire station or emergency R.V.P.	Tier 2
C8	Stoke Road	Hoo	1,224 m	Road connecting to economic centres	Tier 2
C9	Bells Lane	Hoo	1,411 m	Road connecting to fire station or emergency R.V.P.	Tier 2
Private	Marconi Way	Rochester	231 m	Road connecting to bus or coach facilities and fire station or emergency R.V.P.	Tier 2
Unclassified	Ambley Road	Gillingham	1,220 m	Road connecting to economic centres	Tier 2
Unclassified	Anthonys Way	Strood	855 m	Road connecting to economic centres and highway or waste depot	Tier 2
Unclassified	Bailey Drive	Gillingham	345 m	Road connecting to economic centres and major superstores	Tier 2
Unclassified	Canal Road	Strood	507 m	Road connecting to railway station, bus or coach facilities and highway or waste depot	Tier 2

Road Class	Road Name or Section	Area	Length (m)	Criteria for Inclusion in resilient network	Resilient Network Tier
Unclassified	Capstone Road	Chatham	448 m	Road connecting economic centres	Tier 2
Unclassified	Commissioners Road	Strood	157 m	Road connecting to economic centres, bus or coach facilities and highway or waste depot	Tier 2
Unclassified	Courteney Road	Gillingham	209 m	Road connecting to major superstores	Tier 2
Unclassified	Eshcol Road	Hoo	367 m	Road connecting to economic centres	Tier 2
Unclassified	Gibraltar Hill	Chatham	60 m	Link road	Tier 1
Unclassified	Globe Lane	Chatham	293 m	Road connecting to bus or coach facilities	Tier 2
Unclassified	Grosvenor Road	Gillingham	236 m	Road connecting to economic centres	Tier 2
Unclassified	Hempstead Valley Drive	Hempstead	702 m	Road connecting to economic centres and major superstores	Tier 2
Unclassified	Luton High Street	Chatham	277 m	Road connecting to economic centres	Tier 2
Unclassified	Luton Road	Chatham	1,230 m	Road connecting to economic centres	Tier 2
Unclassified	Marlborough Road	Gillingham	877 m	Road connecting to hospital or ambulance station	Tier 2
Unclassified	Montgomery Road	Gillingham	183 m	Road connecting to hospital or ambulance station	Tier 1
Unclassified	North Dane Way	Chatham	954 m	Road connecting to economic centres	Tier 2
Unclassified	Princes Avenue	Chatham	2,577 m	Road connecting to major superstores	Tier 2
Unclassified	Railway Street	Gillingham	336 m	Road connecting to railway station	Tier 2
A2, A230 & Unclassified	Railway Street	Chatham	355 m	Significant road connecting to railway station and bus or coach facilities	Tier 2
Unclassified	Riverside	Strood	220 m	Road connecting to economic centres, bus or coach facilities and highway or waste depot	Tier 2
Unclassified	Rock Avenue	Gillingham	468 m	Road connecting to hospital or ambulance station	Tier 1
Unclassified	Ropers Lane	Hoo	1,149 m	Road connecting to economic centres	Tier 2
Unclassified	Sharsted Way	Hempstead	623 m	Road connecting to economic centres and major superstores	Tier 2
Unclassified	Sir Thomas Longley Road	Strood	224 m	Road connecting to economic centres and highway or waste depot	Tier 2
Unclassified	St Werburgh Crescent	Hoo	101 m	Road connecting to fire station or emergency R.V.P.	Tier 2
Unclassified	Station Road	Cuxton	278 m	Road connection to railway station	Tier 2
Unclassified	Waterfront Way	Chatham	229 m	Road connecting to bus or coach facilities	Tier 2
Unclassified	Whitewall Road	Strood	787 m	Road connecting to economic centres and highway or waste depot	Tier 2
Unclassified	Will Adams Way	Gillingham	444 m	Road connecting to economic centres	Tier 2
Unclassified	Windmill Road	Gillingham	153 m	Road connecting to hospital or ambulance station	Tier 2
Unclassified	York Avenue	Gillingham	413 m	Road connecting to hospital or ambulance station	Tier 2
		Total Length	125,676 m		

Exceptional Heat Plan

July 2022

medway.gov.uk/highway

Contents

1 Introduction

Most highway Authorities including Medway Council have experienced the impacts of climate change on their network. This impact can be seen in a number of ways such as heatwaves, droughts and increased flooding. These events cause millions of pounds worth of damage and significant disruption to the highway network. These extreme events are predicted to occur more frequently and with greater intensity in the future. In order to minimise the cost and disruption caused by these impacts, it is vital that Medway as the Highway Authority plan to adapt to the changing climate.

This document concentrates specifically on cases of 'Exceptional Heat' and the direct effects this has towards carriageways. This includes how Medway Council as the Highway Authority will manage such situations in order to maintain an operational highway network.

2 Effects of Exceptional Heat

2.1 Asphalt Carriageways

Asphalt carriageways are affected by changes in temperature which can accelerate the rate of deterioration of the carriageway binder, therefore leading to the requirement of more frequent surface dressing treatments or resurfacing. High temperatures reduce the stiffness of the carriageway and thus its ability to spread the traffic load. This leads to cracking, rutting and deformation of the carriageway structure over time.

At high temperatures asphalt becomes more susceptible to deformation and rutting is more likely to occur, particularly on highly trafficked roads and at low traffic speeds. Research undertaken by Transport Research Laboratory (TRL) has found that rutting in the asphalt surfacing typically occurs when the temperature of the road surfacing exceeds 45°C.

2.2 Rigid Carriageways

Rigid carriageways (concrete) are more at risk of deterioration during prolonged periods of higher temperatures. This is due to the expansion of the carriageway structure beyond its design limits during hot weather, this then leads to water ingress risks and ultimately carriageways failure in future.

High temperatures and fluctuations in temperature result in thermal expansion and contraction of rigid carriageways, which generate longitudinal internal stresses and excessive movements at joints, if not considered during the design stage. As most concrete surfaces are covered with asphalt, high temperature within the carriageway structure often build up, leading to structural weakness and failure. This can lead to cracks migrating up into the asphalt layers and failure of the carriageway over time. Heavy trafficking increases the speed of failure.

2.3 Modular Carriageways

Modular carriageways are at particular risk from temperature-induced expansion and contraction and can be prone to water ingress. High carriageway surface temperatures can cause slabs to warp when the surface expands faster than the material underneath the slab. When the temperature of a rigid carriageway surface cools the reverse happens; the surface cools more rapidly than the material underneath the slab, causing it to concave at the surface. Cycles of heating and cooling cause expansion and contraction and can lead to cracks developing in the slabs. Extreme changes in temperature can cause cracking, even without trafficking, which can present a hazard to vehicles and pedestrians and can lead to failure of the carriageway.

High temperatures and significant temperature change have the most significant effect on modular carriageways containing large slabs. Therefore, new modular carriageways should be designed with small element modules as surfacing, opposed to large slabs. Modular carriageway slabs that are laid directly onto concrete or other rigid bases can also be particularly susceptible to cracking with expansion and contraction.

3 TRL Report

The Department for Transport (DfT) recognised the detrimental effects that climate change were creating for the highways industry. The DfT therefore commissioned Transport Research Laboratory (TRL) to produce a report in 2008 regarding 'The effects of climate change on highway carriageways and how to minimise them'. The full report can be downloaded from the following: Published Project Report PPR184. The below extracts are taken directly from the TRL report relating to exceptional heat.

Paragraph 11.1.3.1 Leicestershire

'The exceptional heat experience in the summer of 2006 caused significant damage to the rural highways of Leicestershire. As these roads have evolved from cart tracks, they often consist of only a thin bituminous surfacing on top of the track with multiple surfacing dressing laid over the years to preserve the road. The lack of full depth construction as found on the county's trunk and principal roads make them more vulnerable to heat damage.'

Paragraph 11.2.3 High Temperatures

'Past high temperatures have caused local authorities to spread rock dust, sand or grit onto bituminous carriageways to absorb melting bitumen and increase skid resistance. Speed limits have also been reduced, signs warning the public erected and in extreme cases roads closed.'

Paragraph 11.3 International Examples

'Many other countries already experience more extreme weather events than the UK as part of their normal climate. An examination of how these are dealt with may provide some useful ideas for preparing for the climate the UK will experience in the future.'

4 Medway's Resilient Network

The vast majority of carriageways located on Medway's resilient network are of asphalt construction. In industrial areas, the carriageway construction is often Hot Rolled Asphalt (HRA) due to its durability. Those carriageways that are not asphalt construction are constructed of concrete, which are typically overlayed with a thin asphalt surface course.

The roads at highest risk of consequential damage caused by exceptional heat are those constructed of HRA. This is partly because roads constructed in HRA are usually those busier routes that are more likely be used by HGV's and are therefore more likely to rut because of the heavier traffic. Another reason HRA is susceptible to deformation caused by a combination of heat and excessive loading is due to HRA containing a higher binder content in comparison to other asphalt surfaces, therefore making it more easily compressible.

In conjunction to this, roads constructed of concrete may also experience joint failure, however concrete makes up only a smaller percentage of the resilient network. Those concrete roads that have received an overlay treatment consisting of a thinner asphalt surface course can experience delimitation, whereby the bond between the asphalt and concrete break, causing the asphalt surface to strip away in localised areas.

Whilst not part of the resilient network, it's worth noting that our most effected roads by exceptional heat will likely be our rural roads and our older residential roads on the network which have evolved from cart tracks, which historically are only a thin bituminous surfacing on top of the track with multiple surfacing dressing laid over the years.

5 Conclusion

5.1 Reactive

During exceptional heat the Councils Highway Inspectors will be utilised to drive the Resilient Network and identify any issues.

On Asphalt carriageways our Contractor will spread rock dust, sand or grit onto the carriageways to absorb the melting bitumen and increase skid resistance. As a percentage of this rock dust, sand or grit will end up in the surface water system when it rains, a follow up gully cleaning programme will be undertaken.

We may also in agreement with the Council's Traffic Management team, reduce speed limits and erect signs warning the public. In the worst case we would arrange for the roads to be closed.

5.2 Proactive

Review current material specifications to assess their suitability for resistance to the effects of climate change. Consider changing to end performance specifications, which address the adverse effects of climate change. Use polymer modified binders that are less prone to binder stripping and other materials with greater 'stiffness'.

Table 1 – Risks Associated with the Climate Change Hazard of High Temperatures

Climate Change	Carriageway Risks	Other Risks	Consequences
• An increase in the average annual temperatures • An increase in the frequency and temperatures of summer extremes • An increase in the frequency of extremely warm summer days • Exposure of the carriageway to UV radiation	• Carriageway design – thick/thin carriageway: asphalt, rigid or modular • Surface deformation • Carriageway condition • Evolved roads • Inappropriate repairs to concrete carriageways • Joint replacement – Longitudinal stresses and bay expansion	• Traffic flow – Roads with an excessive proportion of HGV's	• Damaged road surfaces • Loss of skid resistance • Rapid structural and surface deterioration • The health and safety of construction workers • Contributing to the increase in ambient temperatures and the heat island effect

Table 2 – Carriageway Deteriorations Resulting from the Climate Change Hazard of High Temperatures

Asphalt Carriageways	Rigid Carriageways	Modular Carriageways
• Increased rutting • Fatting, resulting in reduced skid resistance • Binder softening resulting in a loss of surface integrity • More rapid age hardening of binder, resulting in increased cracking • Contribution to heat island effect	• Warping Concrete • Large seasonal joint movements • Compression failures at joints, in badly constructed or poorly maintained roads • Workability and curing problems with the concrete mixture	• Expansion leading to cracking and spalling at interfaces and possible blow-up with large slabs • Bedding settlement creating warping and trips • Continuous expansion and contraction causing cracking • Note: Effects are greater in larger slabs

Table 3 - Summary of High Temperature Adaption Measures

Asphalt Carriageways	Rigid Carriageways	Modular Carriageways
• Use of rut resistant asphalts surfacing • Use modified binders to reduce rutting and cracking • Increased use of modified binders for surface dressings • Increased adoption of EME2 as binder course • Treat 'fatted' areas with hot fine aggregate • Remove where appropriate, all rut prone material (HRA Surface Course) during routine resurfacing operations	• Ensure properly maintained joint seals • Upgrade joint seal composition • Use a low coefficient of expansion coarse aggregates in the mixture • Modify the concrete mixture to ensure adequate workability and curing time • Restrict concrete paving during periods of high temperatures • Use exposed open-textured aggregate surfaces as low noise layers as an alternative to asphalt • Air-entrained concrete not as necessary as freeze-thaw cycles reduce	• Replace large slabs with small element slabs or blocks

All Carriageways
• Good materials and construction practice • Ensuring the carriageway is in good condition • Increasing surface reflectance, which reduces the solar radiation absorbed by the carriageway using conventional concrete, roller-compacted concrete, concrete-over-asphalt (white topping and ultra-thin white topping), asphalt concrete and surface dressing with light-coloured aggregate, and asphalt carriageways with modified colour • Stiffer foundations utilising slower curing hydraulic binders such as those processed from blast furnace slag • Increasing permeability could cool the carriageways through the evaporation of water • Use a composite structure for noise reduction, which also has been found to emit lower levels of heat at night • Develop water retention and heat shield carriageway

6 Improvement Actions

It would be of benefit to develop the carriageway construction inventory data in order to establish carriageways construction. It may also be of benefit to know what the full depth construction is and whether the carriageway is flexible or rigid. Consider site inspections and/or coring in the future in order to obtain this information.

It is our intention to identify the carriageway construction details for all of the roads included within the resilient highway network.

Periods of exceptional heat during the summer months may result in some roads surfaced with older materials requiring the application of sealing grit to maintain their skid resistance and prevent their deterioration. During prolonged periods of daytime air temperatures in excess of 30°, additional inspections of the resilient network will be undertaken and sealing grit applied as necessary.