

Providing Transport Services Resilient to Extreme Weather and Climate Change



About Transport for London

Transport for London (TfL) is the integrated transport authority for the Capital, providing:

London Underground - London's metro system, delivering more than 3.5 million passenger journeys a day. It has 11 lines covering 402km and serving 270 stations. During peak hours, more than 500 trains are in operation.

Surface Transport - London Buses, the TfL Road Network, maintenance of London's traffic operations, including 6,000 traffic signals, licensing of taxis and private hire vehicles, London river services, Victoria Coach Station, Congestion Charge, Low Emission Zone, Dial a Ride and Barclays Cycle Hire).

London Rail - Tramlink, the Docklands Light Railway, London Overground and the development of Crossrail.

TfL is part of the Greater London Authority and delivers the Mayor's Transport Strategy in partnership with the London Boroughs and other transport providers such as Network Rail and the train operating companies.

Appendix 3 provides detail about TfL's responsibilities under the GLA Act and in relation to climate change.

TfL's Stakeholders

TfL has a wide range of stakeholders, reflecting the broad scope of services it delivers and the policy influence that it has. Most Londoners and visitors to the Capital have the potential to be TfL's customers, using its public transport services or TfL road network to access work, health, education and leisure destinations.

Other key stakeholders for TfL include the Mayor of London and national Government as well as the London Boroughs, London's businesses, TfL's suppliers, contractors such as train and bus operators and its employees.

The Mayor has a clear vision that London's transport system should excel among those of global cities, providing access to opportunities for all its people and enterprises, achieving the highest environmental standards and leading the world in its approach to tackling urban transport challenges of the 21st century.

Summary

This report provides a summary of Transport for London's work to date on assessing and responding to current and future climate change risks to its existing and planned assets and services.

It forms TfL's submission to the Department of Environment, Food and Rural Affairs under the Climate Change Act 2008 Adaptation Reporting Power. A full summary of the issues required by the Government for the purposes of this duty is at Appendix 1.

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1. TfL's Analysis of Potential Climate Change

TfL has assessed and evaluated the future climate impacts on its assets and services, referencing the latest generation of climate projections, the 2009 United Kingdom Climate Projections (UKCP 09). In particular focus has been on the predictions for Greater London rainfall and temperature in the 2020's, 2050's and 2080's. More detail on TfL's approach to this assessment is given in section 3

TfL has liaised with the GLA and used its understanding of what the UKCP 09's range of probabilistic projections mean for London, as presented in the draft Mayor's Climate Change Adaptation Strategy. The medium emission scenario has been used and it has been identified that the risks in the 2050's are likely to be:

Higher summer temperatures, with the average summer days being 2.7°C warmer and very hot days 6.5°C warmer than the baseline average

Warmer Winters - Winters will be warmer with the average winter day being 2.2°C warmer and a very warm winter day 3.5°C above the baseline.

More seasonal rainfall - Summers will be drier, with the average summer 19 per cent drier and the driest summer 39 per cent drier than the baseline average

Wetter Winters - with the average winter 15 per cent wetter and the wettest winter 33 per cent wetter than the baseline average

Sea level rise - Sea levels are projected to rise by up to 96cms by the end of the century.

In most cases, the longer term risks will be similar. For flooding and high temperatures there is likely to be increased frequency and consequence e.g. flooding from increased frequency and intensity of winter storms. High temperatures are more likely to become common in the summer months from the mid 21st century. For example, the hot summer of 2003 is likely to be average by the 2040's and cool by the 2080's.

For low temperature snow and ice events, there is likely to be increased severity when such events occur, although they may not be as frequent.

2. TfL's Analysis of the Potential Impacts of Climate Change on its Assets and Services

There are a number of elements of London's transport network that have the potential to be affected by weather related events, such as flooding, overheating, low temperatures and snow.

The TfL functions which are most likely to be affected by climate change include:

- Those relating to the provision of public passenger transport including tube, rail, bus and river services
- Functions as Highway Authority and Traffic Authority for GLA roads
- Facilitation of the discharge of the Mayor's general transport duty (which is a duty to develop policies and proposals for the implementation of safe, integrated, efficient and economic transport services to, from and within Greater London);
- Implementation of the policies and proposals contained in the Mayor's Transport Strategy, in particular proposals which relate to adaptation to climate change

TfL Business Climate Change Risk Maps

TfL analyses extreme weather and other risks to its assets and services as part of its corporate approach to risk assessment, which is detailed in Appendix 2.

During 2011, all TfL's operational business areas assessed the risks from the changing climate as understood from the United Kingdom Climate Projections 2009. The key results from TfL's review of its risk assessments were incorporated into TfL's risk management system, which generates snapshots of the key current, mitigated risks. These are outlined in the risks maps produced by each TfL business area (Figures 1-4). Managers use these risk maps to provide a current view of the key mitigated risks and as part of their annual risk reviews.

Each business area uses a scoring methodology which is based on TfL's strategic risk assessment scheme which is at Appendix 3. They adapt this to suit any local circumstances, for example there will be a difference in what impacts warrant a 'high' score in different types of operational service. Examples of key scoring mechanisms have been supplied to Defra.

- 1- Extreme Hot Weather - Key track, signals, & communications assets and staff & passengers.
- 2- Rain & Flooding - Track & signal drainage
- 3- Cold & Freeze - Impact on track integrity
- 4- Rain & Flooding – Key infrastructure drainage
- 5- Drought - Vegetation impact
- 6- Snow – track, signalling and depot operations
- 7- Cold & Freeze - Train system components
- 8- Cold & Freeze – Slips/trips for staff and customers.
- 9- Rain, Flooding and snow - Damage to inside of carriages
- 10- Wind- Damage to infrastructure, track and vegetation.
- 11- Drought - Ground stability impacts

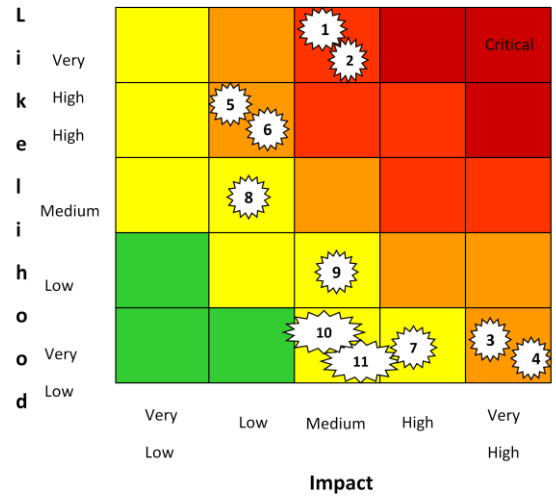


Figure 1 London Underground weather-related risks map

- 1 Heat – key signal, power, communications assets
- 2 Snow and Ice – slips/trips for staff and customers
- 3 Snow - Depot operations
- 4 Snow – Track and street clearances
- 5 Wind – Damage to overhead lines
- 6 Flooding – Depots and Tracks
- 7 Rain – Track drainage

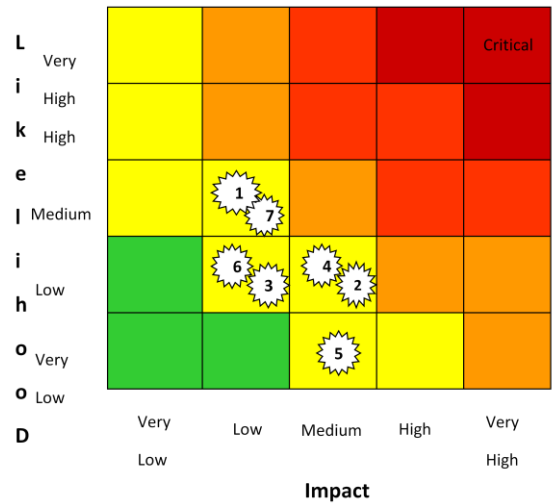


Figure 2 London Rail weather-related risks map

- 1 Flooding (Roads)
- 2 Drought (Roads, Traffic and London Buses)
- 3 Overheating (Roads and London Buses)
- 4 Extreme temperature fluctuations (Roads and London Buses)
- 5 Wind (Woolwich Ferry)

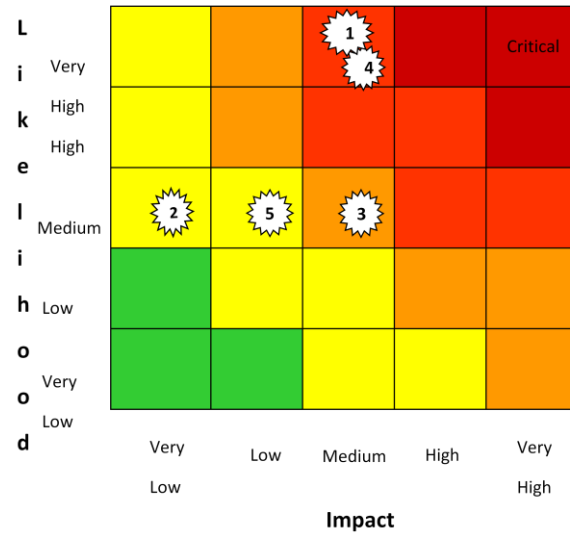


Figure 3 Surface Transport weather-related risks map



Crossrail Climate Change Adaptation Risk Map

As at Dec 2010

Objective: Addressing current and future risks due to climate change

Risks

- 1. High ambient temperature affecting railway tracks (surface tracks)
- 2. Extreme weather events (snow, ice and wind etc) disrupt Crossrail railway operation.
- 3. Pluvial flooding due to heavy rainfall events disrupt Crossrail railway operation.
- 4. Construction Logistics activities affected by extreme weather events in Thames Estuary or operation of Thames Barrier.

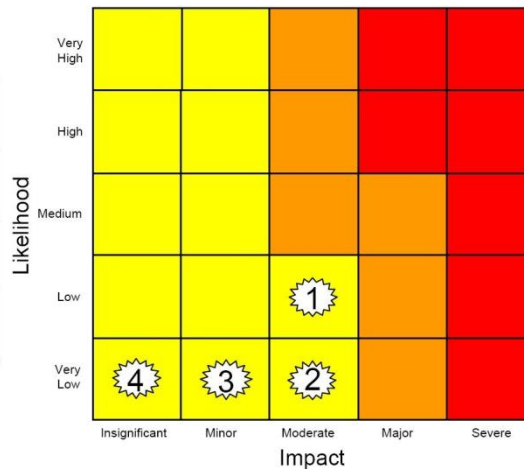


Figure 4 Crossrail weather-related risks map

TfL’s analysis of the highest priority risks from across the business are collated and summarised in Table 1. It should be noted that these are current, mitigated risks. TfL has identified a range of different weather-related thresholds for the different modes of transport it operates. It should be noted that TfL has found thresholds are not always a simple, single factor but can be a complex mixture of factors. For example, a particular rainfall episode may not always cause pluvial flooding, but is more likely to become an issue if it follows a period of drought where the ground is dry and less permeable.

Table 1: Addressing current *mitigated* risks due to climate change

Business function	Climate variable (e.g. increase in temperature)	Primary impact of climate variable (e.g. health)	Threshold(s) above which this will affect your organisation	Likelihood of threshold(s) being exceeded in the future and confidence in the assessment	Potential impacts on organisation and stakeholders	Proposed action to mitigate impact	Timescale over which risks are expected to materialise and action is planned
TfL Road Network and Bus operations	Increase in rainfall especially during winter periods	Localised pluvial flooding at some gullies and pumping stations, leading to traffic disruption, congestion	High intensity rainfall	Very high likelihood of pluvial flooding, high confidence in assessment	Localised, short term impact with medium consequence	Mitigation already under way - drainage plan, gully and pumping station renovation. Interdependency with Thames Water, maps of flooding hotspots on the TfL road network and bus stations and garages at risk of flooding.	Ongoing
Rail, Tube - Rail short circuiting preventing train operation, flooded under-track crossings, cable damage	Increase in rainfall especially during winter periods	Safety and disruption	Rainfall rates – LU has 10mm per hour, 15mm in 12 hours and 24mm in 24 hours	Varying likelihood of pluvial flooding, high confidence in assessment	Localised impact with short term, high consequence	Some assumption that these impacts will be short term disruption. Mitigation includes accurate weather forecasts, planning and response	Ongoing

Business function	Climate variable (e.g. increase in temperature)	Primary impact of climate variable (e.g. health)	Threshold(s) above which this will affect your organisation	Likelihood of threshold(s) being exceeded in the future and confidence in the assessment	Potential impacts on organisation and stakeholders	Proposed action to mitigate impact	Timescale over which risks are expected to materialise and action is planned
Rail and underground tunnels	Sea level rise and increased frequency of tidal surges	Tidal and fluvial (and drainage) flooding Safety and disruption	Breach of Environment Agency fluvial and tidal flood defences, failure of tunnel walls/roofs	Very low likelihood of tidal flooding, medium likelihood of fluvial flooding. Risk of all increasing with high confidence	Potentially wide ranging impact, with high consequence	High level of mitigation already exists. Network management, tunnel mitigation work, emergency preparedness, flood plans	Ongoing
Diverse range of TfL business areas, including London Underground, Rail, buses, trams	Extreme high temperature, especially during the summer	Wellbeing and health, potential passenger and staff discomfort, damage to assets		Medium likelihood, high confidence	Localised, short term impact, potentially high consequence	Optimising service patterns to minimise trains halting in tunnels. Improving heat loss from trains, air conditioned trains on sub-surface lines, Victoria line tunnel ventilation. 'Stay Cool' communication campaign, specify white bus roofs, install upper deck cooling systems on all new buses, relocate street traffic control equipment	Ongoing work deals with excess heat from line upgrades. Further work needed in future decades to prepare for climate change.

Business function	Climate variable (e.g. increase in temperature)	Primary impact of climate variable (e.g. health)	Threshold(s) above which this will affect your organisation	Likelihood of threshold(s) being exceeded in the future and confidence in the assessment	Potential impacts on organisation and stakeholders	Proposed action to mitigate impact	Timescale over which risks are expected to materialise and action is planned
Rail track buckling (not Crossrail),	Extreme high temperature	Safety, disruption, extra maintenance	LU and London Rail have air temperature thresholds for initialising actions re track buckling	Medium likelihood, high confidence	Potentially wide ranging impact with medium consequence	Track maintenance, use of continuous welded track, considering long term solutions like new track materials	LU Asset Management Plans. Other maintenance plans in place. Interdependency with Network Rail.
Rail, Underground and Roads – Earthworks stability e.g. embankments and cuttings	High rainfall or drought affecting the degree of soil moisture in earthworks	Safety, disruption, landslips for embankments and cuttings	LU 15 mm in 1 hour or 30 mm in 1 day.	High likelihood, high confidence	Localised impact with medium consequence	LU Asset management plan, use plant species that can withstand expected adverse conditions, cyclic and reactive landscape maintenance regime in place.	Asset Management Plans and will be reviewed regularly
TLRN, bus network, transport network platforms, rail and tram tracks, signals	Extreme ice and snow	Safety, disruption, delays and disruptions to services, slippery surfaces present injury risk		Medium likelihood, high confidence	Potentially regional impact with localised hot spots causing medium short term impact	Winter Maintenance Plans and a robust Winter Maintenance Programme and communications programme.	

Business function	Climate variable (e.g. increase in temperature)	Primary impact of climate variable (e.g. health)	Threshold(s) above which this will affect your organisation	Likelihood of threshold(s) being exceeded in the future and confidence in the assessment	Potential impacts on organisation and stakeholders	Proposed action to mitigate impact	Timescale over which risks are expected to materialise and action is planned
Construction projects	Extreme levels of snow	Delay to construction		Medium likelihood	Low impact	Part of construction contingency plans	Affecting any future construction work

The key adaptation risks that have been identified by TfL are:

Flooding

There is a medium (mitigated) impact of tidal, fluvial (or drain) flooding affecting London Rail and London Underground tunnels, causing potential safety hazards to customers, staff and trains and also disruption to services. This has a very low likelihood due to the level of flood protection that London receives from the Environment Agency flood protection systems and the range of mitigation actions that have already been put in place.

TfL has identified a risk from pluvial flooding impacting on the TfL Road Network (and also therefore on the bus network and in some cases the Tramlink). Heavy rainfall can overwhelm gullies and drains causing flash floods that make some roadways, particularly underpasses, impassable for a time. In most cases, the nature of rain storms means it is difficult to predict where flooding will occur and almost any area of London can be affected. There are a few areas (such as Hendon) which are known to flood regularly, but these are often related to third party drainage issues, such as maintenance.

Pluvial flooding can also impact on TfL's rail, tram and Tube tracks, stations and signals. In both cases, TfL's record shows that consequences are medium impact although short term.

A significant amount of detailed work has gone into assessing flood risk (fluvial, tidal and pluvial or surface water) at critical points along the Crossrail route.

Extreme High Temperatures

Predicted increase in maximum temperatures has been identified as a potential risk for a diverse range of services and assets across TfL. .

High temperatures can affect the Tube, during periods of hot summer weather, which will become more frequent and intense by the middle of the century. However, TfL's analysis has shown that currently the main source of heat is from the trains themselves. The tunnel cooling programme aims to manage the impact of additional heat from increased services that will be delivered by the line upgrade work. Analysis shows that high temperatures from climate change are not likely to impact the network until the 2040's.

Trains can also be affected by high temperatures when exposed to direct sunlight outside tunnels. Impacts are most likely to be felt if a train is stationary for a long period, as a result of train or infrastructure failure. This would be a particular problem if the air conditioning system failed as it is not possible to open the windows on most trains with air conditioning. The impact of high temperatures can cause discomfort for passengers and staff, particularly for those with existing health conditions.

There is also a potential risk to bus passengers and drivers from high temperatures if the vehicle remains stationary for any period of time in traffic.

Other (medium to low) risks from high temperatures include the potential for melting of road surface, traffic control equipment being affected, rail buckling, communications and substation equipment being affected, points equipment drying out, shrinkage and ageing of wiring, increased risk of fires damaging cable runs, overheating signalling equipment rooms and heat haze distortion for drivers viewing signals.

Low Temperatures and Temperature Fluctuations

TfL has identified that low temperatures, with associated ice and snow, and a shift between freeze-thaw temperature ranges are a risk to its services and assets. In the longer term, climate change is likely to mean that extreme cold weather events will not increase in frequency but could become more severe when they do occur.

For the TfL road network road surface and pavements and other paved surfaces around the transport network, there is risk of freeze/thaw conditions exacerbating the degradation of surface materials, causing issues such as potholes or moved slabs.

Extreme levels of snow can impact on transport depots where approach roads, tracks and equipment can become iced up. Extremely heavy snow loading on depot roofs may cause problems. There can also be impacts on station assets, such as approaches, signs, lifts, public address systems, stairs and platforms.

Tramlink has identified snow and ice as an issue for its rails, particularly where they are integrated with street surfaces. In addition Tramlink has identified lightning as an issue for its power system.

Snow and ice can be a risk to passengers and staff such as slips, trips and falls, staff unable to get to work, staff fatigue. There can be associated issues with availability of grit supplies which can be more of a regional or national issue.

Population Migration Risks

TfL and the GLA have also identified some other risks which may affect the demand on the transport system. It is expected that population dynamics will be affected by global climate change, bringing increased migration above and beyond the increase in London's population that is already forecast. The Mayor's Transport Strategy sets out a programme of upgrades and the delivery of Crossrail to meet the increased demand and reduce congestion problems on its services.

Air Quality

The GLA has identified that the changing climate can exacerbate air quality problems through the urban heat island effect and TfL has taken this into account in its review of risk assessments. Whilst this has not scored highly as a climate change impact, it is recognised as an important issue and is being addressed through the Mayor's Air Quality Strategy.

3. **TfL's Approach to Mitigating the Risks from Climate Change**

TfL's risk assessments show the majority of adaptation risks are in the 'low or medium' categories, when compared with the full range of business risks. TfL seeks to manage any risks assessed to be in the top 3 areas of the risk map out of that category as soon as possible.

At a high level, TfL's approach follows the principles set out in the draft Mayor's Climate Change Adaptation Strategy of 'prevent, prepare, respond, and recover'. TfL manages adaptation issues such as flooding and high temperatures through its wider management of the networks, its emergency planning, resilience and risk management systems. Similarly TfL works to ensure that multiple benefits are realised in projects and business areas. For example, London Underground has a series of Asset Management Plans that consider a number of issues including weather in the management of track, rolling stock, signals and stations. These are regularly reviewed, which helps to implement changes where it is necessary to move from 'business as usual' operation to change in asset type or management.

TfL manages weather-related events as part of its normal business operations and will continue to do so. It is recognised that there will be a need to consider additional measures to address increased frequencies of events in the longer term.

The mitigation delivered by operational services keep the risks from weather-related events to an acceptable level.

Adaptation measures are implemented through relevant processes in each business areas, for example in London Underground's Asset Group Strategies and Asset Management Plans, in the TfL Highways Asset Management Plan and in project flood prevention plans, audits and mitigation.

Over time TfL will consider whether any of these should be strengthened further should the frequency of events increase. This consideration will be part of regular reviews of TfL's structured management of risks.

Flooding Mitigation

London Underground identified this risk arising from security risks several decades ago and worked to improve protection for tunnels. It also developed a series of Flood Plans that identify key tunnel portals, stations and other asset areas, put mitigation measures in place and reviews these regularly.

Third party drainage issues and surface water flooding is being addressed. TfL is undertaking a programme to manage the gullies and pumping stations on a prioritised basis. TfL is also a partner in the GLA's Drain London programme, working with Boroughs on surface water management plans.

For Crossrail, where possible, the design includes 'passive' flood protection measures, such as raising entry or egress levels, raising track or cill levels, or extending portal walls. Where there is still residual flood risk at points which passive

designs cannot mitigate, then appropriate 'active' flood protection measures and procedures have been identified such as flood gates and stop logs.

Design standards for passive fluvial flood protection have been set at all tunnel portals at risk of fluvial flooding against a best estimate peak flood level of a 1 in 200 year return period. This is based on the Environment Agency's 2008 Tidal Thames Extreme Water Levels.

Active flood mitigation measures will be implemented at new stations on the central London section where the modelling results identify flood depths of 0.4m or greater. Flood depths below 0.4m are controlled by passive measures with station entrance thresholds above the local low points outside the station and local active measures may still be deployed by station staff.

Mitigating the Effects of High Temperatures

TfL has been aware of the potential risk from high temperatures for a long time and has put in place mitigations to prevent where possible the stalling of trains in tunnels and is introducing air conditioned trains on the sub-surface lines and ventilation in the deep tunnels e.g. the current work on the Victoria Line. In addition, London Underground has comprehensive detrainment plans for stalled trains and its Network Operating Centre has thresholds for extreme weather-related events and the associated service alterations i.e. speed restrictions where there is a risk of heat affecting track. Work is ongoing to reduce the heat at source through plans to introduce more energy efficient trains.

Another key mitigation measure is the planned communication programme that is put in place when TfL receives notification of periods of high temperatures exceeding certain thresholds. LU's 'Stay Cool' campaign encouraging customers to take a bottle of water when they travel and if they feel unwell to seek help when the train has reached the next station. Analysis of information from records of passengers being taken unwell on trains shows that increased heat is not directly and solely responsible for passengers being unwell. Together with crowding, it can exacerbate other conditions such as already feeling unwell, pregnancy or being under the influence of alcohol or drugs.

All new trains on the London Overground line have air conditioning and systems for managing evacuation in case of this failing when there are high temperatures outside.

To mitigate potential high temperatures on buses, TfL set a specification for all new buses to have white roofs, opening, tinted windows, upper deck ventilation systems and air conditioning in the drivers' cabs. This specification was introduced four years ago and so the majority of buses in service now have these features.

Crossrail is being designed to accommodate higher future temperatures. All Crossrail rolling stock will be mechanically cooled and maintained at a temperature of not more than 29°C and all platforms in the Central section will be mechanically

cooled and maintained at a temperature of no more than 27C. In this way the risk of overheating of trains, platforms and tunnels is avoided and passengers and staff will travel and work at comfortable, safe temperatures during the 30-35 year design life of the equipment even if high external ambient temperatures are experienced.

It should be noted that for Crossrail, adaptation measures have been incorporated into the design. Once it is operational, the main weather-related risks for Crossrail are essentially the same as for any other overland railway on its surface sections, and similar to those for the London Underground system in its tunnelled section and stem from the risks of increased flooding and extreme weather events.

Mitigating Snow, Ice and Temperature Fluctuations

London Underground's infrastructure meets the national standards for low temperatures. At temperatures below – 17 °C there would be service issues. The greatest challenge is in regard to duration of ice/rain/snow on rails and being able to maintain assets. Snow 10cm deep is not an issue, however 15 to 20cm would be, owing to lack of visibility of track and ground lying assets. The weight of snow on roofs of trains is a low risk .

TfL has found through experience of managing weather-related incidents that communication with stakeholders before and during any potential disruption is of prime importance. In its review of performance during recent winter weather events, TfL has highlighted the value of focused planning, collaboration between different organisations and public agencies, and clear communication with business partners and customers. TfL's stakeholders value receiving clear and consistent messaging about the impacts of weather on its services. Providing information and advice that helps stakeholders to plan their route and timing of their journey is an essential part of TfL's activities.

4. TfL's Process for Updating its Risk Assessments with the Latest Climate Projections

TfL's business areas have all reviewed their risk assessments during 2010 to take into account the UKCP 09 projections. This comprehensive review forms a common baseline going forward.

The review of the risk assessments began with a programme of seminars where the predicted implications of climate change were communicated to colleagues such as asset engineers, emergency planners, a range of business planners and risk managers. Each TfL business area has, following the series of workshops, reviewed its risk assessments and mitigation plans.

The work that TfL has done to review its risk assessments this year has ensured that weather-related impacts are embedded in its Risk Management System. As part of this System they will be regularly reviewed and updated.

Uncertainties

TfL's approach to considering adaptation has accepted the uncertainties contained in the United Kingdom Climate Projections 2009. The 90 per cent probabilistic scenarios have been used to give the most confidence but it is accepted that uncertainty is intrinsic

TfL has also recognised some uncertainty in assessing the likelihood and consequence of certain weather-related events. The highest uncertainty is seen with predicting the impacts of localised pluvial flooding events, where the precise location and degree of flooding can not always be accurately predicted in advance, even with the good forecasting services that TfL receives.

TfL's assessment of weather-related risks to its assets and services has sought to minimise uncertainty by considering experience from past examples of extreme weather events where possible.

TfL accepts that some events with low consequences or low frequencies will occur. TfL's risk appetite provides for the acceptance of certain low consequence risks, taking into account the plans for mitigating such risks. For example, in a period of high rainfall it is likely that some station ticket halls may flood and TfL will accept this risk knowing that it can have services operating again at a good level very quickly.

Cost Benefit Analysis

TfL appraises the costs and benefits of all its investment programmes and projects including maintenance works. A range of benefits are considered, including those from avoided risk. Adaptation requirements are assessed where relevant, alongside other benefits such as improved journey time, safety or equality considerations and reduced congestion.

Cost benefit analyses are updated at each stage ('gateway') of the investment and delivery process, from feasibility through to design, procurement and operation. The appraisal process is embedded in TfL's investment gateway process and is delivered locally by project management processes in the businesses. Adaptation to climate change is also included in TfL's Strategic Assessment Framework that is used to appraise all investment against delivery of the Mayor's Transport Strategy outcomes.

Barriers to Climate Change Adaptation

The principal barriers to climate change adaptation are associated with the inherent difficulties of coordinating cost benefit analysis and decision making in an area where uncertainties remain significant factors.

TfL has identified that the main challenge in delivering climate change adaptation is striking the balance between achieving short term benefits and financial efficiencies when considering measures that will have much longer term benefits. The availability of funding and political priorities are the main drivers underlying delivery of TfL's programmes.

Opportunities that May Arise from the Changing Climate

TfL has identified certain opportunities that may arise due to the effects of climate change.

There is a potential for the number of journeys taken through walking and cycling to increase as summers become warmer and drier, although the relationship between transport mode choices and weather different weathers needs further research. Other factors such as flexible working also influence travel behaviours. TfL is therefore linking with researchers who are embarking on studies of the relationship between weather and travel choices.

TfL's provision of public transport, walking and cycling and its promotion of measures that incentivise low carbon travel (such as the Congestion Charging scheme) will help to control the number of vehicles in the capital, so helping to reduce the urban heat island effect.

Climate change is predicted to result in warmer and wetter winters. This may mean less need for winter maintenance activities. For example there may be different approaches needed to de-stress rails or de-ice surfaces.

TfL will continue its programme of including living roofs in new buildings where possible and with planting street trees. While this will mitigate adaptation through provision of shade, insulation and to help alleviate the urban heat island effect, it will also have benefits for the Capital's biodiversity and improved water run off.

Interdependencies with Other Organisations

TfL has assessed risks from the changing climate impact on assets and services that it uses, that are owned or provided by other organisations. TfL has identified the following interdependencies. Those who are also reporting to the Government under the Adaptation Reporting Power are marked with an asterisk:

Contractors and operators – many of TfL’s services are operated by contractors and/or operators on TfL’s behalf and TfL relies on contractors for maintenance and other activities across many areas of the business, for example, Serco, LOROL, bus operators.

Network Rail* – Some TfL services run on Network Rail Tracks (London Overground, certain parts of the London Underground and in the future, parts of Crossrail.).

EDF Energy* (and National Grid*) – provision of electricity services for London Underground, street lighting and buildings/stations.

Thames Water* – Interdependency with their water and sewerage management systems helping to prevent flooding of our roads and rail networks.

Information and Communication Technologies suppliers

London Boroughs – responsibility for local road maintenance.

Environment Agency* – provision of flood defence and related information.

London Resilience Forum – a coalition of key resilience partners working to ensure coordinated forward planning and effective response to incidents in London.

Providers of weather-related information and forecasts – e.g. The Met Office, MeteoGroup and Vaisala

TfL has held a series of meetings and a workshop with Network Rail to consider approaches to adaptation and common issues. These include common approaches to setting thresholds, managing assets and delivering communications programmes.

TfL works with EDF Energy on an ongoing basis to ensure the resilience of electricity supply services and has used this Adaptation Reporting process to cross-check the common issues identified. These include the flood risk of sub-stations and the process for managing electricity demand surges causing summer ‘brown-outs’.

TfL has provided bus operators with a flood risk assessment of depots and bus stations.

Monitoring and Reviewing Risks to TfL’s Assets and Services

TfL's risk management framework involves a quarterly review of strategic risks, more frequent reviews for projects and fast moving issues, bi-monthly risk management group meetings, quarterly risk representative meetings, and annual reviews of risk appetite and strategic risk matters.

Reports on the management of the risks range from in depth reviews, to quarterly reporting direct to the Commissioner (the "Business Management Review" process) and quarterly updates to TfL's Risk Management Group, the Resilience Steering Team, and the Board's Safety, Health and Environment Assurance Committee. This is facilitated by the Group Risk function, and audited by Internal Audit.

TfL will, working with the GLA, continue to make itself aware of the climate change projections and evidence of changing thresholds, and feed this information into the regular reviews of its climate change risks.

Production of this report has enabled TfL to catalyse its work on assessing weather-related risks, to consider how such risks are likely to change over the longer term and to ensure that there is a common baseline from which to measure and report on progress with this issue.

The work that TfL has done to review its risk assessments this year has ensured that weather-related impacts are embedded in the Risk Management System. As part of this system, risk assessments (including residual risks) will be regularly reviewed and updated. In addition and through appropriate project and management reports.

Appendix 1 - Report Summary as required by the Statutory Guidance on the Adaptation Reporting Power

1. Information on organisation	
<p>Name of organisation</p> <p>Organisation's functions, mission, aims, and objectives affected by the impacts of climate change</p> <p>A summary of your organisational purpose and key strategic priorities which are or will be affected by climate change is important when identifying risks to your organisation.</p>	<p>Transport for London</p> <p>TfL organises the delivery of its responsibilities into grouped business areas:</p> <p>London Underground</p> <p>Surface Transport (London Buses, the TfL Road Network (TLRN), maintenance of London's traffic operations infrastructure, including 6,000 traffic signals,, licensing of taxis and private hire vehicles, London river services and Victoria Coach Station, Congestion Charge, Dial a Ride and Barclays Cycle Hire)</p> <p>London Rail (Tramlink, the Docklands Light Railway and London Overground). Crossrail is addressed, covering its design, construction issues and operation.</p> <p>Corporate (including information management, planning, insurance, risk management and health, safety and environment).</p> <p>Transport for London's (TfL) functions which are most likely to be affected by the impacts of climate change include:</p> <ul style="list-style-type: none"> • TfL's functions relating to the provision of public passenger transport including tube, rail, bus and river services • TfL's functions as Highway Authority and Traffic Authority for GLA roads • TfL's facilitation of the discharge of the Mayor's general transport duty (which is a duty to develop policies and proposals for the implementation of safe, integrated, efficient and economic transport services to, from and within Greater London) • TfL's implementation of the policies and proposals contained in the Mayor's Transport Strategy, in particular proposals which relate to adaptation to climate change

2. Business preparedness before Direction to report was issued

Has your organisation previously assessed the risks from climate change?

Have you a baseline assessment of the risks of climate change to your business currently? The requirements of the Direction can build upon any existing risk assessment you have in place. Please include a summary of findings from your previous risk assessment(s) in your report.

As part of its work to ensure that TfL delivers a sustainable transport system, TfL already plans for and manages the impacts of weather related events on the day to day operation of the transport system.

TfL has previously assessed the current and possible future impacts of climate change through its work with the GLA on the transport element of the Mayor's Climate Change Adaptation Strategy for London. TfL's approach aligns with the options framework set out in the Mayor's Climate Change Adaptation Strategy, which are 'prevent', 'prepare', 'respond' and 'recover'.

In addition climate change adaptation is addressed in the Mayor's Transport Strategy.

TfL's business areas, especially those in Rail, London Underground and Surface Transport have long experience in mitigating the impact of weather related issues, through well developed processes and standards. These include TfL's well established risk management system. Each business area will have a specific and relevant assessment of all business risks appropriate to, for example, its assets, services and reputation. Each business is considered according to its own issues and has its own baseline. There is also a TfL-wide top level assessment of business risks, which is updated quarterly.

This reporting requirement has helped to systematise further and allowed some important questions to be asked. However, dealing with and planning for climate impacts and change is not in itself new. Of particular impact however is the length of time that this review requires us to look forward, with a framework extended from up to 5 years (more normal for many strategic issues) up to 70; much longer than normal planning, and a very useful exercise.

TfL has previously used the United Kingdom Climate Projections 2002 as part of its modelling of impacts of heat on London Underground. It has also assessed the risks of tidal, fluvial and pluvial flooding on the road, Underground and rail network (including Crossrail) and has worked with the Environment Agency (in their Thames Estuary 2100 programme for example) to identify the impacts of future flood risks.

TfL's approach to managing risk is described in section 2 of the more detailed report attached to this summary see also section 5 of the report. The approach involves a 'top down' corporate set of strategic risks coupled with a 'bottom up' approach of risks generated by each

	<p>operational business area.</p> <p>Weather related issues have been included at the corporate strategic and business area level for some time. There is no single common baseline due to the varying dates when different areas became part of TfL.</p> <p>The business areas have all reviewed their risk assessments during 2010 to take into account the government's United Kingdom Climate Projections (UKCP 09). This comprehensive activity will form a common baseline going forward.</p>
<p>If so, how were these risks and any mitigating action incorporated into the operation of your organisation?</p> <p>It is useful to understand whether, and to what extent climate change risks are already incorporated into your business risk management processes at the strategic level.</p>	<p>TfL has long experience in planning for and managing the impacts of weather-related events on its operational assets and services. For example, TfL business areas have assessed the likelihood and vulnerability of their key assets and services to different types of flooding. Flood plans are regularly reviewed, tested and additional mitigation measures taken where necessary. Other mitigation examples include London Underground's range of Asset management plans.</p> <p>TfL's businesses have assessed the impact of high temperatures on their assets and services for some considerable time. Some of the mitigating action has included the overall management of the LU network to minimise the risk of trains being held in tunnels, the tunnel cooling programme that improves ventilation on the Victoria Line and the use of portable fans in stations. The first of a planned introduction of air conditioned trains has already been launched on the sub surface lines and on London Overground. The 'Stay Cool' communications campaign helps customers to be prepared for travelling during periods of high temperatures.</p> <p>Relevant weather-related risks are incorporated into key business processes where appropriate. For example, they are included within TfL's strategic resilience framework and resilience policies, processes and procedures. This comprises business continuity, disaster recovery, crisis contingency planning and other resilience actions.</p> <p>Management of weather-related risks are embedded into TfL's delivery of its operations and are also part of TfL's processes for resilience and emergency planning. This is done by both TfL and its contractual partners such as Serco or the bus operating companies.</p> <p>TfL also manages the delivery and maintenance of capital assets for example the East London Line, Tramlink and Crossrail. Adaptation to weather-related events is integrated into design, procurement and is part of the</p>

	<p>project risk management and the business planning processes.</p> <p>TfL has a well-established approach to risk management and resilience. A range of risks, including those related to weather are included amongst a range of potential risks to the business in TfL's integrated risk and governance framework. TfL has a top level summary of the highest strategic risks to its operations, which includes the impact of external events including weather-related impacts. Mitigation plans and action owners are detailed for all risks on the system. Section 2 of the main report provides a more detailed description of this risk management framework.</p>
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3. Identifying risks due to the impacts of climate change

<p>What evidence, methods, expertise and level of investment have been used when investigating the potential impacts of climate change?</p> <p>What evidence have you assimilated to inform your risk assessment? What has been your approach (quantitative, qualitative, scenario based)? What resource (£ / person / days) have been assigned to this assessment? Briefly summarise your approach – in house staff, professional advisors, research expertise?</p>	<p>Each TfL business area has reviewed its existing risk assessments. These previously contained the potential impacts of weather and weather-related events. The reviews were held to ensure that these were still appropriate when taking into account evidence for the impacts of the changing climate available from the new UKCP 09 projections and also considered the longer term change to those risk assessments.</p> <p>The reviews took place between January and August 2010. London Underground, London Rail and Surface Transport did this review using a series of workshops that took into account the findings from the UKCP 09 projections to review a comprehensive series of assets and services. The evidence from UKCP 09 included a summary of quantitative projections, a qualitative summary of scenarios for the 2020's, 2050's and 2080's. Crossrail reviewed its design requirements to deal with future climate change and conducted a risk assessment workshop to confirm and score the findings.</p> <p>The TfL business areas have the main responsibility for managing the impacts of weather-related events on the planning and delivery of transport services. To facilitate the production of this report, the corporate centre has coordinated and supported the business area workshops, drawing together and moderating the findings.</p> <p>The reviews have benefited from partnership working from across each business area, bringing together necessary expertise and experience including risk management specialists, resilience advisers, asset engineers, emergency preparedness managers, environment/climate change managers and business/service planners.</p>
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	<p>Each TfL business area has, following the series of workshops, reviewed and prioritised their risk assessments and mitigation plans, and has updated their risk assessment matrices on the Active Risk Manager software system (ARM) where necessary.</p> <p>A strategic overview of common risks and contingencies across TfL business areas has also been developed.</p> <p>There has also been a group-wide workshop with the Cabinet Office Civil Contingency Secretariat which focused on weather-related thresholds.</p>
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4. Assessing risks	
<p>How does your organisation quantify the impact and likelihood of risks occurring?</p> <p>Provide here a brief summary of the methodological approach to quantification where this has been possible and your categorisation of likelihood and impact. State what criteria you have used to characterise the significance of the risks (high, medium, low, negligible) and how these have been derived. What level of confidence do you have in the analysis?</p>	<p>TfL uses an integrated risk and governance framework. Please refer to section 4 of the report for a description of this framework.</p> <p>At the top level, a risk appetite is set by TfL's Chief Officers as well as a scoring for the organisation-wide strategic risks. In addition, each TfL business area has a local scoring scheme specific to the needs of that business, which sits within this overall framework. Further quantification is undertaken as required in conjunction with using specialist risk modelling software</p>

5. Uncertainties and assumptions

<p>What uncertainties have been identified in evaluating the risks due to climate change?</p> <p>Where are the key uncertainties in the analysis of the impacts of climate change and what impact do these have on the prioritisation of adaptation responses and risks for your organisation. How have these uncertainties been quantified and, in brief, what are the implications for the action plan?</p>	<p>TfL has used the UKCP 09 projections to inform its consideration of the effects of the changing climate. TfL (in consultation with the GLA) has used the medium CO₂ emissions scenario and the 90% certainty climate information.</p> <p>TfL has also recognised some uncertainty in assessing the likelihood and consequence of certain weather-related events. The most regular uncertainty is seen with predicting the impacts of localised pluvial flooding events. Even with the forecasting services TfL receives, the precise location and degree of flooding can not always be accurately specified in advance.</p>
<p>What assumptions have been made?</p> <p>The key strategic business assumptions and methodological assumptions that underpin your analysis of impacts, action plan and analysis of risks. Well-evidenced and justified assumptions are important to the credibility of and confidence in the risk assessment.</p>	<p>An important assumption for TfL is that some risks with low consequences or frequencies will be realised. TfL's risk appetite provides for the acceptance of certain low consequence risks, taking into account the plans for mitigating such risks.</p>



6. Barriers to implementing adaptation programme

What are the main barriers to implementing adaptive action?

What do you see as the key challenges to implementation of your action plan? How will these be resourced and addressed? Briefly, what additional work is required?

Has the process of doing this assessment helped you identify any barriers to adaptation that do not lie under your control?

Interdependencies may arise where others' actions are likely to impact on

Adaptive action is part of TfL's normal business and risk management. The main barriers to implementing adaptive actions are if other deliverables are considered a higher priority (by the Mayor or National Government) than adaptation elements and attract the limited funding available. There are differences when considering the short term management of weather-related impacts and the long term pressures. It will be hard to develop strategies to deliver what are sometimes deemed as long term needs – for example, installing replacement solutions such as larger bore drain pipes, when core service upgrades are at risk from public sector spending cuts.

A focus on longer term adaptation will require pressure from stakeholders and funders to deliver these improvements. TfL and its stakeholders will require further thought on what the longer term priorities will be, for example, building in climate adaptation into just new projects, or focusing on the daily operations.

<p>Has the process of doing this assessment helped you identify any barriers to adaptation that do not lie under your control?</p> <p>Interdependencies may arise where others' actions are likely to impact on your ability to manage your own climate change risks. Briefly comment on where this is the case.</p>	<p>TfL has been managing the impacts of weather-related events on its services for many years and this has helped identify how these weather impacts are likely to change over time. It has also identified barriers not under TfL's control, such as those related to funding decisions. In addition there are third party and external risks not under control or ownership by TfL.</p> <p>TfL has assessed situations where risks from the changing climate that impact on its assets and services are owned by other organisations. Such interdependencies are set out in section 6 of the report and include Network Rail (on whose tracks some of TfL's services run), EDF and National Grid who provide TfL's electricity, Thames Water, flood defence agencies (and related London resilience responders), London Boroughs (e.g. during severe snow or other extreme weather events) as well as those related to continued supply of information and telecommunication networks. TfL has consulted with these organisations on this issue and will continue to do so.</p>
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7. Report and review	
<p>How will the outcome of the adaptation programme be monitored and evaluated and what is the timetable for this?</p> <p>Adaptation programmes are expected to reduce the residual risk to organisations from climate change. What measures will you put in place to monitor this?</p>	<p>TfL manages weather-related impacts on its operational assets and services as part of its core business.</p> <p>It has assessed weather-related risks and found that climate change is most likely to increase their frequency. TfL's business processes and risk management system reviews will continue to assess when such an increase in frequency is likely to require additional action.</p> <p>For example, they are included within TfL's strategic resilience framework and resilience policies, processes and procedures. This comprises business continuity, disaster recovery, crisis contingency planning and other resilience actions.</p>
<p>How do you propose to</p>	<p>TfL business areas set and monitor impact</p>

<p>monitor the thresholds above which impacts will pose a threat to your organisation (including the likelihood of these thresholds being exceeded and the scale of the potential impact)?</p> <p>It is possible that the current risk appetite within your organisation will change on account of the climate change risks identified. How will this be monitored?</p>	<p>thresholds on an ongoing basis, as part of network coordination/emergency preparedness functions.</p> <p>TfL's risk appetite is reviewed regularly through established Risk Management processes.</p>
<p>How will the benefits of the programme be realised and how will this feed into the next risk assessment and options appraisal?</p> <p>Briefly state your plans for the next iteration of your climate change risk assessment.</p>	<p>Benefits will be services and assets which maintain at least current (or improved) resilience to weather events and the changing climate.</p> <p>Climate change risk assessments will be regularly conducted, and the results fed into the TfL risk and governance framework.</p>
<p>How have you incorporated flexibility into your approach?</p> <p>State whether your approach leaves you open to exploring different pathways in future or whether any of the measures have locked the approach into one particular path, with justification</p>	
<p>8. Recognising opportunities</p>	
<p>What opportunities due to the effects of climate change and which the organisation can exploit have been identified?</p> <p>The risk assessment is also</p>	<p>Opportunity assessment is carried out at the modal level. Some opportunities have been identified and are set out in section 3 of the report.</p>

<p>expected to generate opportunities for organisations, have these been captured? What are the key ones and the expected net benefits?</p>	
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9. Further comments / information	
<p>Do you have any further information or comments which would inform Defra (e.g. feedback on the process, the statutory guidance, evidence availability, issues when implementing adaptation programmes, challenges, etc)?</p>	<p>Production of this report has enabled TfL to catalyse its work on assessing weather-related risks and build on its management of weather-related impacts by considering how such risks are likely to change over the longer term. There is now a common baseline from which to measure and report on progress with this issue.</p>

Appendix 2 - TfL's Approach to Assessing the Risks from Climate Change

TfL has long experience in planning for and managing the impacts of weather-related events on the operation of its services. Weather related risks have been included at the corporate strategic and business area level for some time and TfL reviews its weather-related thresholds as part of its routine operation of the transport system. This is part of a wider commitment to providing a sustainable transport system for London and in delivering the requirements of the Mayor's Transport Strategy and Mayor's draft Climate Change Adaptation Strategy.

TfL has previously assessed specific weather-related risks associated with high priority issues for its operations. For example it has used (United Kingdom Climate Impacts Programme) UKCIP 02 to inform modelling of the impacts of heat on the London Underground. It has also assessed the risks of fluvial and pluvial flooding on the road, Underground and rail networks and has worked with the Environment Agency (in their Thames Estuary 2100 programme for example) to identify the impacts of future flood risks and with the GLA on the Drain London surface water management programme.

The quantification of impact and likelihood of risks occurring takes place as part of TfL's risk and governance framework. TfL has a well established approach to risk management. Its risk and governance framework is benchmarked against the National Performance Model used by ALARM (The National Forum for Risk Management in the Public Sector) and endorsed by CIPFA (The Chartered Institute for Public Finance and Accountancy).

The approach has a 'top down' set of strategic risks coupled with a 'bottom up' approach of risks generated by each operational business area.

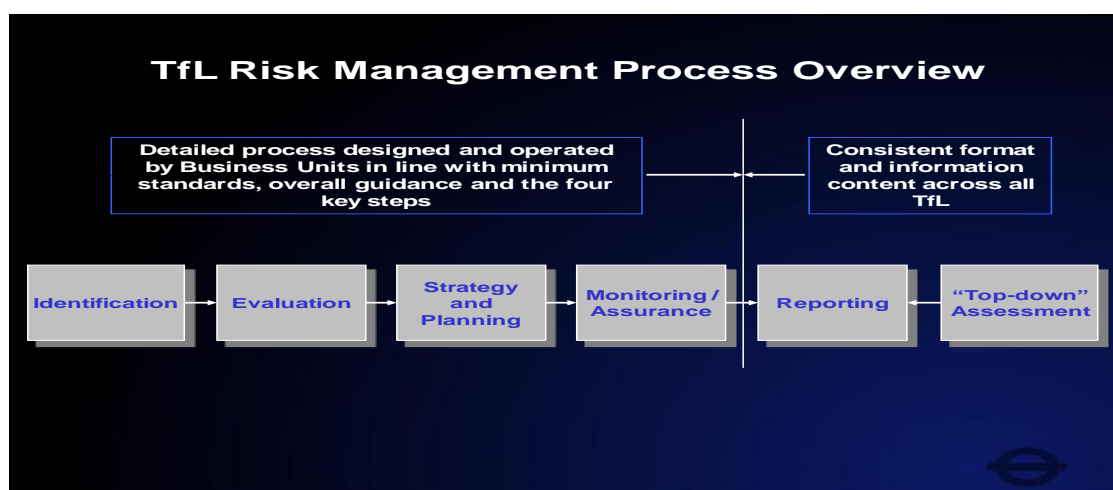


Figure 6 A summary of the process to manage risks in TfL

Weather-related risks are considered amongst a wide range of potential risks to the TfL business areas. Risks are identified, assessed, and recorded on to TfL's risk management system ARM (Active Risk Manager).

It is important to note that TfL’s risk management approach assesses *mitigated* risks, within the context of the agreed corporate risk appetite:

Risks are assessed using the following approach to quantifying the impact and likelihood of risks occurring:

- The risk appetite is set by TfL’s Chief Officers as well as a scoring for the organisation-wide strategic risks (i.e. those that are set ‘top-down’).
- In addition, each TfL business area has a local scoring scheme which reflects the differing nature and requirements of each (‘the bottom up element’). Further quantification is undertaken as required, including using specialist risk modelling software.

Options for mitigation and risk owners are agreed. The final risk maps show risks prioritised with mitigation taken into account. This helps the business to focus on those which are still assessed to be high and require further mitigation.

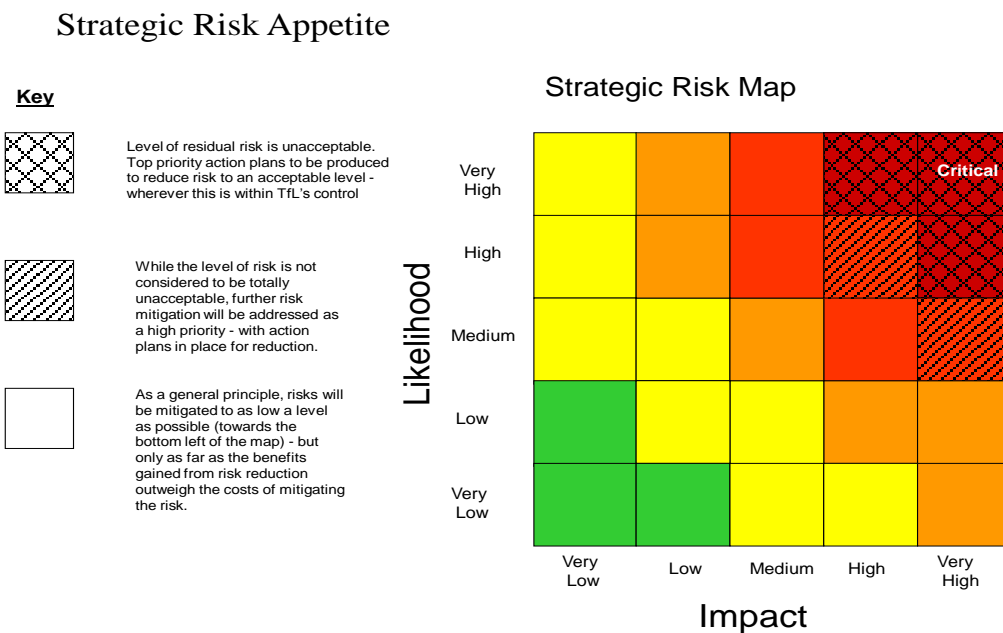


Figure 7 TfL’s Strategic Risk Framework

The impact of external events, including weather-related is one of the 13 TfL strategic risks in the top level Risk Register for the organisation. Mitigation plans and action owners are detailed, as with all risks on the system.

Risks are then communicated across the business in a transparent and consistent manner. These risks include those from daily operations as well as capital projects and procurement processes. Mitigation actions and owners are identified.

Risks are escalated through an agreed process, including up to the strategic level.

TfL's Resilience Management Policy Framework

TfL has a Resilience Management Policy Framework that sets out its approach to minimising the likelihood of harmful or disruptive events such as weather-related events and maintaining adequate capability to prepare for, manage and recover from them.

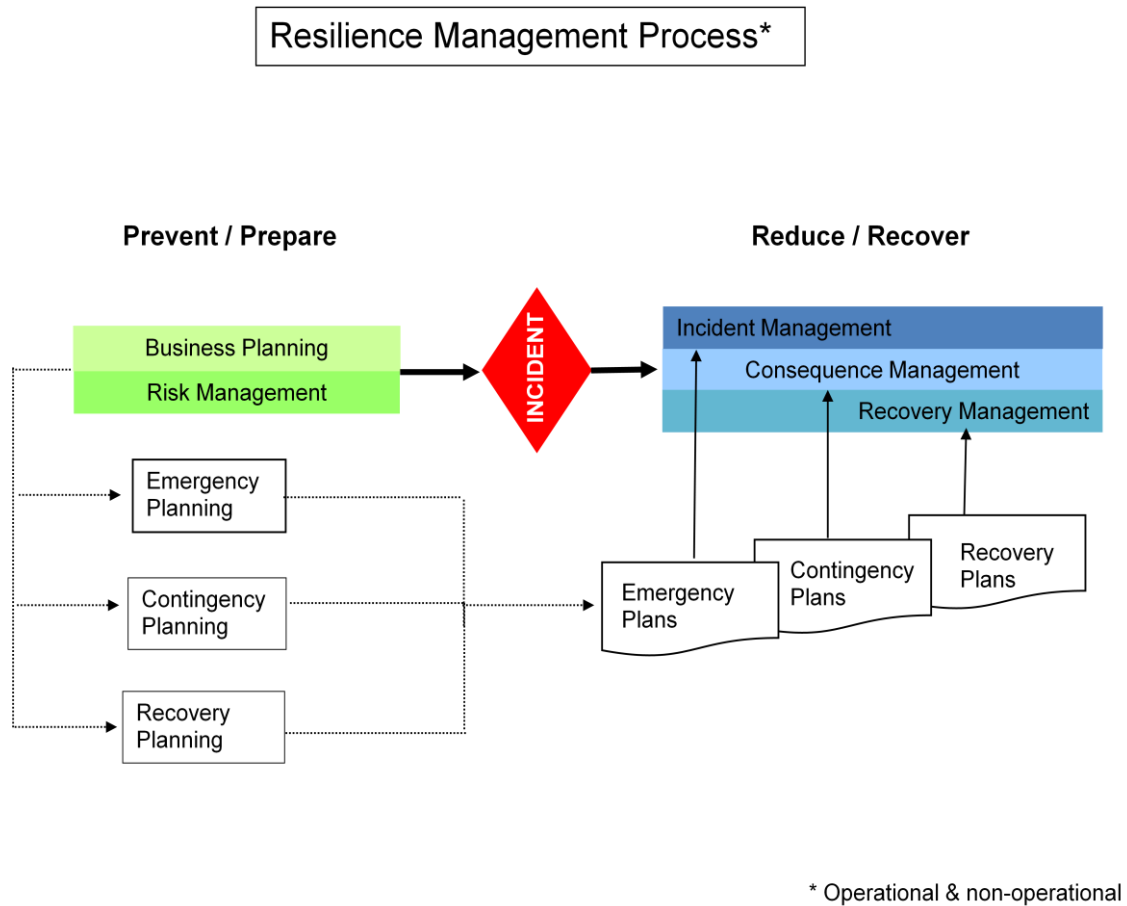


Figure 5 Overview of TfL's Resilience Management Policy Framework

Appendix 3 - Detailed Responsibilities of Transport for London

About Transport for London

Transport for London (TfL) provides most of the Capital's transport system. TfL organises the delivery of its responsibilities into grouped business areas:

London Underground providing London's metro system, responsible for more than 3.5 million passenger journeys a day. It has 11 lines covering 402km and serving 270 stations. During peak hours, more than 500 trains are in operation.

Surface Transport (London Buses, the TfL Road Network (TLRN), maintenance of London's traffic operations infrastructure, including 6,000 traffic signals, licensing of taxis and private hire vehicles, London river services, Victoria Coach Station, Congestion Charge, Dial a Ride and Barclays Cycle Hire).

London Rail (Tramlink, the Docklands Light Railway and London Overground). In this report, Crossrail is also considered. Whilst it is a project under delivery, there are opportunities for adaptation and related long term operational aspects are being mitigated through design. Construction-related issues are also considered.

Corporate (including information management, planning, insurance, risk management and health, safety and environment).

In addition, TfL is the licensing authority for hackney carriages (taxis) and for private hire vehicles (PHVs), the highway authority for GLA roads and is the traffic authority for GLA roads and GLA side roads. As a traffic authority TfL regulates the way in which the public uses highways and is responsible for traffic signs, traffic control systems, road safety and traffic reduction.

The primary role of TfL, which is a functional body of the Greater London Authority, is to implement the Mayor of London's Transport Strategy and manage transport services across the Capital both directly and through its subsidiary companies such as London Underground Limited. TfL is a statutory corporation established under section 154 of the Greater London Authority Act 1999 ("the GLA Act").

The GLA Act requires that, when preparing his Transport Strategy, the Mayor must have regard to the effect the proposed strategy would have on climate change and the consequences of climate change. The 2010 Mayor's Transport Strategy (MTS) therefore includes proposals 110 to 114 specifically relating to adapting to climate change which can be summarised as follows:

- Proposal 110: Determine the vulnerability of transport assets to the impacts of climate change and maintain existing infrastructure to improve resilience to climate change.
- Proposal 111: Prepare adaptation strategies to improve network safety and resilience to threats posed by climate change, which include – impacts risk assessments of infrastructure and operations; prioritisation of identified risks

for appropriate management and mitigation including emergency planning and investment plans; and guidelines for major procurement projects.

- Proposal 112: Develop the transport system with climate change in mind by designing, locating and constructing new infrastructure to withstand climatic conditions anticipated over its design life; introduce energy efficient air conditioned rolling stock where feasible; continue to investigate cooling methods for the Tube network; and ensure all new buses entering the fleet feature specific climate change adaptation measures.
- Proposal 113: plant additional street trees.
- Proposal 114: develop and test plans and procedures to minimise risk to people and property, manage disruption and ensure rapid transport system recovery from the impacts of climate change events.

These proposals are to be achieved by working with Boroughs, Network Rail and other relevant stakeholders including transport infrastructure owners, the Highways Agency and airport operators.

The Mayor has also consulted on his proposed Climate Change Adaptation Strategy, required by the GLA Act and due for publication during 2011. This will include an analysis of the impacts of climate change on London and proposals for the GLA Functional Bodies and other organisations to help become adapted to the changing climate.

TfL's Stakeholders

TfL has an extensive range of stakeholders, reflecting the wide scope of services it is responsible for delivering and the policy influence that it has. At the broadest level, most Londoners and visitors to the Capital have the potential to be TfL's customers, using its public transport services or TfL road network to access work, health, education and leisure destinations. People visiting London or commuting into the Capital are also important.

Other key stakeholders for TfL include the Mayor of London and national Government as well as the London Boroughs, London's businesses, TfL's suppliers, contractors such as train and bus operators and its employees.

TfL has identified climate change adaptation risk interdependencies with other organisations that are also stakeholders. These are described in more detail in section 7 of this report.

The broad scope of stakeholders for TfL means that there are a number of issues relating to the impact of climate change that are important to them. These can be summarised into how they affect service availability, reliability, safety and comfort.

TfL has found through experience of managing weather-related incidents that communication with stakeholders is of prime importance as well as highlighting the value of focused planning, collaboration between different organisations and public agencies, and clear communication with business partners and customers. TfL's stakeholders value receiving clear and consistent messaging about the impacts of

weather on its services. Providing information and advice that helps stakeholders to plan their route and timing of their journey is an essential part of TfL's activities. The legal functions of TfL are set out in Part IV of the GLA Act. These include the power to:

- provide and secure the provision of public passenger services to, from and within Greater London;
- regulate the London bus network;
- operate London Underground;
- exercise control over London River Services and the promotion of the safe use of the Thames for passenger and freight movement;
- provide certain London railway passenger services such as DLR, Tramlink and London Overground
- make road user charging schemes;
- make transfer schemes;
- provide travel concessions;
- issue penalty fares;
- promote private bills in parliament; and
- provide financial assistance (to a person or body doing anything which in the opinion of TfL is conducive to the provision of safe, integrated, efficient and economic transport facilities or services to, from or within Greater London).

The general transport duty is a duty on the Mayor to develop and implement policies and proposals for the promotion and encouragement of safe, integrated, efficient and economic transport facilities to, from and within Greater London.