A303 Amesbury to Berwick Down

TR010025

Deadline 2
8.10.15 Socio-economic effects (Se.1)

Volume 8

APFP Regulation 5(2)(q)

Planning Act 2008

The Infrastructure Planning (Examination Procedure) Rules 2010

May 2019

Infrastructure Planning

Planning Act 2008

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A303 Amesbury to Berwick Down

Development Consent Order 2019

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Regulation Number:	Regulation 5(2)(q)
Planning Inspectorate Scheme Reference	TR010025
Application Document Reference	8.10.15
Author:	A303 Amesbury to Berwick Down Project Team, Highways England

Version	**Date**	**Status of Version**
Rev 0	03.05.2019	Deadline 2 Issue

List of Chapters

15 Socio-economic effects (SE.1)

Question SE.1.1

Socio-environmental impacts

Would the local authority, the EA and Natural England state whether the Proposed Development complies with the need to be designed to minimise social and environmental impacts and improve quality of life in accordance with para 3.2 of the NPSNN?

Response

1. Chapter 6 of the Design and Access Statement [APP-295] provides an overview of the rationale for the design of the Scheme. In particular, paragraphs 6.2.9 to 6.2.13 describe the principles of sustainable design applied to the Scheme design. Section 5.3 sets out how the environmental and social context of the site has been considered.

2. In addition, the mitigation identified in the Environmental Statement (document reference APP-038 to 291) and the Environmental Mitigation Schedule (ES Appendix 2.1, document reference APP-186) demonstrate how the environmental context of the Scheme has been considered and improved upon wherever possible.

3. In regard to improving quality of life, the Environmental Statement Chapter 13: People and Communities [APP-051] reports significant beneficial residual impacts for non-motorised users through the provision of new routes. It also reports significant beneficial impacts on driver stress through reduction in frustration, fear of accidents and route uncertainty. It also reports a permanent significant beneficial impact on access to community facilities west of Longbarrow Roundabout to Winterbourne Stoke [APP-051, Table 13.27, page 13-71]).

Question SE.1.4

Socio-economic effects

What provision is there in the dDCO for ensuring appropriate liaison with land owners and restoration/aftercare/monitoring after completion of the restored land?

Response

4. Liaison with landowners is an ongoing process and has been documented within 9.2 Annex B of the Statement of Reasons [APP-023] and reproduced as an updated document in response to section 51 advice as the Land Acquisition and Temporary Possession Negotiations Schedule [AS-011]. This document will be updated as required for Deadline 2 of the Examination. Highways England will continue to liaise with landowners with a view to acquire, or use land temporarily, as required for the Scheme through agreement. This has been detailed in section 4.11 of the Statement of Reasons [APP-023].
5. Environmental Statement Appendix 2.2 - Outline Environmental Mitigation Plan (OEMP) [APP-187] includes requirements to liaise with people and communities, including landowners, occupiers and agents as appropriate about preliminary works (reference PW-COM1) and main works (reference MW-COM1), including the provision of a Community Relations Manager as set out in Table 2.1 of the OEMP. Compliance with the OEMP is secured through Schedule 2, paragraph 4 of the draft Development Consent Order (DCO) [APP-020].
6. The Scheme design seeks to minimise the areas of land required both temporarily and permanently. Land occupied and used temporarily for the construction of the Scheme pursuant to powers of temporary possession in the draft DCO would be subsequently restored to the reasonable satisfaction of its owner as required under Article 29(4) of the draft DCO [APP-020].
7. The OEMP, which is secured through Schedule 2, paragraph 4 of the draft DCO [APP-020], sets out requirements for the restoration and monitoring of land, including:
    a. MW-G30 (Clearance and reinstatement of sites on completion), which sets out that “the main works contractor shall ensure that on completion of construction works, plant, materials, equipment, temporary buildings and vehicles not required during subsequent activities are removed from the site and that land is restored to its former use or in accordance with the design as appropriate.”
    b. MW-GE03 (Soils Management Strategy), which requires that “the main works contractor shall produce a detailed Soils Management Strategy that will identify the nature and types of soil that will be affected and the methods that will be employed for stripping soil and the restoration of agricultural land.”

c. MW-COM4 (Restoration of agricultural land and aftercare), which sets out that "where land is to be restored to agriculture the main works contractor shall liaise with the landowner / tenant and set out the detail for restoration on each specific area of farmland. The land restoration will proceed with full consultation between with the landowner/tenant and the main works contractor including inspection of works where applicable and in accordance with requisite site health and safety procedures."
d. MW-COM5 (Monitoring of agricultural land) further specifies that "the main works contractor shall undertake further inspections of restored agricultural land with the landowner/tenant and Highways England's soils experts (and valuer, if required) to assess the progress of the restoration. These will be carried out with timing appropriate to any perceived issues or concerns. Concerns will be assessed by all parties and appropriate remedial actions or compensation agreed within the parameters of the compensation code and/or any previous agreements made at the time of acceptance of the initial restoration works and handover to the landowner/tenant."

Question SE.1.6

Socio-economic effects

The ES identifies a moderate significant residual effect from impacts to agricultural land (BMV) and agricultural holdings more generally during construction. It suggests that the OEMP [APP-187] and ‘appropriate liaison’ are measures which should be secured to address these impacts.

Can the Applicant explain how such measures are secured and in formulating a Response consider points raised by National Farmers’ Union regarding the role of an Agricultural Liaison Officer?

Response

- As set out fully in the response to question SE.1.4, provisions have been made in the draft Development Consent Order (DCO) [APP-020] and Outline Environmental Management Plan (OEMP) (Environmental Statement Appendix 2.2 [APP-187]) to ensure liaison with landowners and appropriate restoration, aftercare and monitoring after completion of the Scheme and the restoration of land.

- The measures set out in the OEMP [APP-187], including liaison with landowners, occupiers and agents contained therein, are secured through Requirement 4 in Schedule 2 to the draft DCO [APP-020].

- Discussions with regards to the role of an Agricultural Liaison Officer (ALO) are currently ongoing with the National Farmers’ Union (NFU) through the development of a Statement of Common Ground (SoCG). The points and detail raised are being considered by Highways England.

Question SE.1.7

Socio-economic effects

Can you advise the ExA on your intentions in respect of the WHS and whether the current proposal would lead to a revaluation of the WHS status?

Response

1. In terms of Highways England's intentions for the WHS, one of the fundamental objectives of the Scheme, as stated in the Case for the Scheme [APP-294], is to help conserve and enhance the World Heritage Site. The Scheme is assessed in the Heritage Impact Assessment [APP-195] to have a Slight Beneficial effect on the Outstanding Universal Value (OUV) of the WHS as a whole. This takes into account that of the seven attributes of OUV for the WHS, whilst the Scheme will have a slight adverse effect on two of those attributes, it will have a beneficial effect on the remaining five (being a slight beneficial effect on three of the attributes, a large beneficial effect on one, and a very large beneficial effect on one). This conclusion also takes into account that the Scheme will have a slight beneficial effect on the authenticity and integrity of the WHS. Overall, the OUV of the WHS would be sustained.

2. Section 12 of Environmental Statement Appendix 6.1 - Heritage Impact Assessment [APP-195] considers the risk to the inscription of the site as a World Heritage property and concludes that the Scheme would not impact upon the continuing relevance and application of the WHS inscription criteria, and in fact the Scheme will bring extensive benefits to the WHS.

3. The HIA notes the criteria for inscription of the WHS:

   "The inscription of the WHS is based on three criteria:

   - 'Criterion (i): The monuments of the Stonehenge, Avebury and Associated Sites demonstrate outstanding creative and technological achievements in prehistoric times.
   - Criterion (ii): The World Heritage property provides an outstanding illustration of the evolution of monument construction and of the continual use and shaping of the landscape over more than 2000 years, from the Early Neolithic to the Bronze Age. The monuments and landscape have had an unwavering influence on architects, artists, historians and archaeologists, and still retain a huge potential for future research.
   - Criterion (iii): The complexes of monuments at Stonehenge and Avebury provide an exceptional insight into the funerary and ceremonial practices in Britain in the Neolithic and Bronze Age.

4. Together with their settings and associated sites, they form landscapes without parallel.' " [APP-195, para 12.5.2].

5. The HIA then reports the assessment of the Scheme's impact on those criteria, concluding that it would not impact on the inscription criteria:

"It is assessed that the Scheme would not impact upon the continuing relevance and application of the WHS inscription criteria in relation to the Stonehenge, Avebury and Associated Sites WHS. The OUV of the WHS is expressed in the SoOUV which justifies inscription of the WHS under the above criteria." [APP-195, para. 12.5.3].

"Although parts of the Scheme would have a Slight Adverse effect on certain assets and Asset Groups and certain Attributes of the OUV of the WHS, none of these effects are deemed significant overall, and they would not erode the OUV of the WHS, its Integrity or Authenticity." [APP-195, para. 12.5.7].

Question SE.1.8

Socio-economic effects

What consideration has there been in respect of the status of the site as a WHS, the economic value this brings to the area, and the degree of risks the works as currently proposed have to the future status of the site as a WHS?

Response

1. The Scheme has been designed throughout in full recognition of the site's WHS status, the economic value that the WHS brings to the area and to minimise any risks of the works to the future status of the site as a WHS. The design process has involved extensive consideration of heritage issues, which have influenced the design of the Scheme throughout the development of the DCO design. Heritage partners have attended and input to design team workshops, making sure that the status of the WHS is fully recognised by the integrated, collaborative Project Team, alongside the WHS's economic value that it brings to the surrounding area. Risks to the WHS status have been minimised wherever possible through design. The Scheme seeks to avoid and minimise adverse impacts on the Attributes that convey the Outstanding Universal Value (OUV) of the WHS, its Integrity and Authenticity, wherever possible, and is assessed to have a Slight Beneficial effect on the OUV of the WHS as a whole and to sustain the OUV of the WHS.

2. The economic value that the WHS brings to the area, and the impact on that from the Scheme, is assessed in the Economic Case contained within the Case for the Scheme [APP-294]. By providing a free-flowing and reliable connection to the South West, as part of the upgrading of the A303/A358 corridor, the Scheme will help to boost productivity in the region. The Scheme will make the South West an easier place for tourists to access, which is a major part of the region's economy. It will also facilitate new jobs and long-term prosperity, meeting the needs of a growing population. The value of the benefits which are brought about through improvements to Stonehenge are described within Chapter 5 the Economic Case contained within the Case for the Scheme [7.1 Case for the Scheme and NPS accordance, APP-294]. A summary of the economic benefits for the Scheme over a 60 year appraisal period is set out in Table 5-5 and comes to approximately £1,300 million. The value to people in the UK of removing the existing surface A303 from the WHS as part of the Scheme is valued at £955 million, by means of a contingent valuation [APP-294, para. 5.3.13].

3. The Case for the Scheme notes that "Stonehenge has long been one of the top ten major paid attractions in England. The stone circle and visitor centre attract around 1.6 million visitors a year and is a key draw for tourists visiting the region […]" [APP-294, para. 2.5.10]. "Tourism related to the WHS is also fundamental to the tourist economy of Wiltshire, supporting jobs, infrastructure and services which benefit local communities. Congestion on the A303 makes it more difficult for people to access the WHS and until this problem is resolved it will be more

difficult to build on the economic benefits of the WHS and attract more visitors." [APP-294, para. 2.3.13].

4. However, the Case for the Scheme notes that "There is a view among local residents that they suffer the inconvenience and disruption associated with traffic accessing Stonehenge, but receive little economic benefit in return. Wiltshire Council supports this view in the Council's Core Strategy which states that 'despite the number of visitors Stonehenge attracts, Amesbury and the surrounding area see little economic benefit from it'. Improving local connections, enhancing the visitor experience at Stonehenge, and encouraging people to dwell longer in the WHS and providing access to the wider WHS landscape from the Amesbury end of the WHS, will provide opportunities to deliver local economic benefits." [APP-294, para. 2.5.10-2.5.11].
5. The summary of Scheme benefits and opportunities in the Case for the Scheme notes that "Increased A303 capacity will support economic growth. It will support growth in housing and employment, reduce time wasted in congestion, improve local economic activity due to increased confidence in reliable journey times and improve productivity due to better traffic flow. It will also provide a boost to the tourist economy, both locally within the Stonehenge WHS and regionally in the South West." [APP-294, para. 5.7.3].
6. With regard to the wider WHS (and outside the scope of the Scheme), Highways England have obtained Designated Fund (DF) money to support the WHS in delivering three of the 2015 Management Plan objectives, including the Land Access Strategy, Sustainable Tourism Strategy and Sustainable Transport Strategy. By funding these key priorities of the 2015 WHS Management Plan Highways England will be able to assist its partners to move these aspects forward in order to realise the full potential benefits that the Scheme can bring to the WHS, its visitors and local communities. It will do this through working with the World Heritage Site Partnership Panel to plan for the post-Scheme future, and working with the National Trust and English Heritage Trust as they develop the ongoing Partnership Plan. In the operational phase, Highways England will continue to perform its existing responsibilities with regard to operating a road within a WHS, and the management strategy currently managed by English Heritage and the National Trust (see response to SE.1.37 for further detail) will continue to operate in terms of visitors to the northern part of the WHS.
7. Environmental Statement Appendix 6.1, Heritage Impact Assessment [APP-195], Section 12.5 discusses the risk to the inscription of the site as a World Heritage property and concludes that the Scheme would not impact upon the continuing relevance and application of the WHS inscription criteria, and in fact the Scheme will bring extensive benefits to the WHS. At para. 12.5.2 it notes the criteria for inscription of the WHS:

"The inscription of the WHS is based on three criteria:

a. ‘Criterion (i): The monuments of the Stonehenge, Avebury and Associated Sites demonstrate outstanding creative and technological achievements in prehistoric times.

b. Criterion (ii): The World Heritage property provides an outstanding illustration of the evolution of monument construction and of the continual use and shaping of the landscape over more than 2000 years, from the Early Neolithic to the Bronze Age. The monuments and landscape have had an unwavering influence on architects, artists, historians and archaeologists, and still retain a huge potential for future research.

c. Criterion (iii): The complexes of monuments at Stonehenge and Avebury provide an exceptional insight into the funerary and ceremonial practices in Britain in the Neolithic and Bronze Age.

Together with their settings and associated sites, they form landscapes without parallel." [APP-195, para 12.5.2].

8. At para. 12.5.3-12.5.7 it continues regarding the risks of the works to the future status of the site as a WHS, concluding that it would not impact on the inscription criteria:

"*It is assessed that the Scheme would not impact upon the continuing relevance and application of the WHS inscription criteria in relation to the Stonehenge, Avebury and Associated Sites WHS. The OUV of the WHS is expressed in the SoOUV which justifies inscription of the WHS under the above criteria.*" [APP-195, para. 12.5.3]

“*Overall, it is assessed that the effects of the Scheme on OUV, Integrity and Authenticity would be Slight Beneficial.”* [APP-195, para. 12.5.4]

“*The impacts of the Scheme have been minimised by iterative, heritage-led design such that effects on Attributes of OUV are Slight Adverse at worst and Very Large Beneficial at best.”* [APP-195, para. 12.5.5].

“*The Scheme is assessed to have a Slight Beneficial effect on the Integrity and Authenticity of the WHS as a whole.”* [APP-195, para. 12.5.4].

"*Although parts of the Scheme would have a Slight Adverse effect on certain assets and Asset Groups and certain Attributes of the OUV of the WHS, none of these effects are deemed significant overall, and they would not erode the OUV of the WHS, its Integrity or Authenticity.*" [APP-195, para. 12.5.7].

Question SE.1.9

Potential impact on operation of PAC – Electricity Supply

Project Allenby Connaught (PAC) is a MOD PFI with Aspire for the Garrisons on Salisbury Plain (Tidworth, Larkhill, Bulford). The Garrisons electricity supply is taken from the National Grid at Ratfyn.

PAC require confirmation that any A303 Works do not affect this supply and it's supporting infrastructure, including communication fibres.

Response

1. Highways England's understanding from its discussions with SSE is that the Garrisons electricity supply is in fact taken from SSE's Amesbury substation.
2. SSE has indicated that the A303 Works would not affect any infrastructure (including supporting infrastructure) supplying electricity to Project Allenby Connaught (PAC).
3. In the event that Highways England's understanding is incorrect, the Protective Provisions set out in Part 1 of Schedule 11 of the draft Development Consent Order would ensure appropriate protection and continuity for the relevant electricity supplier.

Question SE.1.10

Potential impact on operation of MOD Boscombe Down

MOD seek reassurance that proposal would facilitate abnormal loads to Boscombe Down, access is currently via Allington track.

Please confirm how this would be facilitated both during construction and post construction.

Response

1. During construction, until the proposed Allington Track diversion is complete, the existing abnormal loads to Boscombe Down route using Allington Track from the A303 will remain.
2. Once the proposed Allington Track diversion is complete and the access from the A303 closed, access for abnormal loads to Boscombe Down would be from the Solstice Park Junction and the proposed Allington Track diversion via Equinox Drive.
3. Therefore abnormal loads will be fully facilitated both throughout construction and post construction

Question SE.1.11

Baseline socio-economic effects/impacts

A number of RRs raise the question as to the financial/economic benefits the scheme would bring. The CPRE report (www.cpre.org.uk/what-we-do/transport/roads) questions the approach and justification for the broader strategy.

What evidence can you provide to refute this?

Response

1. It is assumed that the Campaign to Protect Rural England (CPRE) report referenced in the question is the 2017 publication '*The end of the road? Challenging the road-building consensus*'[1]. The report summarises CPRE research on the impact of road schemes on traffic, landscape and economy.

2. The Applicant would note from the outset that it is the NPSNN which forms the focus of the policy background against which the Scheme should be assessed, pursuant to section 104 of the Planning Act 2008. This Act was passed by Parliament and sets out what projects for the alterations and improvement of the strategic road network should be judged against. The NPSNN also forms Government policy. As such, the Applicant considers that it is not appropriate for the Examination to consider issues of government policy and the statutory background against which schemes must be judged, and indeed the NSIP process was created with that point in mind, i.e. that national policy statements are designated by the Secretary of State following scrutiny in Parliament and therefore should not be questioned.

3. Chapter 2 of the NPSNN sets out the need for development of national networks and states Government policy. Paragraph 2.2 states that "there is a critical need to improve the national networks to address road congestion…; and to provide a transport network that is capable of stimulating and supporting economic growth.". Paragraph 2.10 states that "The government has therefore concluded that at a strategic level there is a compelling need for the development of the national networks". Paragraph 2.23 further goes on to note that enhancement to the existing national road network will include "improvements to trunk roads, in particular dualling of single carriageway strategic trunk roads… to increase capacity and to improve performance and resilience"; the Scheme fulfils this latter point.

4. The compliance of the scheme with NPSNN is set out in The Case for the Scheme [APP-294]. The CPRE's recommendations for changes to policy are therefore not relevant in this context.

5. In particular it is noted that paragraph 4.6 of the NPSNN states that "the national methodology and national assumptions around the key drivers of demand" are to

[1] The end of the road? Challenging the road-building consensus. Campaign to Protect Rural England (CPRE). March 2017. https://www.cpre.org.uk/resources/transport/roads/item/download/4851 [Last accessed: 24/04/2019].

be followed. Paragraph 4.7 of the NPSNN specifically refers to WebTAG as the appropriate guidance. The application of the WebTAG methodology to transport modelling and economic appraisal of the scheme is given in the Combined Modelling and Appraisal (ComMA) report [APP-298].

6. The CPRE report recommends: changes to national policy (which includes the Roads Investment Strategy (RIS) programme through which the A303 Amesbury to Berwick Down scheme would be delivered; changes to the appraisal of road schemes; and changes to the evaluation of road schemes post-opening. The report also states that road schemes "*induce traffic, often far above background trends over the long-term*". The CPRE report also stated that road schemes "*induce traffic, often far above background trends over the long-term*".

7. Such comments need to be seen in the above context and the points set out below:

   - The financial/economic benefits of the scheme have been assessed in accordance with the Department for Transport's (DfT) Web-based Transport Analysis Guidance (WebTAG). The appraisal of the scheme has followed traffic forecasting guidance in WebTAG unit M4 'Forecasting and Uncertainty' and economic appraisal guidance in WebTAG unit A1-1 'Cost-benefit analysis', which is aligned to guidance given in Her Majesty's Treasury (HMT) Green Book; all pursuant to the NPS requirement referred to above.
   - The methods set out in WebTAG unit M2 and unit A1-1 explain how induced traffic should be considered in forecasting and appraising road schemes. Chapter 2 of Appendix B to the Combined Modelling and Appraisal (ComMA) report [APP-300] sets out the key considerations of the design of the local transport model with Chapter 3 of the report stating how the aforementioned guidance has been followed in the development of the local transport model. Paragraph 3.2.15 of Appendix D to the ComMA [APP-302] states the guidance followed in the appraisal of the scheme, which includes the aforementioned WebTAG units.

8. Further to this, Highways England evaluates schemes following implementation producing Post Opening Project Evaluation (POPE) reports '1 year after' and '5 years after' the opening of a road scheme.

9. Figure 4 of Highways England's Evaluation Insights Paper (which sets out the results of the meta analysis of scheme POPE reports) shows that while 59% of forecasts reviewed were within 15% of the observed flows post opening, there was a tendency over the period to overestimate rather than understate traffic volumes. The report attributes this to the economic downturn and notes that "more recent schemes have accounted for this within their traffic growth assumptions". The traffic growth assumptions used in the forecasting methodology adopted for assessment of the A303 Amesbury to Berwick Down scheme have used up-to-date traffic growth assumptions. These assumptions are set out in the ComMA and in ComMA Appendix C – Transport Forecasting Package [APP-301].

10. The key points from CPRE's report, as summarised here in paragraph 2, are therefore either not relevant in the policy context against which the scheme must be assessed (NPSNN) or are refuted by recent evidence from Highways England's POPE monitoring process or addressed by the modelling and appraisal methods advocated in the NSPNN.

Question SE.1.13

Baseline socio-economic effects

In light of the RR from CPRE South West can you provide evidence to respond to the concerns identified in relation to the following:

i. The degree of assessment of the cumulative effects of the programme in terms of increased traffic and emissions.
ii. The Infrastructure Commission identified the need for connectivity improvements, and Highways England's own statistics show that the need is for better sub regional business and leisure connections.
iii. The benefits of highway and public transport options and whether these have been considered together.

Response

1. The Relevant Representation by the Campaign to Protect Rural England (CPRE) South West [RR-1683] covers a number of points. In relation to the three items above, it is assumed that the following points made by CPRE South West are referenced:

   "*No assessment of the cumulative effects of the programme in terms of increased traffic and emissions.*"; and

   "*The Infrastructure Commission identified the need for connectivity improvements, and Highways England's own stats show that the need is for better sub regional business and leisure connections and the benefits of highway and public transport options have not been considered together.*".

2. With respect to cumulative effects:

   a. It is assumed that the 'programme' referred to in RR-1683 is the upgrade of the A303 / A358 corridor. The A303 Amesbury to Berwick Down scheme is one of eight proposed schemes to upgrade the A303 / A358 corridor.
   b. The National Policy Statement for National Networks (NPSNN) paragraphs 4.6 and 4.7 note that it is expected that the "national methodology" is followed in development of the local transport model. This is the guidance provided in the Department for Transport's (DfT) Web-based Transport Analysis Guidance (WebTAG). Traffic forecasts have been prepared in accordance with guidance given in WebTAG unit M4 'Forecasting and Uncertainty'.
   c. Without-scheme and with-scheme cases, referred to as the 'Do Minimum' and 'Do Something' respectively, have been developed as per guidance in WebTAG unit A1-2 sections 2.2.1 and 2.2.2. Both future development and infrastructure that are considered to be 'near certain' and 'more than likely' have been included in both cases. These are captured in the Uncertainty Log as recommended in WebTAG unit M4, and presented in Appendix A of the Combined Modelling and Appraisal (ComMA) report Appendix C – the Transport Forecasting Package [APP-301].

d. Three of the schemes on the A303 / A358 corridor are categorised as either ‘near certain’ or ‘more than likely’ by virtue of being part of the first Road Investment Strategy (RIS1) programme: these are the A303 Sparkford to Ilchester (currently at DCO examination), the A358 Taunton to Southfields (which has completed options’ consultation) and the A303 Amesbury to Berwick Down. Both the A303 Sparkford to Ilchester and A358 Taunton to Southfields schemes therefore form part of the without-scheme or ‘Do Minimum’ network.

e. The five remaining schemes are not sufficiently developed, are not part of the current RIS programme and do not have sufficient certainty to be included in the assessment. These schemes are therefore excluded from the assessment. These schemes are all on the A303 west of the Amesbury to Berwick Down scheme, being: A303 Wylye to Stockton Wood; A303 Chicklade Bottom to Mere; A303 Podimore Roundabout; A303 Cartgate Roundabout; and A303 South Petherton to Southfields.

f. The ‘with-scheme’ or ‘Do Something’ assessment therefore presents the cumulative effects of the three RIS1 schemes on the corridor.

g. On the basis of each of these factors the Applicant considers the concerns raised by CPRE South West are unfounded. The Applicant has undertaken an assessment of the cumulative effects in accordance with Environmental Impact Assessment Regulation (The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017) and Scoping Opinion (APP-188) and the Applicant therefore considers that the approach taken is demonstrated and evidenced to be appropriate.

3. On the need for connectivity improvements and better sub-regional business and leisure connections:

   a. Chapter 2 of the NPSNN sets out the need for development of national networks and states Government policy. Paragraph 2.2 states that “there is a critical need to improve the national networks to address road congestion…; and to provide a transport network that is capable of stimulating and supporting economic growth.”. Paragraph 2.10 states that “The government has therefore concluded that at a strategic level there is a compelling need for the development of the national networks”. Paragraph 2.23 goes further to note that enhancement to the existing national road network will include “improvements to trunk roads, in particular dualling of single carriageway strategic trunk roads… to increase capacity and to improve performance and resilience”. The Applicant considers that the A303 Amesbury to Berwick Down scheme fulfils this latter point as supported by the scheme benefits and opportunities set out in Chapter 5 of the ‘Case for the Scheme and NPS accordance’ [APP-294].

   b. The National Infrastructure Commission (NIC) does identify the need for connectivity improvements in its ‘National Infrastructure Assessment’ report of July 2018. Chapter 3 of the report largely focuses on the need for connectivity and other improvements to facilitate electric vehicles and connected and autonomous vehicles (CAVs). Page 63 of the report recommends that "government should address the implications of technological innovation in long term transport planning processes, including the next rail control period and road investment strategy". The report makes no comment on RIS1 (the programme within which the A303 Amesbury to Berwick Down scheme is included) and does not contradict the objectives of the proposed scheme.

c. Highways England's conclusions presented in its 2017 report 'Socio-economic analysis, future forecasts and the strategic road network[2]' note that "growth in employment and GVA in peripheral regions would be enhanced by effective connections that reduce effective distance with urban agglomerations, improve access to international gateways and reduce journey times for tourists and leisure travellers". The A303 Amesbury to Berwick Down scheme fulfils these points.

d. Furthermore, analysis of the distribution of traffic using the A303 past Stonehenge, and as presented in Figure 2-2 of the ComMA [APP-298], shows that only 11% of trips have both an origin and destination within 10 miles (16 kilometres) of Stonehenge (i.e. are local), with the average length of journeys being 100 miles (160 kilometres). This highlights both the sub-regional and regional connectivity provided by the A303 and which business and leisure users (including tourists during busy periods) would benefit from with the proposed improvement scheme. Analysis of the scheme benefits is set out in Section 6 of Appendix D to ComMA [APP-302], with Section 6.7 explaining the local, sub-regional and regional distribution of benefits that the scheme would deliver.

4. Public transport and highway assessments have been undertaken as part of the options appraisal process:

   a. Development of the scheme has fully taken account of the 'Assessment Principles' set out in chapter 4 of the NPSNN and thus the assessment of viable modal alternatives as noted in paragraph 4.27. A full options appraisal in accordance with NPSNN paragraph 4.27 and following Highways England's Project Control Framework (PCF) process considered alternatives to road improvements. Paragraphs 8.5.1 to 8.5.7 of the Transport Assessment [APP-297] summarise the assessment of alternative modes to meet the objectives of the proposed scheme, whilst Appendix 8.5 provides further detail on the consideration of alternative modes and potential for rail interventions.

   b. As Appendix 8.5 of the Transport Assessment [APP-297] notes, a review of the extent to which rail improvements could reduce traffic volumes on the A303 has shown that hypothetically, assuming a step-change in rail services, the maximum achievable reduction in traffic flow on the A303 would be 11%. Such a level of modal transfer would reduce the 2041 'without-scheme' forecast traffic flows by Stonehenge to 31,000 vehicles per day. This is higher than present day traffic volumes and would leave a residual stress

[2] https://highwaysengland.citizenspace.com/he/strategic-economic-growth-plan/supporting_documents/Socioeconomic%20analysis%20future%20forecasts%20and%20the%20SRN%20%20final.pdf [Last accessed: 17/04/2019]

factor of 1.36. Therefore even a step-change in rail improvements could not solve the issues on the A303 at Stonehenge.

Question SE.1.16

Socio-economic effects

A significant number of RRs refer to the loss of view of the Stones which they perceive would prevent the stones being viewed without having to pay.

i. Is this correct?

ii. In the event this is correct, what regard have you had for low income groups being able to view the Stones?

iii. What implications would this have for the broader tourism industry in the locality?

Response

i. **Is this correct?**

1. This is not correct. A principal aim of the Scheme, supporting the aims of the World Heritage Site (WHS) Management Plan 2015, is to remove the surface A303 and the sight and sound of traffic using it from much of the WHS landscape, thereby re-uniting Stonehenge with its surrounding monuments in their natural chalk downland setting.

2. Whilst the Stonehenge monument will not be visible from the A303 once the tunnel is built, there will be a significant opportunity for the public to view the Stonehenge monument from the enhanced public rights of way network, (as shown on the Rights of Way and Access Plans [APP-009]) notably the restricted byway being created on the line of the existing road. Visitors will continue to have free access by using the public rights of way that cross the WHS landscape and via the National Trust's right to roam policy.

ii. **In the event this is correct, what regard have you had for low income groups being able to view the Stones?**

3. As explained in point (i), it is not correct that the Scheme would prevent the Stones being viewed without having to pay. The opportunity to explore the landscape and view the Stonehenge monument from the enhanced public rights of way network, is being delivered as a principle aim of the Scheme and will be open to all, regardless of income level. The response to HW.1.14 provides detail with respect to the Equalities Impact Assessment [APP-296] undertaken for the application which concluded that the proposed Scheme is likely to provide a range of benefits that can be shared by groups with protected characteristics.

iii. **What implications would this have for the broader tourism industry in the locality?**

4. The tourism sector stands to benefit from the provision of an improved transport corridor to the South West and this benefit has been considered as one of the reasons why the Scheme is needed. At the same time, the Scheme, notably the diversion of the surface road within the WHS into tunnel and deep cutting, would transform the WHS landscape around Stonehenge, enhancing the experience for

visitors and contributing to this part of Wiltshire being an attractive tourist destination. The Heritage Impact Assessment, Environmental Statement Appendix 6.1 [APP-195], considers the implications of the Scheme in the context of Stonehenge and the WHS, concluding that the Scheme would bring about a slight beneficial effect on tourism in relation to the WHS [APP-195, para. 9.3.36].

5. As the scheme will not result in the loss of access to those visitors who do not wish to pay to visit Stonehenge or result in the loss of access for groups on a low income, it is not anticipated that the scheme would have implications for the broader tourism industry in the locality with regard to either of these aspects. Highways England will continue to work with partners to maximise the tourism opportunities that could arise from the scheme.

Question SE.1.18

Socio-economic effects

In light of the sensitivity of the archaeological environment through which the scheme is proposed:

i. What allowance has been taken into account to fully assess the archaeological findings, and what effect this would have on the time frame of this for the scheme?

ii. Should the scheme be delayed as a consequence of the need to develop more slowly in light of archaeological sensitivity what account within the scheme has there been for impacts on the local community economically, socially, and environmentally?

iii. How does this remain within the scope of the ES?

Response

i. What allowance has been taken into account to fully assess the archaeological findings, and what effect this would have on the time frame of this for the scheme?

1. A full and comprehensive programme of archaeological evaluation surveys has been completed.

2. As noted in ES Chapter 6, Cultural Heritage [APP-044], "A comprehensive programme of archaeological field work has been undertaken to inform the assessment, both inside and outside the WHS. The scope of the field work programme within the WHS has been developed in consultation with HMAG and the Scientific Committee to reflect approaches employed by current academic research projects in the WHS. Outside the WHS, a similarly detailed approach combining detailed geophysical survey, sampling of artefacts in the plough zone and targeted trial trenching has been employed to ensure a consistent approach across the Scheme [...] The comprehensive programme of archaeological fieldwork has included detailed geophysical survey across the area defined by the Scheme boundary, surface artefact collection procedures including test pitting with accompanying sieving and sieving samples of the topsoil from intrusive trial trenching, as well as extensive trial trenching of the Scheme main line footprint and land take for landscaping and excavated material deposition" [APP-044, paras. 6.6.13 - 6.6.14]. Archaeological evaluation was carried out in accordance with:

   - an Archaeological Evaluation Strategy and Overarching Written Scheme of Investigation for Archaeological Evaluation developed in consultation with and approved by the Heritage Monitoring and Advisory Group (HMAG) and with input from the Scientific Committee of independent experts set up to advise the Scheme through HMAG; and

- individual Site Specific Written Schemes of Investigation (SSWSIs) approved by HMAG.

  "*The majority of the land within the Scheme boundary has been evaluated by recent detailed archaeological geophysical surveys, either as part of academic projects or in support of the Scheme. This provides a robust baseline against which to assess the impact of the Scheme. Additional evaluation fieldwork has been completed for sections of the Scheme within and adjacent to the WHS (eastern portal and approaches, western portal and approaches, new Longbarrow Junction and approaches, and the Rollestone Corner improvement).*" [APP-044, paras. 6.6.13 - 6.6.14].

3. Much of the Winterbourne Stoke bypass alignment was archaeologically evaluated for previous A303 improvement schemes [see ES Appendix 6.10 - Previous archaeological and antiquarian investigations within the Stonehenge World Heritage Site and its environs, APP-219].

4. Fieldwork was undertaken between January and August 2018 and the results of that work were reported in paragraphs 6.6.13- 6.6.52 (fieldwork) and paragraphs 6.6.53 to 6.6.111, Appendix 6.2 [APP-211] and Figures 6.8 [APP-074] (baseline) of the Environmental Statement. The conclusions of the Environmental Statement were informed by those results, the non-intrusive archaeological geophysical survey of the entire Scheme boundary (referred to at ES paragraph 6.4.1(f) and Appendix 6.10 [APP-219]) and the results of historic surveys and fieldwork (referred to in ES paragraph 6.6.15 and summarised and listed at ES Appendix 6.10). This allowed a robust assessment of baseline (as referenced above), approach to mitigation (ES section 6.8) and likely significant effects (ES section 6.9).

5. Confirmatory surveys and sampling consisting of trial trenching on the Winterbourne Stoke Bypass, test pitting on one part of the Western Portal approach and geophysical surveys at Countess East and Amesbury Road were completed in October 2018.

6. The results of this confirmatory survey and sampling work were reviewed against the archaeological baseline, approach to mitigation and assessment of effects presented in the ES and they confirm its findings. No changes to the conclusions as to the likely significant effects of the Scheme were identified or were required.

7. Archaeological Evaluation and Survey Reports were submitted to the Examination [REP1-041 – REP1-056] and provide the detail behind the results and baseline already reported in paragraphs 6.6.13-6.6.52 and 6.6.53-6.6.111, Appendix 6.2 and Figure 6.8 respectively of the Environmental Statement, and also incorporate the results of the confirmatory surveys and sampling referred to above. The reports have been subject to detailed review and comment by HMAG.

8. The results of the 2018 archaeological evaluation surveys, confirmatory surveys and sampling work have been incorporated into the detail of mitigation and areas for preservation in situ, set out in the draft Detailed Archaeological Mitigation Strategy (DAMS) as submitted at Deadline 2. The draft DAMS has been

prepared in consultation with the HMAG, who will continue to be consulted as the DAMS is finalised prior to the end of the Examination.

9. It is clear from the above, that a comprehensive programme of archaeological evaluation has been undertaken, reflecting the sensitivity of the archaeology. As a result, a lot of the uncertainty as to archaeological finds has been removed, compared with other schemes.

10. The scope and timing of the proposed archaeological mitigation programme is set out in the draft DAMS. Archaeological mitigation will commence as part of the Preliminary Works (PW) stage and will be scheduled to be completed before the start of the Main Works (MW) stage, except specific works that will necessarily only take place under the Main Works contract (see section 6 of the draft DAMS). Archaeological site works will take place over three phases spanning the PW and MW stages, as set out below (and in section 6 of the draft DAMS).

Preliminary Works stage

Phase 1 – preliminary data collection, installation of protective measures such as fencing (where required) and mitigation of small-scale advanced works such as site clearance:

i. Ploughzone artefact collection (fieldwalking);

ii. Archaeological evaluation trenching where required;

iii. Topographic surveys;

iv. Small-scale investigation of historic landscape features and small archaeological sites;

v. Archaeological monitoring and recording (AMR) of advanced works during the PW stage, such as installation of highway boundary fencing, construction of temporary utility connections, road diversions, ecology works and woodland clearance at certain locations, as required by the detailed Scheme design;

vi. Protective fencing will be installed around selected sites to prevent damage;

vii. Archaeological mitigation at selected sites to facilitate the installation of protective fencing will be carried out, including boundary fencing; and

viii. Heritage assets that require relocation will be moved.

Phase 2 – implementation of the main body of the archaeological mitigation works programme

a. Geo-archaeological investigations;

b. Archaeological excavation and recording (AER) and strip, map and sample (SMR) at archaeological sites requiring preservation by record; and

c. Additional sites that require preservation in situ will be identified and measures implemented.

Main Works stage

Phase 3 – archaeological mitigation of areas not available during the preliminary works stage.

a. Monitoring of archaeological sites that have been protected in situ;

b. Archaeological mitigation in compound areas where it is unfeasible to achieve a no-dig solution (for example in areas required for concrete batching plants or tunnel spoil processing plants), following archaeological evaluation at Phase 1; and

c. Archaeological mitigation in advance of the installation of tunnel movement monitoring stations above the tunnel section of the Scheme, where this has not been possible during the PW stage.

11. The DAMS requires that artefactual, geo-archaeological and palaeo-environmental assessment of material recovered during the archaeological mitigation works be undertaken concurrently with the on-site archaeological works. This will enable the significance of the findings to be determined whilst works are ongoing on site and allow archaeological features and deposits to be suitably targeted commensurate with the potential significance of the remains.

12. In terms of unforeseen finds, the DAMS sets out the procedure to be followed to investigate and protect unforeseen cultural heritage finds made during the course of the works. As set out above, the majority of archaeological works are being undertaken in the Preliminary Works phase to mitigate against the risk of unforeseen finds being located within the Main Works; archaeological remains would be excavated and recorded during the Preliminary Works phase, in advance of construction, to avoid, as far as is practicable, previously unknown archaeological remains being uncovered during construction and affecting the programme. In line with paragraph 5.1.10 of the draft DAMS, if unexpected finds (sites, artefacts, environmental remains or ecofacts, monuments or features) were made during the Preliminary Works or Main Works stages a site consultation meeting(s) would be convened between the Archaeological Contractor, HMAG / WCAS and the Technical Partners' Archaeologist to consider the significance of the finds. Depending on the outcome of the consultation meeting, an addendum to the Site Specific Written Scheme of Investigation or a new Site Specific Written Scheme of Investigation would be prepared by the Archaeological Contractor and approved by the Technical Partners' Archaeologist, in consultation with HMAG / WCAS. An allowance would be made for a minimum period of time to deal properly with any unexpected finds during the construction process, as agreed between the contractor and Highways England and recorded in the Construction Environmental Management Plan (CEMP) (see the response to CH.1.52 for further detail). It is considered that the phasing of the DAMS and the timeframes allowed for in the programming of the archaeological mitigation works are sufficiently robust to avoid any delay to the delivery of the Scheme in order to consider archaeological finds.

13. The design and programming of the archaeological mitigation strategy as set out in the DAMS therefore makes adequate provision for the assessment of the archaeological findings, informed by the extensive archaeological evaluation already undertaken. The requirements of the DAMS have been fully taken into account in the Preliminary Works and Main Works programmes, and the programming of the Scheme therefore fully allows for the archaeological mitigation works. There would be no effect on the Scheme due to the timing of these assessments.

ii) Should the scheme be delayed as a consequence of the need to develop more slowly in light of archaeological sensitivity what account within the scheme has there been for impacts on the local community economically, socially, and environmentally?

14. It is not proposed that the Scheme be delayed in light of the archaeological sensitivity of the site. As reported above, a full and comprehensive programme of archaeological evaluation surveys has been completed and analysed, and an archaeological mitigation strategy designed and programmed, having full regard to the sensitivity of the archaeology involved. A Detailed Archaeological Mitigation Strategy (DAMS), submitted at Deadline 2, has been developed for the Scheme, having regard to the results of the archaeological evaluation work undertaken and, again, with full regard to the archaeological sensitivity. Programming of the archaeological mitigation works is set out in the draft DAMS (see section 6 of the DAMS). As explained above, the time frame is felt to be realistic and deliverable in terms of the archaeological mitigation works and what has been uncovered by the extensive geophysical surveys and trial trench evaluations. It is therefore not considered that the Scheme should be delayed, as there is not a need to develop the Scheme more slowly than planned.

15. The potential for the Scheme to impact local communities has been assessed through the EIA, as reported in the Environmental Statement, and consideration has been given to minimising as far as is practicable the potential for impacts on local communities through the development and refinement of the Scheme. This includes the provision of environmental screening past Winterbourne Stoke and noise barriers on the Countess flyover. Temporary impacts during construction would also be minimised through the adoption of mitigation measures set out in the Outline Environmental Management Plan (OEMP) [APP-187] submitted with the DCO, for example, in relation to control of dust and noise, reducing the risk of spillage and pollution, and limiting or avoiding any disruption caused by materials being delivered to site. Compliance with the OEMP is secured under paragraph 4 of Schedule 2 within the draft DCO [APP-020]. Further information on the potential for impacts on people and local communities can be found in ES Chapter 5 - Air Quality [APP-043] section 5.9, ES Chapter 7 – Landscape and Visual [APP-045] section 7.9, ES Chapter 9 - Noise and Vibration [APP-047] section 9.9, and ES Chapter 13 - People and Communities [APP-051], section 13.9. During construction, a dedicated Community Relations Manager will keep local residents informed throughout the Preliminary Work and Main Works

regarding the activities or works that are planned and the progress being made. The dedicated Community Relations Manager will ensure ready lines of communication are available at all times for queries or concerns to be raised, as secured through the OEMP, item MW-G32. Overall, once completed, the Scheme will deliver significant benefits for local people, including as a result of reduced rat running in local villages and reduction in traffic and associated effects through Winterbourne Stoke.

16. As discussed above, the potential for the Scheme to impact local communities has been assessed through the EIA, as reported in the Environmental Statement, and consideration has been given to minimising as far as is practicable the potential for adverse impacts on local communities through the development and refinement of the Scheme. With respect to the impact on the local community in connection with the archaeological sensitivity, as explained above, the proposed mitigation works and their programming have had full regard to the archaeological sensitivities, and the timeframe under which those works are proposed to be undertaken is considered appropriate. As a result, impacts on the local community related to the timing with which archaeological works are undertaken are not anticipated. During construction, as stated above, a dedicated Community Relations Manager will keep local residents informed throughout the Preliminary Work and Main Works regarding the activities or works that are planned and the progress being made. The dedicated Community Relations Manager will ensure ready lines of communication are available at all times for queries or concerns to be raised, as secured through the OEMP, item MW-G32.

iii) How does this remain within the scope of the ES?

17. As explained above, it is not proposed that the Scheme be delayed in light of the archaeological sensitivity of the site; the archaeological sensitivity has already been taken into account in the programming of the Scheme including the archaeological mitigation works as put forward in the draft DAMS submitted at Deadline 2. As there is no change to the timeframe of delivery of the Scheme, the programming remains as proposed and as assessed in the Environmental Statement. Given the detailed work that has informed the programming (as set out in this response), it is considered a robust approach to have assessed the Scheme’s impact on the basis of the timeframes proposed.

Question SE.1.19

Socio-economic effects

Do the socio-economic benefits as calculated rely on each of the proposed sections of improvement to the A303 going ahead or are they dealt with in isolation?

Response

1. The socio-economic benefits presented in the Development Consent Order (DCO) application specifically relate to the Amesbury to Berwick Down scheme and are not reliant on improvements elsewhere on the A303 / A358 corridor, for the reasons given below.

2. The Assessment of Accordance with the National Policy Statement for National Networks (NPSNN), included as Appendix A to the Case for the Scheme [APP-294], sets the context of the A303 Amesbury to Berwick Down scheme as one of eight proposed improvement schemes on the A303 / A358 corridor. However, different levels of certainty are attached to these schemes with only three schemes included in the current Road Period. Specifically, section 2.24 of Appendix A to the Case for the Scheme highlights that there are eight identified improvement schemes but that only three of these are included in the current Road Period:

   "*The Government's aim, announced in the Road Investment Strategy for the 2015/16 to 2019 Road Period ("RIS1") is to upgrade all remaining single carriageway sections of the A303 between the M3 and the A358 to create a high quality dual carriageway route to the South West on which mile-a-minute journeys are the norm, and to tackle specific issues on this section of the SRN. In pursuit of this aim, eight improvement schemes have been identified. It is proposed that these will form a staged programme of improvement. Three of the schemes, including A303 Amesbury to Berwick Down, are included in the current (2015/16 to 2020/21) Road Period.*"

3. Socio-economic benefits have been presented in several application documents, including: the Combined Modelling and Appraisal Report (ComMA) [APP-298] and, ComMA Appendix D – the Economic Appraisal Package [APP-302].

4. The assessment of the Scheme benefits has been undertaken in accordance with relevant guidance. Traffic forecasts have been prepared in accordance with guidance given in the Department for Transport's (DfT) Web-based Transport Analysis Guidance (WebTAG) unit M4 'Forecasting and Uncertainty'. Economic appraisal has followed guidance in WebTAG unit A1-1 'Cost-Benefit Analysis'.

5. Without-scheme and with-scheme cases, referred to as the 'Do Minimum' and 'Do Something' respectively, have been developed as per guidance in WebTAG unit A1-2 sections 2.2.1 and 2.2.2. Both future development and infrastructure that are considered to be 'near certain' and 'more than likely' have been included in both cases. These are captured in the Uncertainty Log, as recommended in

WebTAG unit M4, and presented in Appendix A of ComMA Appendix C – the Transport Forecasting Package [APP-301].

6. Three of the schemes on the A303 / A358 corridor are categorised as either 'near certain' or 'more than likely' by virtue of being part of the first Road Investment Strategy (RIS1) programme, these are: the A303 Sparkford to Ilchester (currently at DCO examination); the A358 Taunton to Southfields (which has completed options consultation); and, the A303 Amesbury to Berwick Down. Both the A303 Sparkford to Ilchester and A358 Taunton to Southfields schemes therefore form part of the without-scheme or 'Do Minimum' network.
7. The five remaining schemes are not sufficiently developed, are not part of the current RIS programme and do not have sufficient certainty to be included in the assessment so have, therefore, been excluded. These schemes are all on the A303 west of the Amesbury to Berwick Down scheme, being: A303 Wylye to Stockton Wood; A303 Chicklade Bottom to Mere; A303 Podimore Roundabout; A303 Cartgate Roundabout; and, A303 South Petherton to Southfields.
8. Whilst the A303 Sparkford to Ilchester and A358 Taunton to Southfields schemes are assumed to be implemented in the assessment of the scheme, their inclusion in the without-scheme scenario means that the benefits presented are solely for the Amesbury to Berwick Down scheme. Therefore the socio-economic benefits presented are not reliant on any other improvements on the A303 / A358 corridor.

Question SE.1.21

Socio-economic effects

i. There would clearly be significant disruption during the construction process, how are you ensuring that this is minimised so that local business, people and communities suffer the least disruption?

ii. Where is this set out?

Response

1. **There would clearly be significant disruption during the construction process, how are you ensuring that this is minimised so that local business, people and communities suffer the least disruption?**

1. Environmental statement Chapter 13 - People and Communities [APP-051] assesses the construction phase of the Scheme's effect on businesses, people and communities in respect of disruption arising from: land required temporarily and/or permanently; severance/changes to travel patterns experienced by drivers and non-motorised users; the amenity of local residents and workers; and their health. No significant adverse effects were identified in these assessments. Significant adverse temporary and permanent effects would arise during construction in respect of agricultural land (paragraph 13.9.6) and holdings (paragraphs 13.9.15 and 13.9.17), with mitigation measures outlined in Section 13.8 (and discussed below) being proposed that seek to minimise disruption experienced by the limited number of agricultural businesses affected. The mitigation measures are set out in the Outline Environmental Management Plan (OEMP) [APP-187], secured through Paragraph 4 of Schedule 2 to the Draft Development Consent Order [APP-020].

2. With regard to disruption arising directly from traffic, Chapter 7 of the Combined Modelling and Appraisal Report – Appendix C [APP-301] sets out the traffic impacts anticipated during the construction phase. Tables 7-1, 7-2 and 7-3 and paragraphs 7.2.7 to 7.2.13 set out analysis of the changes in journey times and relevant flows on the A303 and surrounding roads by phase of construction. Based on the analysis presented, the predicted results assess that, although there will be traffic related construction impacts potentially resulting in disruption to businesses, people and communities, these will not be significant.

3. Section 9.9 of Environmental Statement Chapter 9 - Noise and Vibration [APP-047] identifies that there are no significant noise effects arising from construction traffic, with noise effects arising from construction activities being limited to the closest receptors to the works at Countess Roundabout and Foredown House on the northern edge of Winterbourne Stoke. As outlined in Section 9.8 (and discussed below), construction noise/vibration mitigation measures are proposed that would minimise disruption to local business, people and communities, including at these locations. The mitigation measures are set out in the Outline Environmental Management Plan (OEMP) [APP-187], secured through Paragraph 4 of Schedule 2 to the Draft Development Consent Order [APP-020].

ii. Where is this set out?

4. The below sets out how each of the key mitigation measures in section 9.8 and 13.8 of the ES are secured:

    i. During construction, implementation of measures contained within Environmental Statement Appendix 2.2 - Outline Environmental Management Plan (OEMP) [APP-187] would control and limit the potential for impacts on local residents and communities. The OEMP is secured through Paragraph 4 of Schedule 2 to the Draft Development Consent Order [APP-020].

    ii. Requirement 9 in Schedule 2 of the Draft Development Consent Order [APP-020] states that no part of the development can take place until a Traffic Management Plan (TMP) has been approved by the Secretary of State, following consultation with the local highway authority.

    iii. The TMP will be developed by the main works contractor and will include the requirements set out in Table 3.2b of the OEMP, Reference MW-TRA2. This will set out how the contractor will minimise the traffic impacts of the Scheme on the highway network.

    iv. Reference MW-TRA3 within Table 3.2b of the OEMP states that the main works contractor will also develop a construction workforce travel plan to reduce the impact of the construction workforce on the transport network.

    v. Reference PW-COM1 in Table 3.2a and Reference MW-COM1 in Table 3.2b within the OEMP, relevant to agricultural holdings and notification of works, set out that the preliminary and main works contractors shall advise and liaise with landowners, occupiers and agents with regards to the programme of preliminary and main works. Access routes to be used by construction traffic and, where relevant, agricultural machinery and/or livestock will also be discussed as part of the liaison between the contractors and these parties.

    vi. Reference MW-COM3 within Table 3.2b of the OEMP, regarding liaison with landowners, sets out that landowners, occupiers and agents will be consulted on measures regarding maintaining livestock water supplies, fencing requirements, and locations of carcass burial sites such that disruption in these respects would be minimised.

    vii. Reference MW-G16 in Table 3.2b of the OEMP, states that impacts during Solstice events will be managed by suspending surface works within the western section of the World Heritage Site for up to 48 hours.

viii. References MW-G31 and MW-G32 in Table 3.2b of the OEMP, set out the commitments around community engagement and coordination with external parties to ensure the impacts of the works are minimised.

ix. Construction noise mitigation is secured through the OEMP, Reference MW-NOI1 which requires the contractor to adopt Best Practicable Means (BPM), which will be set out in the required Noise and Vibration Management Plan to be produced by the contractor (OEMP Reference MW-NOI3).

Concern to be managed	**How?**	**Draft DCO Ref** **[APP-020]**	**OEMP Ref** **[APP-187]**
Traffic Impacts	Traffic Management Plan	Requirement 4 Requirement 9	MW-TRA2
Traffic Impacts	Construction workforce travel plan	Requirement 4	MW-TRA3
Agricultural holdings Impacts	Notification of preliminary works	Requirement 4	PW-COM1
Agricultural holdings Impacts	Notification of main works	Requirement 4	MW-COM1
Agricultural holdings Impacts	Liaison with landowners	Requirement 4	MW-COM3
Solstice Events	Suspension of surface works in WHS for up to 48 hours	Requirement 4	MW-G16
General Impacts	Community Engagement	Requirement 4	MW-G31
General Impacts	Coordination with external parties to minimise impacts	Requirement 4	MW-G32
Noise Impacts	Contractor to adopt Best Practice Means (BPM)	Requirement 4	MW-NOI1

Question SE.1.22

Socio-economic effects

In Table 13.2.6 Access to Work and Training [APP-287] it is indicated that having a 'local employment and procurement policy' would help to promote employment by underrepresented groups.

- Is it intended to have such a policy for the contract?
- If so where is this set out as a requirement?

Response

i. **Is it intended to have such a policy for the contract?**

i. The Applicant intends to promote access to work and training opportunities for local people, including employment of underrepresented groups, through an outcome-based requirement in the contract for detailed design and construction. Information regarding this outcome-based requirement will be included in the tender documents and contractors will be invited to submit proposals for how they will deliver the requirement, with these being evaluated as part of the tender review process. The proposed initiatives of the successful tenderer will be subsequently incorporated into the final scope as a contractual requirement. Discussions will be taking place with Wiltshire Council to develop the specific employment requirement for local people and how this is best delivered.

5. The contract will also include requirements for the contractor to assist the Applicant to contribute to achieving the "Transport Infrastructure Skills Strategy" (https://www.gov.uk/government/publications/transport-infrastructure-skills-strategy-building-sustainable-skills) ambition for recruiting and developing underrepresented groups.

6. To reflect Procurement Policy Note (PPN) 01/18 "Supply Chain Visibility" (https://www.gov.uk/government/publications/procurement-policy-note-0118-supply-chain-visibility) the Contractor will be required to advertise subcontracting opportunities >£25,000 on the Government's "Contract Finder" website. This will enable local suppliers to tender for contracts on the Scheme.

7. By requiring potential contractors to propose how they will deliver these outcomes/opportunities, and evaluating them as part of the tender process, the experience of the contractors, including their innovative practices, will be utilised effectively and the required outcomes will become contractual requirements. This approach will deliver successful outcomes from the Scheme in respect of access to work and training, including promoting employment by underrepresented groups.

ii. **If so where is this set out as a requirement?**

8. The requirement(s) in this regard will be set out within the contract specification. Discussions will be taking place with Wiltshire Council to agree upon how this is best delivered.

Question SE.1.23

Socio-economic effects

[RR-1725] from English Heritage identifies concerns in respect of the ease that people would be able to continue to visit the Stonehenge Visitor Centre, both during the construction phases and after the scheme is finished. Ease of access and signage to the Stonehenge Visitor Centre is key to this. English Heritage do not consider the dDCO and application papers give any detail on what road signage would be installed to ensure it is clear and intuitive for drivers wanting to visit Stonehenge. In addition, there is a lack of detail on the temporary infrastructure for the construction period therefore English Heritage is unable to assess its impact on the WHS and our visitor operation.

In light of the fact that this is the major tourist attraction in the area and a significant part of the tourism economy please provide information to address this concern.

Response

9. A detailed signage strategy would be developed during the detailed design stage. It would include clear signing from the A303 directing traffic to use the Longbarrow junction for access to the Stonehenge Visitor Centre. This would be developed in consultation with the relevant bodies, which includes the English Heritage Trust.

10. A traffic management plan is required to be approved and implemented pursuant to Requirement 9 of Schedule 2 of the draft Development Consent Order (DCO) [APP-020]. As required by the Outline Environmental Management Plan (OEMP) [APP-187], which is secured through Requirement 4 of Schedule 2 of the draft DCO [APP-020], the main works contractor would prepare and implement the detailed Traffic Management Plan (TMP), which would include details of temporary traffic management layouts, signage, and other apparatus as well as access arrangements, in consultation with relevant organisations, including the English Heritage Trust (OEMP Ref: MW-TRA2).

11. Confirmation that the English Heritage Trust would be consulted on the development of these elements of the Scheme will be included within a Statement of Common Ground between the parties, to be issued to the Examination at deadline 2.

Question SE.1.24

Socio-economic effects

In light of the Comment from Esso [RR-1726] relating to the pipeline and "*barring infrequent maintenance, the pipeline operates on a continual 24/7 basis and interruption to its operation would have a significant impact on fuel supply in the south west of England*".

i. Please advise of the latest position of the parties and if agreement has now been reached.

ii. In the event that matters are not resolved please advise of the effects of a potential impact on the pipeline.

Response

i. **Please advise of the latest position of the parties and if agreement has now been reached.**

1. Highways England is engaged in discussions with Esso regarding the permanent diversion of the Esso pipeline. Following consideration of the available options, an agreement in principle has been reached between Highways England and Esso in terms of the permanent diversion of the pipeline.

Negotiations continue between Highways England and Esso in respect of agreeing the Protective Provisions for the protection of Esso.

ii. **In the event that matters are not resolved please advise of the effects of a potential impact on the pipeline.**

2. The operation of the pipeline is under the control of Esso and any interruption to its operation would be managed solely by Esso.

3. There is only a limited number of outstanding items between Highways England and Esso in relation to the Protective Provisions and it is Highways England's view that the parties will reach an agreement on those Protective Provisions.

4. In the unlikely event that an agreement is not reached between the parties, Highways England will make supported submissions to the Examining Authority as to what it believes to be appropriate Protective Provisions in this context together with the necessary justification (and we would expect that Esso would do the same). This would allow the Examining Authority to test those submissions and report to the Secretary of State to determine the necessary protection for Esso, thereby ensuring appropriate safeguards are in place.

Question SE.1.25

Socio-economic effects

Reference in Paragraphs 5.1.22/23 refer to a peer reviewed assessment Has this been provided as part of the evidence to the ExA? If so can you clarify where.

In light of the importance of the rationale behind the figure associated with the monetised benefit associated with the removal of the A303 from the WHS and the considerable degree of concern that has been identified by RRs in this respect. It is essential for the Ex A to understand the veracity of this figure.

Response

1. Dealing first with the second part of the question referring to the importance of the monetised benefit, in discussions around the contingent valuation report (CVR) it is important to note that the work around it was primarily relevant to the Department for Transport's (DfT) investment decision in the Scheme, not the planning merits of the Scheme.

2. The CVR does not assess benefits to the economy of the Scheme. Instead it interprets benefits in order to express them in an economic framework. Contingent valuation is a tool / mechanism to compare factors that are not able to be easily balanced (i.e. social welfare related benefits), because they are not measured in a common unit.

3. The purpose of the CVR in the context of the A303 was to monetise the significant benefits resulting from the cultural heritage improvements delivered by the Scheme. Monetising those benefits allowed them to be incorporated alongside other financial costs and benefits in the assessment of the benefit cost ratio (BCR) for the Scheme, in order to determine whether the scheme offered value for money (VfM) and ultimately inform the Government decision to invest in the Scheme.

4. In the context of the planning / DCO decision, the BCR and VfM are not planning considerations. However, the information underlying the assessment of BCR of the Scheme, as noted in paragraphs 4.3 and 4.5 of the National Networks NPS, is. In this case, that would be the heritage chapter of the ES and the Heritage Impact Assessment, rather than the financial results of the CVR. BCR and VfM considerations require all factors being balanced to be converted to the same unit of measurement (i.e. monetary units) in order to be compared. A planning decision as to whether to grant the DCO balances those same factors, however, those factors are measured in their own units, which are different for each factor. In other words, no conversion / monetisation is first required in order to undertake the planning balancing exercise; it is a qualitative exercise.

5. It follows that the valuation of heritage benefits in monetary units is not primarily relevant to the decision on whether to grant development consent of the Scheme, because those cultural heritage benefits do not need to be monetised in order to be taken into account in the planning balance. The valuation in the CVR was relevant only to DfT's investment decision, which is not a planning consideration.

6. Moving on to the second part of the question, the peer review documentation referred to in paragraph 5.1.23 of the Combined Modelling and Appraisal Report [APP-298] has not been provided to the Examination, the Applicant's reasoning being that this would unnecessarily burden the ExA with a significant level of detail that would not be helpful to it. This is due to the multiple layers of peer review (referred to in paragraph 5.1.23) and the fact that the peer reviews were carried out on previous, now superseded versions of the contingent valuation report. The comments would therefore be very difficult to follow against the terms of the final report, would largely be out of date and would raise significant risk of confusion on the part of interested parties and the taking up of time on discussion of points that were not relevant to the final report.

7. The purpose of the peer review was to identify potential areas for improvements and change at two stages - in advance of data collection and prior to publication of the final report – and to edit and improve the relevant materials accordingly. The authors followed due process in responding to the peer reviewer's comments in full, and made all necessary adjustments to the survey and report at each stage. In both instances the peer reviewers approved the changes and gave their approval to the final version of the survey/report.

8. The final report therefore incorporates the comments of the peer reviewers, which informs the Applicant's reasoning at the point of application that it would be of greatest assistance to the ExA and Interested Parties to focus primarily on its terms. The Applicant will of course make itself and the authors of the report available to answer any of the ExA's questions on the report and the veracity of the figures in it, including at hearings if it would be helpful to the ExA.

Question SE.1.26

Socio-economic effects

In Paragraph 5.1.14 of Document 7.5 Combined Modelling [APP-298] you specify a transport user benefit of £370 million at 2010 prices.

In Table 6.1 of the same document you set out a calculation of the cost benefit which has a Transport Economic Efficiency benefit of £252 million, the Executive Summary refers to two different values £262 million and £257 million

Explain the distinction in the terms and the difference in the figures.

Response

1. The differences in the figures noted is due to the presentation of different components of the scheme benefits.
2. The Combined Modelling and Appraisal (ComMA) report [APP-298] provides a summary of the economic impacts of the scheme. This summarises the different components of the cost-benefit analysis. Further detail is provided in ComMA Appendix D – the Economic Appraisal Package [APP-302]. It should be noted values are rounded to the nearest million pounds.
3. Table SE.1.26-1 summarises the key components of the scheme benefits as presented in the ComMA noting those that comprise the values referred to in the question. The table also indicates where these components fall in the Department for Transport's (DfT) standard reporting of scheme appraisal benefits, being the Transport Economic Efficiency (TEE) table, the Public Accounts (PA) table, or the Analysis of Monetised Costs and Benefits (AMCB) table. Further detail is provided in the subsequent paragraphs.

Table SE.1.26-1: Summary of scheme benefit components by quoted values

DfT table	Benefit component	Paragraph 5.1.14 (£370m)	Table 6-1 (£252m)	Executive Summary (£257m)	Executive Summary (£262m)
TEE table	Travel times	✓	✓	✓	✓
	VOC	✓	✓	✓	✓
	Construction impacts	✗	✓	✓	✓
PA table	Indirect Tax	✓	✗	✓	✓
	Corporation Tax	✗	✗	✗	✓

AMCB table	Accidents	✕	✕	✓	✓
	Air Quality	✕	✕	✓	✓
	Noise	✕	✕	✓	✓
	Greenhouse Gases	✕	✕	✓	✓

4. Paragraph 5.1.14 of the ComMA notes a transport user benefit of £370 million in 2010 prices and values. This is the total of the user benefits of the scheme assessed using the Department for Transport's (DfT) standard Transport User Benefits Appraisal (TUBA) software. These benefits comprise travel time, Vehicle Operating Cost (VOC) and indirect tax benefits arising from the scheme. As this value is an output from TUBA of the 'Core' scenario forecasts neither the impacts of construction (calculated via separate TUBA runs of the construction transport models) nor impacts monetised through other appraisal methods (e.g. accidents, air quality, noise, greenhouse gas emissions that would be present in the AMCB table) are included in this value.

5. Table 6-1 of the ComMA summarises the scheme costs and benefits. The Transport Economic Efficiency (TEE) benefits of £252 million noted here comprises travel time and VOC benefits arising from the scheme and additionally includes the impacts of construction. Construction impacts are detailed in Table 6-16 of ComMA Appendix D and total £31 million. Indirect tax revenue impacts (which form part of the £370 million value given in paragraph 5.1.14) are not included in the £252 million presented as the TEE benefit in Table 6-1 of the ComMA and are instead presented as a separate item alongside other components that would form the AMCB table.

6. The £257 million presented in the Executive Summary is the total of all components forming the initial Present Value of Benefits (PVB). This can be calculated from the itemised values in the 'Publically Funded' column of Table 6-1, being the TEE benefits, indirect tax revenues, accident benefits and monetised air quality, noise and greenhouse gas emissions.

7. The £262 million presented in the Executive Summary is the total of all components forming the initial PVB were the scheme to be taken forward via a privately financed route. This can be calculated from the itemised values in the 'Privately Financed' column of Table 6-1, the difference from the 'Publically Funded' value being the addition of Corporation Tax revenues of around £6 million. The rationale for the additional Corporation Tax revenue element is set out in section 4.3 and Appendix J of ComMA Appendix D [APP-302]. Following

an announcement by the Government in the 2018 Budget3, the Private Finance 2 (PF2) method to fund future projects was withdrawn. Therefore the statement of benefits and costs outlined in the ComMA assuming private funding is no longer relevant. An update on the funding statement and PF2 is provided in more detail in response to questions CA.1.15 and CA.1.16.

[3] Budget 2018: Private Finance Initiative (PFI) and Private Finance 2 (PF2). Her Majesty's Treasury. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/752173/PF2_web_.pdf [Last accessed: 17/04/2019]

Question SE.1.27

Socio-economic effects

i. In light of a number of concerns expressed both by the National Farmers' Union, land agents and farm businesses what assessment has been carried out of the implications of the effects on the farm businesses that would be affected through the construction of the project:

   (a) During Construction?

   (b) Post construction?

ii. In light of the Government Policy to facilitate growth and create jobs, how have the specific impacts on these businesses been addressed in the overall impacts of the scheme?

Response

1. Environmental Statement Chapter 13 - People and Communities [APP-051] sets out the physical impacts and effects of the proposed Scheme on individual farm holdings in terms of area of land required (as a percentage of the overall holding), severance (and accessibility to severed land), impacts on infrastructure and other disruptive effects. The Environmental Statement has not examined economic effects as these lie outside the environmental assessment and are dealt with under the provisions of land negotiation and ultimately statutory compensation.

2. Whilst there is wide Government support (policy) to facilitate and create jobs, it is axiomatic that if the construction of the proposed road requires agricultural land (as it does) that this will have an adverse impact on the agricultural economy.

3. As part of the engagement process, landowners and tenants have been interviewed to gauge the scale of the farming activity, including details of staff employment. For the most part, the holdings affected are large and the scale of impact post construction will be modest – mainly less than 10% land lost, and most less than 5%. During construction the requirement for land will inevitably be higher but profit foregone will be eligible for compensation such that the construction process itself, would not require the closure of employment posts. Some posts may, in fact, be created during the construction process for activities such as dust suppression and ground clearance for local agricultural contractors/operators.

4. There is though the possibility that rural employment opportunities will be lost as a result of the scheme at Scotland Lodge Farm (through a diminution in horse riding activities – one job) and possibly one employment opportunity at Manor Farm, Stapleford, due to the proportion of land required. But these limited employment losses have to be weighed in the overall balance of a scheme that would:

- create a high-quality reliable route between the South East and the South West that meets the future needs of traffic;
- enable growth in jobs and housing by providing a free flowing and reliable Connection between the South East and the South West.
- help conserve and enhance the World Heritage Site and to make it easier to reach and explore; and
- improve biodiversity and provide a positive legacy for nearby communities. (Introduction to the Application [APP-001, 2.1.2]).

5. The Case for the Scheme [APP-294] suggests that economic growth (employment) in the South West is constrained by inefficient transport infrastructure that this Scheme seeks, in part, to address: The Government is concerned that the UK economy is not functioning efficiently due to ‘market distortions’ or ‘failures’. The economy of the South West performs poorly compared to other regions of the UK, with a lower than average economic performance. This is largely due to its location but is made worse by the congestion, delays and unreliable journey times caused by inefficient transport infrastructure. [APP-294, para 2.3.1].
6. Following the construction of the Scheme, agricultural land taken temporarily would be restored to agricultural land. All land restored to agriculture following construction would be restored to the pre-construction condition, as set out in ES Chapter 13, People and Communities [APP-051], Section 13.4, and would be subject to monitoring, as set out in the OEMP [APP-187], item MW-COM5. The OEMP is secured through paragraph 4 of Schedule 2 of the draft Development Consent Order [APP-020]. The proposed extent of ‘land to be returned to agricultural use’ post-construction is shown indicatively on the Environmental Masterplan, ES Figure 2.5 [APP-059].

Question SE.1.28

Socio-economic effects

A number of parties suggest that (eg [RR-1732]) the economic case is extremely weak and very strongly depends on a manufactured heritage “benefit” expressed in monetary terms.

In light of the importance that you put on the delivery of the removal of the current A303 from the WHS and the benefits you consider this brings to the overall OUV of the WHS:

i. Where in the dDCO is the removal/adaption/improvement of the A303 set out?

ii. When would it be delivered?

iii. What is the trigger for its delivery?

Response

1. ***Where in the dDCO is the removal/adaption/improvement of the A303 set out?***

i. The removal and improvement of the existing A303 is set out in three areas of the DCO.

2. Firstly, it forms part of the definition of the "authorised development" defined in article 2(1) by reference to the description in Schedule 1 to the DCO, see in particular Work Nos. 1A(a)(i), 1H, 3, 4, 6, and the Ancillary Works (a) and (b)(iii).
3. Secondly, the stopping up of parts of the existing A303 to be replaced by the new and improved A303 is described in detail in Part 1 of Schedule 3 to the draft DCO and shown on the Rights of Way and Access Plans [APP-009], and given effect by article 10.
4. Thirdly, requirement 4 requires the authorised development to be carried out in accordance with the Outline Environmental Management Plan (OEMP) [APP-197]. Measure D-CH2 in the OEPM requires the breaking out of the road surface of the redundant A303 within the WHS, except to the extent it is required to create a new public right of way and/or private means of access.
5. ***When would it be delivered?***
6. The timing for the removal of the existing A303 within the WHS will depend on the construction methodology adopted for the Scheme. It is anticipated that the existing A303 would remain in use until such time as the new and improved A303 is ready to be opened for traffic. Once traffic is no longer using the existing A303 works to remove the redundant surface and replace it with a restricted byway would commence.

7. ***What is the trigger for its delivery?***

8. Delivery of the removal of the redundant sections of the A303 is secured through requirement 4 (OEMP measure D-CH2) and article 10. In practice, Highways England could not permanently stop up the existing private means of access to the existing A303 under article 10, until such time as

9. the replacement private means of access is in place. In respect of the private means of access within the WHS, these are co-incident with the new restricted byway. Taken together, Highways England could not permanently stop-up the existing A303 and related private means of access until such time as the new and improved A303 and the new restricted byway, are open to the public.

Question SE.1.29

Socio-economic effects

It has been suggested that official economic estimates give over optimistic assessments of the value and benefit of transport projects.

Have reviews been undertaken post construction of other schemes to validate the estimates of improved economic performance which assist in validating such forecasts/estimates?

Response

1. Highways England produces Post Opening Project Evaluation (POPE) reports '1 year after' and '5 years after' following the opening of a road scheme. POPE studies have been undertaken for all of Highways England's major schemes since 2002, and form the mechanism whereby Highways England has:
   - Assessed whether schemes have delivered the anticipated value for money;
   - Validated the accuracy of the estimated scheme costs, impacts and benefits which were agreed as part of the business case for investment, and used to improve future scheme appraisals; and,
   - Promoted transparency and accountability to our stakeholders.
2. An independent 'meta report' is published at two- year intervals, taking an overview of all the evaluations to date.
3. The latest Meta Report (dated January 2019) states that ‘Looking across the programme, 90% of all scheme objectives have been achieved, with only 2% of these not observed to have been achieved’. The report comments that traffic forecasts were ‘more frequently over-predicted than under-predicted.’and explains that this is associated with the economic downturn. As explained in NPSNN paragraphs 4.6-4.7, the Department for Transport maintains WebTAG, which includes updates to national economic parameters.
4. In addition to benefiting from insights and improvements to WebTAG managed by the DfT, the A303 Amesbury to Berwick Down scheme specifically drew upon post opening data from the A3 Hindhead Tunnel scheme which was used as part of the development of a speed/flow relationship for the proposed Stonehenge tunnel. This relationship helped to inform the journey time forecasts for the scheme and hence improve the estimation of the economic benefits of the scheme.

Question SE.1.30

Socio-economic effects

There is an indication that the project would create in the region of 300 construction jobs.

i. Where is it anticipated that the workers would be accommodated during the predicted five-year life of the project?

ii. What proportion of construction jobs do you seek to accommodate from the local area? How would this be achieved?

Response

1. ***Where is it anticipated that the workers would be accommodated during the predicted five-year life of the project?***

i. The construction phase of the Scheme will generate employment opportunities at the three construction compounds. Contractors will be invited to submit proposals for how they will deliver the outcome of promoting employment opportunities for local people, with these being evaluated as part of the tender review process. Workers sourced from the local community would not typically require new or different accommodation.

ii. Other workers will be drawn from outside the local community and will require living accommodation within the local area so that they are located in close proximity to the compounds. Visitor accommodation comprising hotels, inns, bed and breakfast accommodation, self-catering accommodation and caravan parks are anticipated to be the main types of accommodation suitable for workers. A range of factors will influence the extent to which construction workers will use the accommodation within the local area, such as: proximity to the site, availability, quality and price of accommodation and the range of leisure and amenity services in the immediate area. The level of demand for accommodation from workers will vary during the construction period based on the intensity of activity, with approximately 300 construction workers representing the expected total peak workforce requirement.

2. ***What proportion of construction jobs do you seek to accommodate from the local area? How would this be achieved?***

iii. The Applicant intends to promote access to work and training opportunities for local people, through an outcome-based requirement in the contract for detailed design and construction. At this stage, there is no requirement set for the proportion of jobs sourced from the local area although this requirement is currently being developed as part of the preparation of the tender documents. Information regarding these outcomes will be included in the tender documents and contractors will be invited to make proposals for how they will deliver the outcomes, with these being evaluated as part of the tender review process. The proposed initiatives of the successful tenderer will be subsequently incorporated into the scope as a contractual delivery requirement with this being set out in the contract specification. Discussions will be taking place with Wiltshire Council to develop the specific employment requirement for local people and how this is best delivered.

iv. By requiring potential contractors to propose, alongside other outcomes related to employment, what proportion of the workforce would be drawn from the local area, and evaluating these as part of the tender review, the experience of the contractors in this regard will be utilised effectively in order to secure a successful outcome from the Scheme in employing people from the local community.

Question SE.1.31

Socio-economic effects

[RR-0389] expresses concern about the reliance on the Halcrow Study to show the benefits of the proposal. The RR suggests that this lacked substantive evidence and that Highways England did not properly justify the scheme relative to alternatives which were available.

How would you respond to these concerns?

Response

1. The ‘A303/A30/A358 Corridor Feasibility Study’ produced by CH2M Hill (formerly Halcrow) in February 2015 contained a review of existing evidence to identify key transport issues and challenges on the corridor. This report was produced as part of Highways England’s Project Control Framework (PCF) Stage 0 ‘Strategy, shaping and prioritisation’. PCF Stage 0 is the stage at which potential transport issues are identified and prioritised. The CH2M Hill report was focused on the need for improvement to the corridor and did not therefore consider options or alternatives for the A303 Amesbury to Berwick Down scheme as that was outside the scope of the study.
2. Consideration of route and modal alternatives was undertaken in detail at PCF Stage 1. This was reported as part of the Scheme Assessment Report (SAR) [REP1-023] and Technical Appraisal Report (TAR) [REP1-031].
3. Sections 8.5.3 to 8.5.7 of the Transport Assessment [APP-297] provide a summary of the assessment of alternative modes undertaken at PCF Stage 2. This work determined that alternative mode interventions would not be able to adequately resolve the identified problems.
4. The Environmental Statement (ES) Chapter 3 – Assessment of Alternatives [APP-041] discusses the process and rationale for selection of the A303 Amesbury to Berwick Down preferred route alignment.
5. The Applicant therefore considers that the concerns raised by [RR-0389] are unfounded and disagrees with the suggestion that there is a lack of substantive evidence. The Applicant has properly justified the scheme relative to available alternatives and this is documented in the SAR, TAR and Chapter 3 of the ES.

Question SE.1.32

Socio-economic effects

How has the project assessed the potential of a knock-on effect on the Avebury Heritage Site to the north both in terms of the consequences of heritage impacts but also the socio-economic impacts which could occur?

Response

1. A number of relevant representation responses expressed concern about the potential for impacts on the Avebury half of the World Heritage Site (WHS) [RR-0861, RR-1567, RR-2268, RR-2329, RR-1896]. In response, Highways England noted that "Given the distance of the works from the Avebury element of the WHS (40km), the Scheme will have no direct physical impacts on it. In terms of indirect impacts, it is pertinent to note that the main or predominant characteristics of visitors to Stonehenge and Avebury are distinct; those visiting Stonehenge are often either from the international market, visiting iconic tourist attractions, or part of an organised tour or event; those visiting Avebury are often more dedicated, in-country visitors interested in the prehistoric period and its monuments. As the existing A303 will remain open throughout construction, and because of the predominantly different nature of visitor each site attracts, it is not anticipated that visitors and tour operators will change their tour schedule to visit Avebury rather than Stonehenge during construction, or following Scheme opening and in the operational phase. It is therefore expected that the construction or operation of the Scheme will not have an indirect impact on Avebury."

2. As well as access being maintained on the A303 throughout construction, as noted above, there is no planned closure of access to either site as a result of the Scheme. Socio-economic impacts will therefore be minimal on Avebury from the construction of the Scheme.

Question SE.1.33

Socio-economic effects

A number of land owners and their representatives have expressed concern in respect of the economic impacts upon their individual holdings.

What degree of sensitivity testing has been undertaken to establish the accuracy of the level of effect that is currently suggested in Chapter 13 of the ES?

Response

1. Chapter 13 People and Communities of the Environmental Statement (ES) [APP-051] does not, and is not intended to, report the economic impacts of the Scheme on individual holdings even though the criteria used might be assumed to have an implied economic assessment.

2. The environmental impact assessment methodology follows the long-established guidance and practice set out in Volume 11 of the Design Manual for Roads and Bridges (DMRB), and reports the physical impacts of the Scheme on individual farm holdings (e.g. land required, severance, impacts on farm buildings and other farm infrastructure, disruptive effects) and assesses the significance of effects based on a combination of the degree of physical impact and the sensitivity of the farm holding. The methodology for assessment (and significance criteria used) is set out in section 13.3 of ES Chapter 13 [APP-051].

3. Specifically, the assessment of the temporary and permanent effects on farm holdings does not include the economic impacts of the Scheme in terms of compensation, which is a matter that lies outside of the ES. As such, there has been no sensitivity testing of the economic impact of the Scheme on this basis within ES Chapter 13 [APP-051].

4. In terms of the sensitivity testing of the temporary and permanent effects, there are very few reported impacts that are open to variability. The area of land required or the degree of severance on an individual farm, for example, are factual records of the Scheme and will not vary other than by a re-design of the Scheme. Any sensitivity testing would lie in first establishing the assessment criteria, and whether for example, a major magnitude of impact should be the loss of more than 20% of a farm, as adopted, or some other proportion. These criteria for agricultural holdings are set out clearly within sections 13.3.12 and 13.3.13 of ES Chapter 13 [APP-051], and have been applied consistently across all farm holdings to report the assessment of effect on each holding.

Question SE.1.35

Socio-economic effects

In light of the importance of Stonehenge and the WHS to the local economy:

i. What mitigation is proposed to be put in place to minimise impacts to the attractiveness of the site as a tourist attraction during a potential five-year construction programme?

ii. How would the construction programme be monitored to ensure the mitigation was achieving the desired effects?

iii. How would this be achieved through the DCO?

Response

i. **What mitigation is proposed to be put in place to minimise impacts to the attractiveness of the site as a tourist attraction during a potential five-year construction programme?**

1. Environmental Statement Appendix 2.2 - Outline Environmental Management Plan (OEMP) [APP-187] contains the mitigation measures that would form part of the main works contractor's construction environmental management plans. This includes measures to reduce the visual impact associated with construction works, such as compound and lighting measures (items MW-G28 and MW-G29 of the OEMP [APP-187]); fencing within the World Heritage Site (WHS) to be agreed in consultation with Heritage Monitoring and Advisory Group (HMAG) (item MW-CH3 of the OEMP [APP-187]); the retention of trees / hedgerows and the early planting of the landscaping scheme, where possible, to assist in landscape integration and screening (items MW-LAN3 and MW-LAN4 of the OEMP [APP-187]); community engagement specifically with the Visitor Centre and notifications to local businesses and residents about upcoming works (item MW-G31); and traffic management (requirement 9 of the DCO and item MW-TRA2 of the OEMP).

2. The use of a bored tunnel will also remove construction of the dual carriageway from the central part of the WHS past Stonehenge, the only visible construction works in this section being the downgrading of the existing A303 to a Non-Motorised User (NMU) route and chalk grassland. Temporary fencing requirements for these short-duration downgrading works along the existing A303 will be confirmed in consultation with HMAG. These measures will help to minimise impacts to the attractiveness of the site as a tourist attraction during the construction programme.

ii. **How would the construction programme be monitored to ensure the mitigation was achieving the desired effects?**

3. Adherence to the provisions and measures outlined within the OEMP [APP-187], and ultimately the Construction Environmental Management Plan (CEMP) for the construction phase, would be ensured through Requirement 4 in the Development Consent Order [APP-20] and contractual agreement between

Highways England and the appointed contractor. The Main Works Contractor's Environmental Manager, and ultimately Project Manager, are responsible for ensuring that controls and measures specified within the CEMP are implemented (refer to Table 2.1 within the OEMP [APP-187] for Roles and Responsibilities). The OEMP [APP-187] sets out a number of commitments that the Main Works Contractor would have to implement during construction including construction air quality monitoring [MW-AIR4]; the installation of vibration and ground surface movement monitors to monitor ground surface movement and vibration in relation to heritage assets above the tunnel [MW-CH1]; the monitoring of heritage assets (designated and non-designated) during construction to ensure compliance with the DAMS, the OEMP and the Main Works Contractor’s CEMP and Heritage Management Plan (HMP) [MW-CH7]; noise and vibration monitoring [MW-NOI2, MW-NOI3, MW-NOI6) including the monitoring of vibration sensitive cultural heritage assets [MW-NOI5]; and the monitoring of traffic management measures, traffic flows and public services [MW-TRA11]. These measures would help to ensure the mitigation was achieving the desired effects or implement further measures where necessary.

iii. **How would this be achieved through the DCO?**

4. The OEMP [APP-187] and the measures within it are secured through Paragraph 4 of Schedule 2 of the Draft Development Consent Order [APP-020].

Question SE.1.36

Socio-economic effects

Should the attractiveness of the WHS be adversely affected during the construction programme:

i. **What are the implications for local businesses during this period?**

ii. **How will any adverse economic effect be minimised?**

Response

1. It is not expected that the attractiveness of the WHS will be adversely affected during the construction programme, given the A303 will remain open throughout construction and none of the assessments within the Environmental Statement (ES) [APP-038 – APP-292] have concluded any significant adverse effects on the attractiveness of the WHS. On that basis, it is not considered that there will be any implications for local businesses related to this matter.

2. Although the ES has concluded the attractiveness of the WHS will not be adversely affected during the construction programme, measures will be put in place to minimise any potential impacts on local businesses. During construction, a dedicated Community Relations Manager (Outline Environmental Management Plan (OEMP) [APP-187] Table 2.1) will be employed as part of a range of community engagement measures set out in the OEMP [APP-187 item MW-G31]. Compliance with the OEMP is secured under paragraph 4 of Schedule 2 within the draft DCO [APP-020].

3. These measures include the provision of update information online and through newsletters, and specifically for local businesses, the provision of notices at least two weeks before the commencement of works setting out the nature and anticipated duration of planned construction works that may affect them. Information included in the notifications will include, as appropriate:

1. The location of the planned works;
2. The activities to be carried out;
3. The duration of the planned works and the periods within which works will be undertaken (i.e. whether during normal working hours, during the evening or overnight);
4. The anticipated effects of the planned works; and
5. The measures to be implemented in line with the CEMP to manage and minimise the impact of the planned works.

4. Maintaining ease of access to the Stonehenge Visitor Centre is a key factor for attracting visitors to the area and the consequential economic impact of their custom. To this end, the OEMP requires specific liaison with the Visitor Centre by the main works contractor, and the posting of information about construction at the centre. Furthermore, pursuant to Requirement 9 of the draft DCO [APP-020], the main works contractor, in consultation with relevant organisations, will

prepare and implement a detailed traffic management plan, which will include specification of temporary construction signage and access arrangements (OEMP [APP-187] Ref.: MW-TRA2).

Question SE.1.37

Socio-economic effects

If the scheme is completed, it is argued that the WHS will become more attractive, reuniting the historic landscape currently divided by the A303.

i. Have any plans been prepared to cater for this?

ii. How would this be managed to continue to safeguard the future of the WHS?

Response

1. It is not expected that the attractiveness of the WHS will be adversely affected during the construction programme, given the A303 will remain open throughout construction and none of the assessments within the Environmental Statement (ES) [APP-038 – APP-292] have concluded any significant adverse effects on the attractiveness of the WHS. On that basis, it is not considered that there will be any implications for local businesses related to this matter.
2. Although the ES has concluded the attractiveness of the WHS will not be adversely affected during the construction programme, measures will be put in place to minimise any potential impacts on local businesses. During construction, a dedicated Community Relations Manager (Outline Environmental Management Plan (OEMP) [APP-187] Table 2.1) will be employed as part of a range of community engagement measures set out in the OEMP [APP-187 item MW-G31]. Compliance with the OEMP is secured under paragraph 4 of Schedule 2 within the draft DCO [APP-020].
3. These measures include the provision of update information online and through newsletters, and specifically for local businesses, the provision of notices at least two weeks before the commencement of works setting out the nature and anticipated duration of planned construction works that may affect them. Information included in the notifications will include, as appropriate:

   i. The location of the planned works;
   ii. The activities to be carried out;
   iii. The duration of the planned works and the periods within which works will be undertaken (i.e. whether during normal working hours, during the evening or overnight);
   iv. The anticipated effects of the planned works; and
   v. The measures to be implemented in line with the CEMP to manage and minimise the impact of the planned works.

4. Maintaining ease of access to the Stonehenge Visitor Centre is a key factor for attracting visitors to the area and the consequential economic impact of their custom. To this end, the OEMP requires specific liaison with the Visitor Centre by the main works contractor, and the posting of information about construction at the centre. Furthermore, pursuant to Requirement 9 of the draft DCO [APP-020],

the main works contractor, in consultation with relevant organisations, will prepare and implement a detailed traffic management plan, which will include specification of temporary construction signage and access arrangements (OEMP [APP-187] Ref.: MW-TRA2).

Appendices Se.1

Appendices SE.1

Question SE.1.13

1. Socioeconomic analysis future forecasts and the SRN final (1)
2. CCS001_CCS0618917350-001_NIC-NIA_Accessible

Socio-economic analysis, future forecasts and the strategic road network

This report was commissioned by Highways England to inform the emerging Strategic Economic Growth Plan (SEGP) and better understand the relationship between economic growth and the strategic road network. This is a draft report and provides further information to complement the SEGP discussion paper. This report does not inform or relate to planning matters or investment decisions.

Queries relating to this report should be sent to growthandplanning@highwaysengland.co.uk

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This document has 74 pages including the cover.

Document history

Job number: 5146133			Document ref:			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	Final Report	NA/JG	JM	TD	RC	29/11/16

Client signoff

Client	Highways England
Project	Strategic Economic Growth Plan
Document title	Socio-economic analysis, future forecasts and the strategic road network
Job no.	5146133
Copy no.	
Document reference	

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Executive summary

This report presents socio-economic evidence to support the development of the Strategic Economic Growth Plan (SEGP) for Highways England. It describes the pattern of socio-economic and demographic activity across the country and explores the role of the SRN in supporting current economic activity and scenarios of future growth through mapping of sectoral and socio-economic data. It aims to inform understanding of the economic significance of the SRN. It provides a summary of where SRN investment may need to be focused to support economic growth. The analysis also provides evidence and a supporting narrative that explains how the performance of key sectors of the economy is particularly dependent on access to the SRN.

The SRN can support economic growth through four key mechanisms:

- Improving productivity, by improving efficiency, facilitating agglomeration economies and increasing competition;
- Increasing domestic and international trade;
- Facilitating investment by businesses and developers, as well as supporting inward investment;
- Supporting employment growth through better access to employment opportunities.

The SRN is a key determinant of where people choose to live and work and it plays an important part in the commercial and domestic life of residents of England with 95% of residents and 99% of vehicles using the SRN at least once a year, with the vast majority of the population living in close proximity to the SRN.

- 97% of the population live within 15km of an SRN corridor;
- 96% of the population is within one hour's drive from an SRN junction;
- 95% of the population is within one hour from a national or regional interchange rail station; and
- 94% of the population is within one hour from a large airport.

Historic population growth reflects the economic geography of England, which is underpinned by disparity. London and the South East are the most prosperous regions of England. In 2014, London's GVA per head was 68% higher than the average for England. GVA per worker on the whole is higher in the South of England than the North. However, England's core cities are increasingly growing and generating employment and productivity growth. The SRN has an important role in lifting productivity in areas of low productivity and strengthening areas of higher productivity by reducing distances between firms and markets, increasing competition and supporting access to labour markets.

Current and future economic growth is concentrated in town and city centres, business parks, other urban centres, enterprise zones or near to key infrastructure (large industry, port, airport or university). Businesses are also mobile and increased globalisation has led to firms relocating, expanding and spreading their operations across countries and borders.

Economic forecasts indicate that future growth is expected to be highest in Greater London and along routes to the west, north and south, in the major city regions and in other hotspots such as Nottingham, Cambridge, Peterborough and York[1]. Greater London and the South East, Birmingham, Leeds, Liverpool, Manchester, South Gloucestershire and Milton Keynes are forecast to have the highest increases in terms of absolute change in the number of jobs created and in increased intensification of employment. This demonstrates that urbanisation and agglomeration of economic activity is a key driver of future employment growth and highlights the importance of the SRN in serving and connecting concentrations of economic activity across England.

The majority of England's population, employment and businesses are centred on urban agglomerations, with the highest density of population in and around the core cities. As jobs concentrate in city centres, population growth in commuter belts outside these centres will mean that the SRN is needed to connect employees from their homes to employment centres. However, a

[1] Econometric-based economic forecasts produced by Cambridge Econometrics. It should be noted that these forecasts represent only one set of scenarios of possible future economic change. These scenarios are influenced by past trends and do not take account of the impact of policy or other market interventions.

number of important employment areas are more remote: access to the SRN is also critical in connecting these areas to both employees and markets.

Economic growth forecasts provide evidence of economic activity spreading across a wider area around major urban agglomerations. This spread is most evident across the South East on key corridors radiating from London. The Oxford to Cambridge arc, Shropshire, Wiltshire and Gloucestershire are other notable examples of growth areas.

Analysis of growth forecasts demonstrates that the SRN is largely located in the right corridors to serve future growth across England. Future investment should focus on providing efficient connectivity between city regions and growth clusters of urban agglomerations. Growth in employment and GVA in more peripheral regions will be enhanced by focusing on the connectivity needs of different parts of local economies, to include interventions to reduce effective distance with urban agglomerations, improve access to international gateways and reduce journey times for people visiting as tourists.

SRN-dependent sectors

This report explores the role of the SRN in meeting the needs of different parts of the economy. It draws on evidence on supply chain linkages between different sectors of the economy and research into the locational decisions of different sectors. It highlights the fundamental role of the SRN in the operation and competitiveness of particular business sectors.

Cambridge Econometrics has determined the sectors of the economy that are the primary users of road transport services, based upon sectoral interdependencies set out in the UK Input-Output tables. The following are identified as SRN-dependent sectors:

- Land Transport
- Retail and wholesale trade
- Primary materials
- Manufacturing – users of transport services
- Manufacturing – reliant on other sectors which are users of transport services
- Construction

Economic forecasts for sectors dependent on the road network show that concentrations of growth are clustered around the SRN and international gateways. It demonstrates the importance of the network in providing high quality transport connectivity with centres of economic mass and ports and airports to the functioning of these sectors.

GVA forecasts for SRN-dependent sectors show a number of hotspots of growth where advanced manufacturing and high value business clusters are important. These include the West Midlands, Derby, Sunderland and Swindon; and port-related activity in Southampton, Portsmouth and Liverpool. The mapping shows linkages to wider activities in transport sectors such as Motorsport Valley. The maps also highlight the importance of the SRN to the logistics sector and key clusters for this sector in South and West Yorkshire, the M62 Corridor and Essex/Kent.

Growth in employment and GVA for SRN-dependent sectors is strongest around areas that have good access to markets and international gateways. Businesses operating in these sectors tend to concentrate on key nodes on the SRN where they have good access to markets across the country, which is particularly evident in the industrial and logistics markets. Key growth areas are around the M25, particularly east to Dartford and Medway, the Midlands and north and west of London. The London – Bristol – Birmingham triangle is a high productivity area and an important location of future growth in SRN-sensitive sectors.

The SRN is vital to the industrial and logistics markets. These industries have a high level of dependence on the SRN to transport goods and services to markets generating a high frequency of trips that are often long distance. A primary purpose of the SRN is therefore to support SRN-dependent sectors and to provide capacity for growth.

The SRN also plays an important role in the location decisions of major retail and leisure destinations and is important in providing access to these destinations.

The SRN is integral to location decisions and the functioning of key sectors that are dependent on the road network. It plays a critical role in serving and connecting urban agglomerations and international gateways. Analysis shows that the SRN is largely located in the right corridors to serve locations of high growth and to serve future growth in sectors that are dependent on the SRN. The challenge is to ensure enough capacity to support and facilitate growth.

Future growth forecasts provide support for spatial rebalancing of the economy. A number of areas across the Midlands and the North have strong growth dynamics with productivity predicted to grow at a higher rate than in the South. Future investment in the network targeted in the right locations could support productivity growth across regions with low productivity and help balance productivity growth across wider areas of the economy.

1. Introduction

1.1. Study Context

This report presents socio-economic evidence to support the development of the Strategic Economic Growth Plan (SEGP) for Highways England. It describes the pattern of socio-economic and demographic activity across England and takes into account forecasts of sectoral growth and spatial analyses. It explores the relationship between the Strategic Road Network (SRN) and current and future economic growth across England through mapping of sectoral and spatial socio-economic data and future forecasts.

It aims to develop a high level understanding of the economic significance of the SRN. It does not imply causality or provide analysis of how SRN schemes will deliver economic outcomes. It highlights current and future patterns of population and economic growth and provides evidence to support where SRN investment may need to be focused to support economic growth. The analysis also provides evidence to explain how key sectors of the economy are dependent on access to the SRN.

This document forms part of a suite of 6 evidence reports produced to support the production of the SEGP. These are:

- Economic growth and the SRN
- Commercial development and the SRN
- International gateways and the SRN
- Socio-economic analysis, future forecasts and the SRN
- Assessment of growth impacts
- Economic value of the SRN

1.2. Structure of this Report

The report is structured in the following sections:

- **Section 2** – Brief contextual information for the analysis, identifying the current economic development and policy background and the key challenges facing the Strategic Road Network.

- **Section 3** – Socio-economic analysis focusing on:

    - Population – Distribution of population across England and relationship with the SRN.
    - Deprivation – Distribution of deprivation across England and relationship with the SRN.
    - Enterprise and Employment – Distribution of employment, businesses and productivity across England and relationship with the SRN.
    - SRN-dependent sectors – Distribution of business sectors that rely most on the SRN and their performance in terms of employment, business density and productivity.

- **Section 4** – The future of England, exploring the economic future and how the economic geography of the UK could change on the basis of current trends and forecasts.

- **Section 5** – A summary of conclusions from the report.

The report does not aim to cover all socio-economic themes but provides a high level overview of the key issues. It provides an insight into the challenges, drawing linkages between socio-economic themes and the Strategic Road Network (SRN).

1.3. Caveats

There are a number of caveats that should be considered when reading this document. The data that is presented is through Standard Industrial Classifications and in some cases at high geographic levels of detail. The focus of the analysis is comparatively narrow, focusing largely on demographic and economic (employment and productivity) change. The report is also focused on maps generated through research undertaken to support the SEGP.

The forecasts presented in this report are outputs of Cambridge Econometrics local economic forecasting model. These forecasts represent only one illustration of scenarios of possible future economic change. These scenarios are strongly influenced by past trends and existing local structural factors. These do not take account of the potential impact of policy or other market interventions.

This document should be considered alongside the suite of evidence reports that accompany the SEGP and additional data tables produced by Cambridge Econometrics, Atkins, Volterra and Cushman & Wakefield.

2. Report Context

2.1. Study Context

Highways England's Delivery Plan 2016-2017[2] identifies a series of ambitions including the aim to:

"Support the country's economic growth and longer-term vision for our road network"

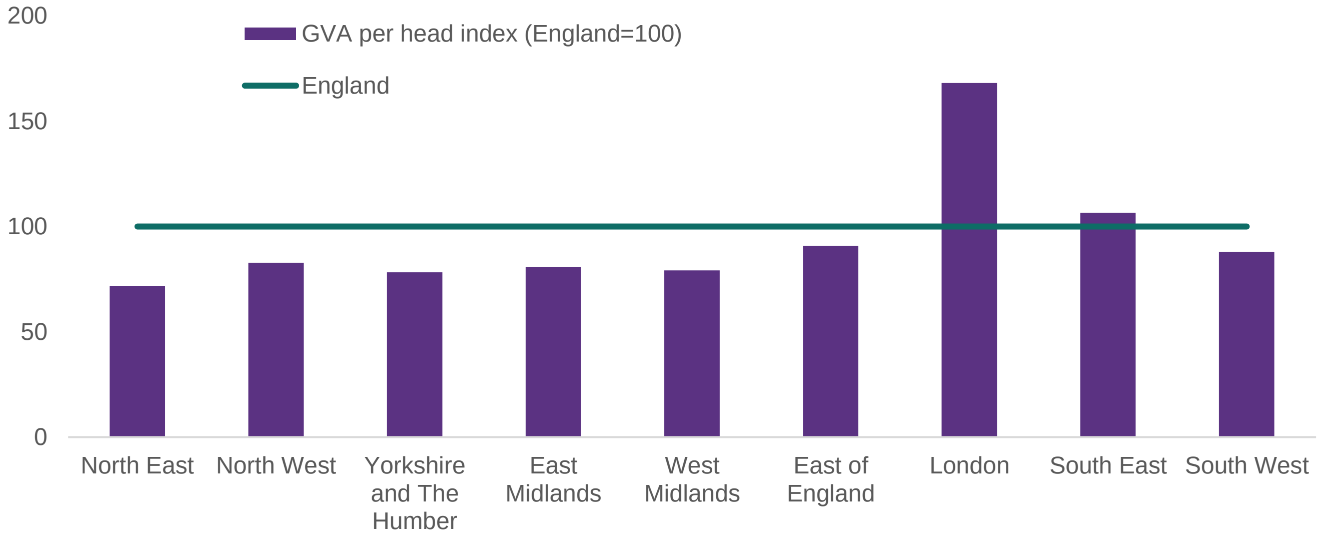
In doing so, it is clear that socio-economic issues highly important to the work of Highways England due to the interactions between the organisation's activities, assets and work outcomes, and social, economic, cultural and environmental factors in England.

The current political and economic landscape is fast moving and this document should be considered within that context. As such, there is potential for this work to be further enhanced by additional research and assessment of different themes (e.g. industrial strategy themes or opportunities from economic restructuring connected to the UK leaving the European Union).

2.1.1. Socio-Economic Context

The economic geography of England (and the UK) is underpinned by disparity. London and the South East are the most prosperous regions of England. In 2014, London's GVA per head was 68% higher than the average for England. The total output in London accounted for 22.9% of UK Gross Value Added (GVA) (£364 billion of the UK's £1,590 billion)[3]. London and the South East outperform other regions on several measures including employment, job creation, inward investment and economic output (Figure 2-1).

Figure 2-1 GVA per head index (England - 100)



Source: ONS (Atkins 2016)

The focus on this disparity has regained public policy interest in recent years as productivity growth has slowed at a national level. This has led to a renewed focus on economic growth and economic development at a sub-national level. These issues are mainly captured through the work of the Local Enterprise Partnerships (LEPs) and mechanisms for sub-national collaboration including the Northern Powerhouse, Midlands Engine and England's Economic Heartland.

2 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/538130/S160049_Highways_England_Delivery_Plan_2016_Final_-_Digital_version.pdf

3 ONS 2015

The Government and LEPs use a range of approaches to economic development to both raise the economic performance of less prosperous areas and support and enhance the performance of more prosperous areas. These approaches include:

- Taxation policy (e.g. reduction of taxes or business rates);
- Education and skills policy (e.g. promoting apprenticeships to support key industries);
- Labour market interventions (e.g. supporting long term unemployed into work);
- Trading liberalisation (e.g. reducing barriers for company establishment or entrepreneurs);
- Diversification (e.g. seeking to support niche and growing industries);
- Regeneration (e.g. revitalising the built environment of an area);
- Infrastructure investment (e.g. investing in broadband to support new and existing businesses);
- Spatial planning (e.g. planning new developments to concentrate activity); and
- Inward investment (e.g. attracting foreign direct investment for projects).

This is not a complete list but demonstrates that a wide range of factors are important to driving economic success. There is no single approach to economic development, but effective transport is cited by many commentators as integral to the success of local economies[4].

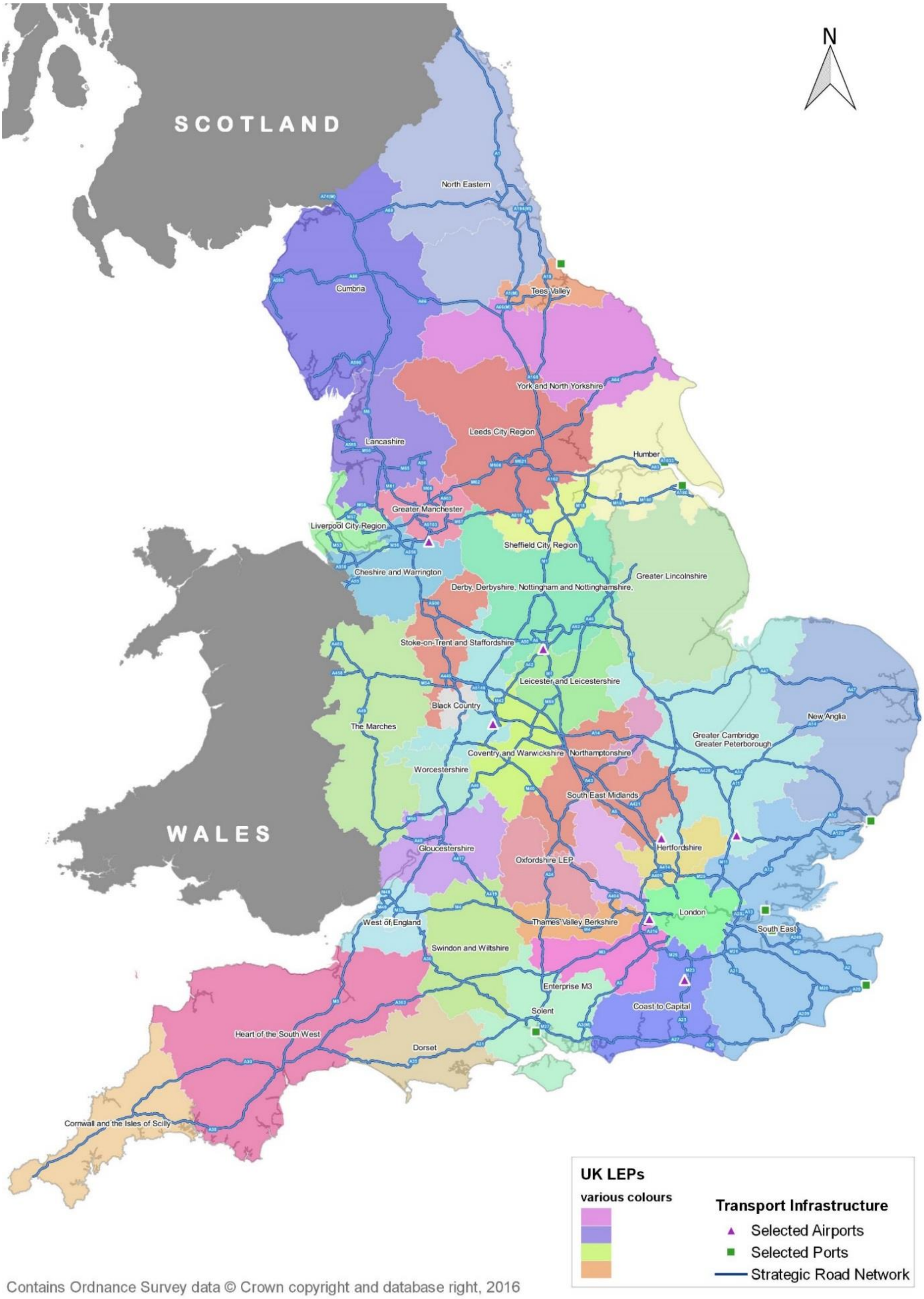
The 39 Local Enterprise Partnerships (LEPs) and the SRN in England are presented in Figure 2-2. This shows that all LEPs have at least one route of the SRN located within their boundaries. The relationships of the LEPs and their local economies are all different.

The map shows that some areas (e.g. Lincolnshire) appear to have fewer linkages to the SRN than others. However, it can be argued that this increases the importance of key SRN routes in enabling these areas to access the rest of the country. For example, in the case of Lincolnshire, the A46 is critical in enabling Lincoln to connect to other parts of the Midlands, the north and south via the A1, and the A47 outside Lincolnshire at Peterborough is critical in connecting the (non-SRN) A16 from the agri-food sector in southern Lincolnshire to the rest of the UK.

Other areas (e.g. South East Midlands) are served by multiple routes, but in many cases the routes in the SRN play different roles, with the A5 catering for sub-regional movements and the M1 carrying longer-distance traffic. The role of the SRN in supporting local economies is therefore unique to each area.

[4] E.g. Venables, A.J. et al, 2014. Transport investment and economic performance (TIEP): Implications for project appraisal. DfT Commission.

Figure 2-2 Local Enterprise Partnerships



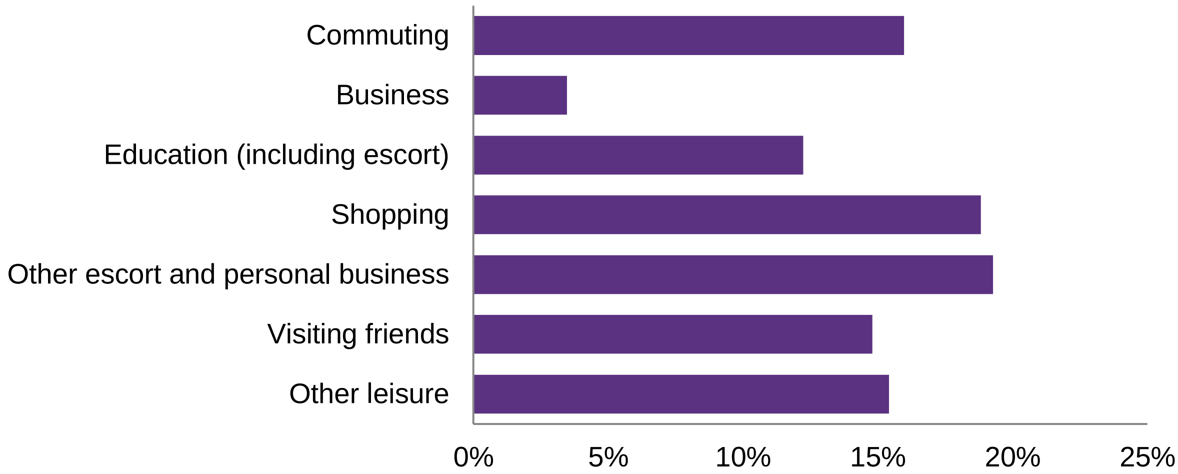
Source: Department for Business, Energy & Industrial Strategy, April 2012 **(**https://www.gov.uk/government/publications/local-enterprise-partnerships-local-authority-mapping)

2.2. The Strategic Road Network

Highways England manages the SRN (Figure 2-4) which comprises 4,400 miles of England's motorways and major trunk roads. These roads provide the capacity and connectivity to support national and local economic growth, linking communities and businesses.

The SRN is used for a range of travel purposes. The National Travel Survey provides data on the different purposes for people's journeys, as shown in Figure 2-3. This includes all journeys, including those made on local transport networks, but the SRN is also important in supporting a wide range of travel needs, demonstrating its importance to people and the economy.

Figure 2-3 Purpose share - average number of trips by all travel modes: England, 2014



Source: Department for Transport statistics - National Travel Survey 2014

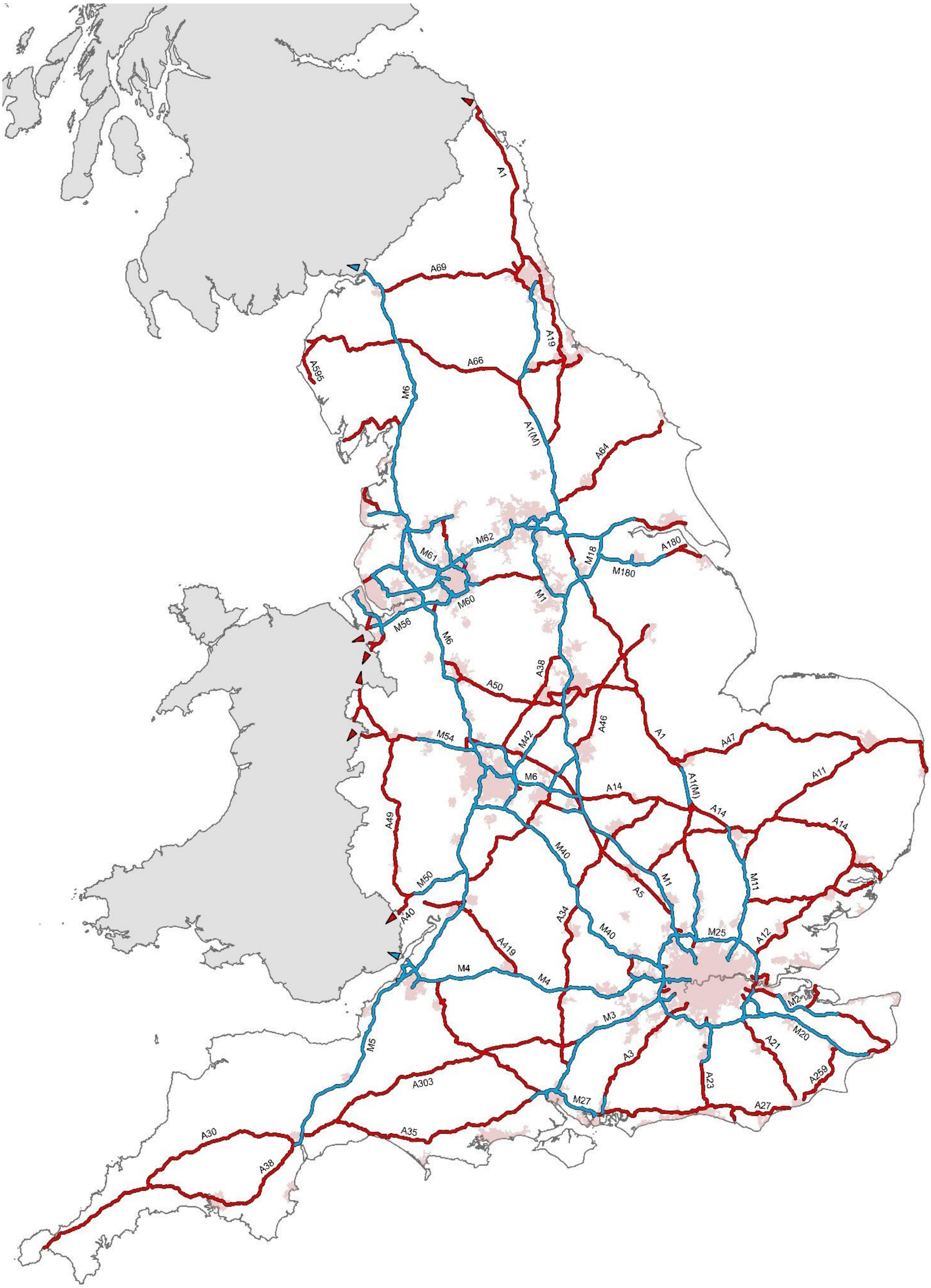
The SRN plays an important part in the commercial and domestic life of residents of England with 95% of residents and 99% of vehicles using the SRN at least once a year.

The SRN can support economic growth through four key mechanisms:

- Improving productivity, through improving efficiency, facilitating agglomeration economies and increasing competition;
- Increasing domestic and international trade;
- Facilitating investment by businesses and developers, as well as supporting inward investment; and
- Supporting employment growth through better access to employment opportunities.

Of these, improving productivity and increasing trade are likely to be of the greatest importance to national economic growth. The SRN is also important in supporting investment by domestic firms and attracting inward investment. This is key for supporting local and regional economic growth, although may be less relevant in increasing overall national output (due to potential displacement effects). The evidence suggests that the ability of SRN investment to reduce unemployment is less significant, although employment growth is possible through reducing costs of commuting and improving access to employment areas.

Figure 2-4 Strategic Road Network (SRN, 2014)



Source: © Crown Copyright and database rights 2014. Ordnance Survey Licence Number 100039241 Department for Transport gisu1112j178

2.2.1. Strategic Road Network Challenges

The SRN faces challenges linked to socio-economic factors, particularly population growth and economic growth. These factors (and other social trends) drive a series of pressures on the SRN which include congestion, delays and poor journey reliability.

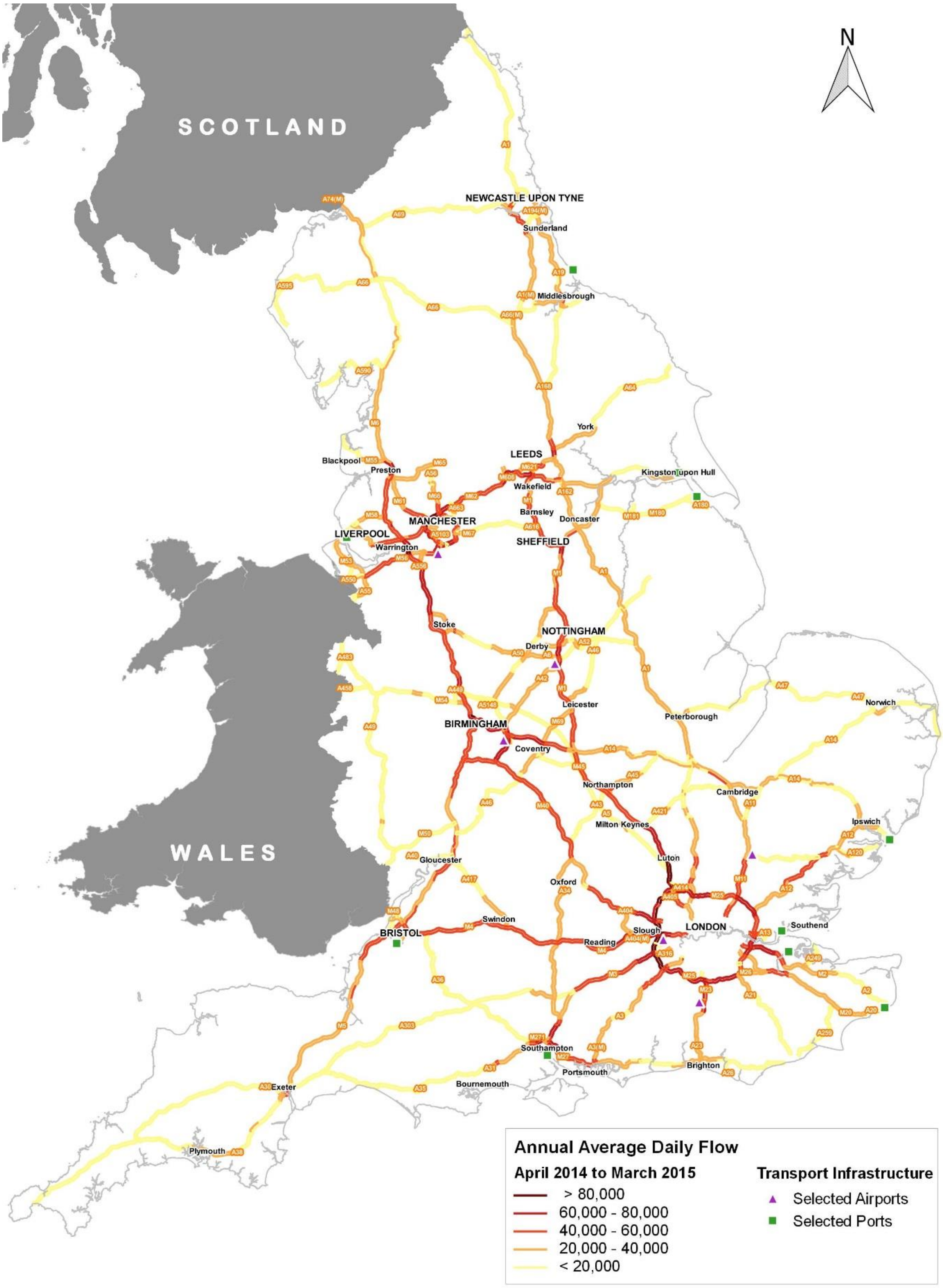
The maps on pages 14 to 17 highlight the key challenges for the SRN:

Table 2-1 Challenges for the SRN

Map[5]	Comment
Figure 2-5: Annual Average Daily Traffic Flows Volume of traffic on each link of the SRN (Page 14) (Source: Highways England)	This map shows the heaviest traffic volumes on the SRN, on which there are lower traffic speeds due to high levels of congestion. The busiest sections of the SRN are: - M25 Junctions 10-17 (west of London, Heathrow Airport) - M1 Junctions 6-9 (Watford to Luton) - M6 Junctions 20-21 (Warrington) - M60 Junctions 15-18 (North Manchester) This map clearly shows that traffic flows are heaviest in the vicinity of major cities, reflecting concentrations of people living and working in these areas.
Figure 2-6: Annual Average Daily Traffic Flows – Percentage HGV: Proportion of HGVs on each link of the SRN (Page 15) (Source: Highways England)	Large amounts of HGVs are indicative of trade of goods across the country. The sections of the SRN with the highest proportion of HGVs show where goods have entered or are leaving the country by road, rail and air and travelling along key distribution routes. The highest proportions of goods traffic are on: - M25 Junctions 17-21 (near Heathrow) - M25 Junctions 28-29 (connecting to London ports) - M50 Junctions 2-3 (connecting South Wales to the Midlands) - M62 Junctions 21-24 (connecting Manchester to Leeds) Higher proportions of goods traffic are also likely to impact on operating conditions on the road, due to overtaking of lorries and lower average speeds.
Figure 2-7: Total Delay to Vehicles: Delay in hours to vehicles on each link of the SRN (Page 16) (Source: Highways England)	Delays to traffic impact on the movement of goods, business journeys and commuting to work. The sections of the SRN with the highest total delays reflect both high traffic volumes and congested conditions. These include the M25 (numerous sections), M1 (Northampton, South Yorkshire), M3 (Surrey), M6 (Staffordshire and Cheshire), M62 (north and west of Manchester) and A1 (Gateshead). This again demonstrates that the greatest challenges are on parts of the network near to or connecting major urban areas, which impacts on commuting, business trips and movement of goods.
Figure 2-8: Annual Average Speed: Average vehicle speed on each link of the SRN (Page 17) (Source: Highways England)	There are some parts of the SRN with low average speeds, highlighting bottlenecks and concentrations of vehicle traffic. Low average speeds are indicative of capacity issues, accident 'black spots' or ongoing maintenance issues. The sections of the SRN with the lowest average speeds are: - A46 Coventry South - A52 Nottingham South - A63 / A1033 Hull - A1 Junctions 68-72 Furthermore, there are areas of the SRN with low average speeds across the country, including many single carriageway routes (e.g. A49 in the Marches, A36 Bath to Southampton, A47 through Cambridgeshire and A64 in North Yorkshire).

[5] Source of data: Highways England, HATRIS Data April 2014 – March 2015, revised March 2016

Figure 2-5 Annual Average Daily Traffic Flows



Source: Highways England, HATRIS Data for April 2014 to March 2015. Received March 2016.

Figure 2-6 Annual Average Daily Traffic Flows – Percentage HGV

Source: Highways England, HATRIS Data for April 2014 to March 2015. Received March 2016.

Figure 2-7 Total Delay Hours

Source: Highways England, HATRIS Data for April 2014 to March 2015. Received March 2016.

Figure 2-8 Annual Average Speed

Source: Highways England, HATRIS Data for April 2014 to March 2015. Received March 2016.

3. Socio-Economic Analysis

3.1. Overview

This section presents an analysis of key socio-economic factors in relation to the SRN. It focuses on the following topics:

- **Population –** There are several aspects of population that are of interest to policy makers in transport infrastructure including skills profile and age composition. It is also important to assess population growth, as this is one of the key drivers for infrastructure investment and underpins investment in housing and economic change.

- **Deprivation –** Deprivation is caused by lack of income and other resources, which cumulatively can be seen as living in poverty[6]. Deprivation is often identified using the Indices of Multiple Deprivation which take a wide-ranging approach to identifying poverty through different indicators of poverty or deprivation[7].

- **Enterprise & Employment** – The current and future economic development of local areas in England is one of the main drivers for infrastructure investment. Rather than undertaking a full assessment of economic drivers the analysis is focused on:

  - Productivity (as measured by GVA per employee) highlighting the most economically productive areas of England;

  - Employment growth and density highlighting areas which have concentrations and potential future (or further) concentrations of employment; and

  - Density of businesses and commercial accommodation.

We also focus further analysis on key sectors of the economy that are most reliant on the SRN and wider transport infrastructure, together with the retail & leisure and energy sectors.

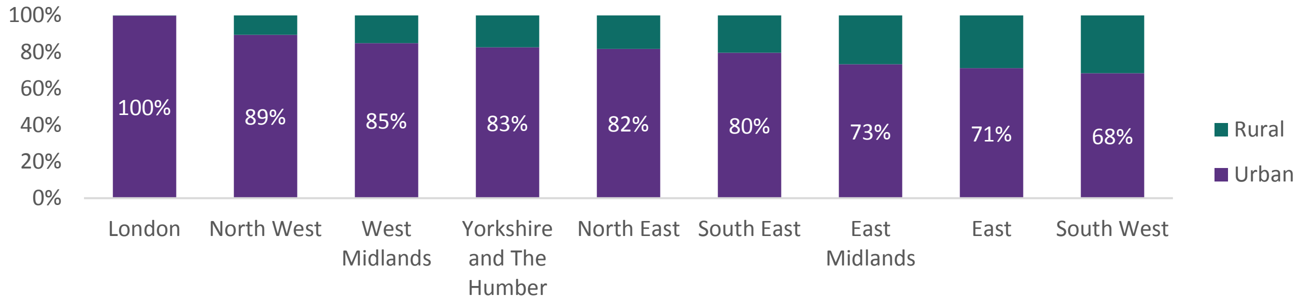
3.2. Population

The population of England is 53 million, making England one of the most densely populated countries in the world. However, despite this, there are large sparsely populated rural areas and urban areas with available space. People live in different areas for a multitude of cultural, historical, economic, environmental and social reasons.

The vast majority of England's population is centred on urban agglomerations, with the highest density of population in and around the core cities. Cities are seen as the key drivers of population and are where the majority of the population live. Given the structural trend of urbanisation (Figure 3-1 shows the proportions of urban dwellers in each English region in 2011) and growth of agglomeration economies this is expected to continue. This is further reinforced by current trends in the business and commercial office development market of developers and tenants preferring city centre locations.

[6] http://www.poverty.ac.uk/definitions-poverty/deprivation-and-poverty
[7] Maps of Deprivation in England can be viewed here: http://dclgapps.communities.gov.uk/imd/idmap.html

Figure 3-1 Proportion of the usual resident population living in urban & rural areas, 2011



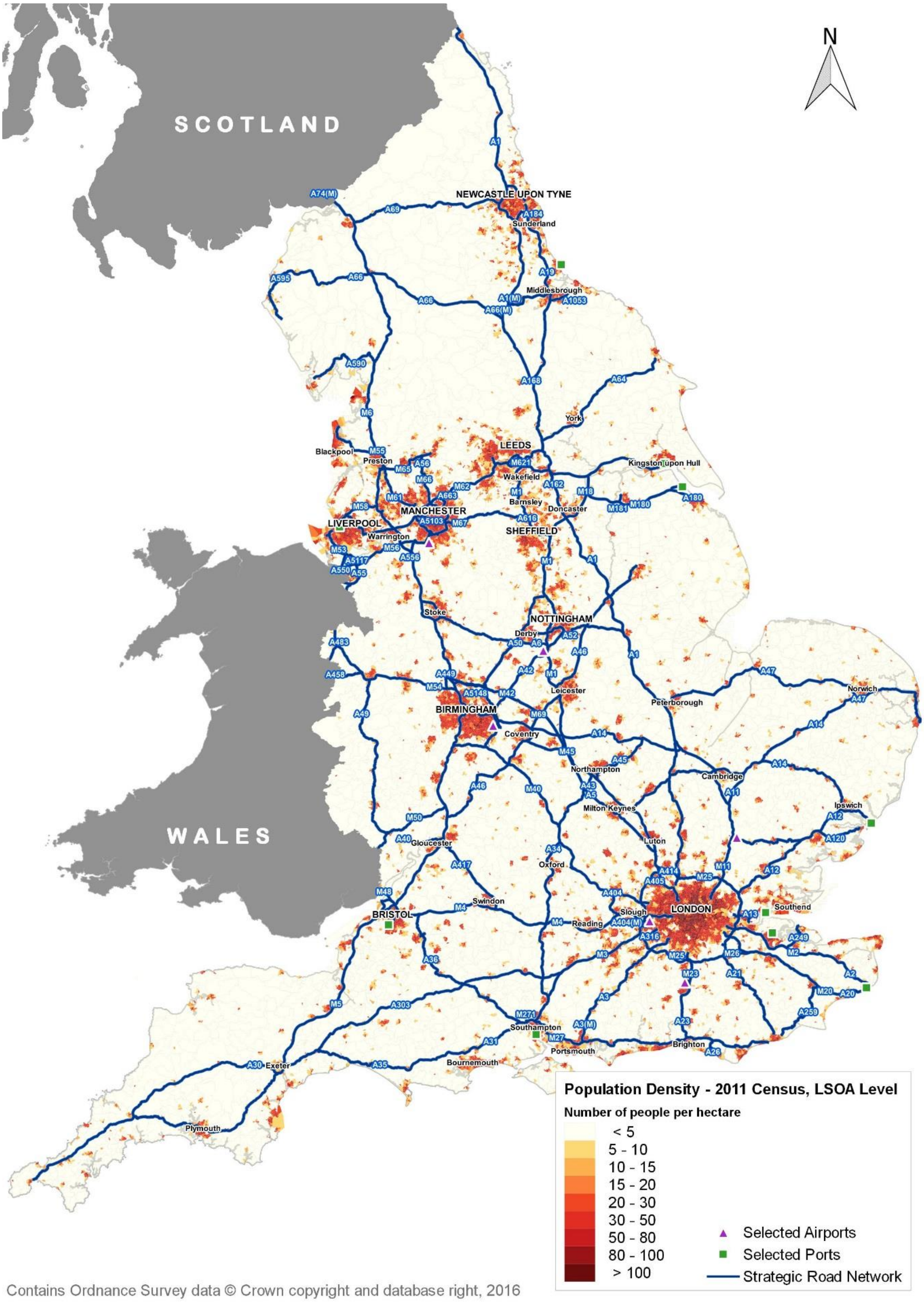
Source: ONS Census 2011

Figure 3-2 shows population density in relation to the SRN. Analysis of the data that underpin this shows that 97% (51.3 million people) of the population live within 15km of the SRN and 70% (37.2 million people) live within 5km of the SRN. This shows the importance of the SRN for the movement of people for leisure and work activities. Further work by Highways England shows that:

- 94% of population of England within an hour of a large airport;
- 95% of the population within one hour of national or regional interchange rail station; and
- 96% of the population of England are within one hour's drive of a SRN junction.

Figure 3-2 also shows that the SRN connects key urban populations including London, Birmingham, Bristol, Leeds, Liverpool, Manchester, Newcastle, Nottingham and Sheffield. It also connects and transects rural and smaller urban areas.

Figure 3-2 SRN and Population Density



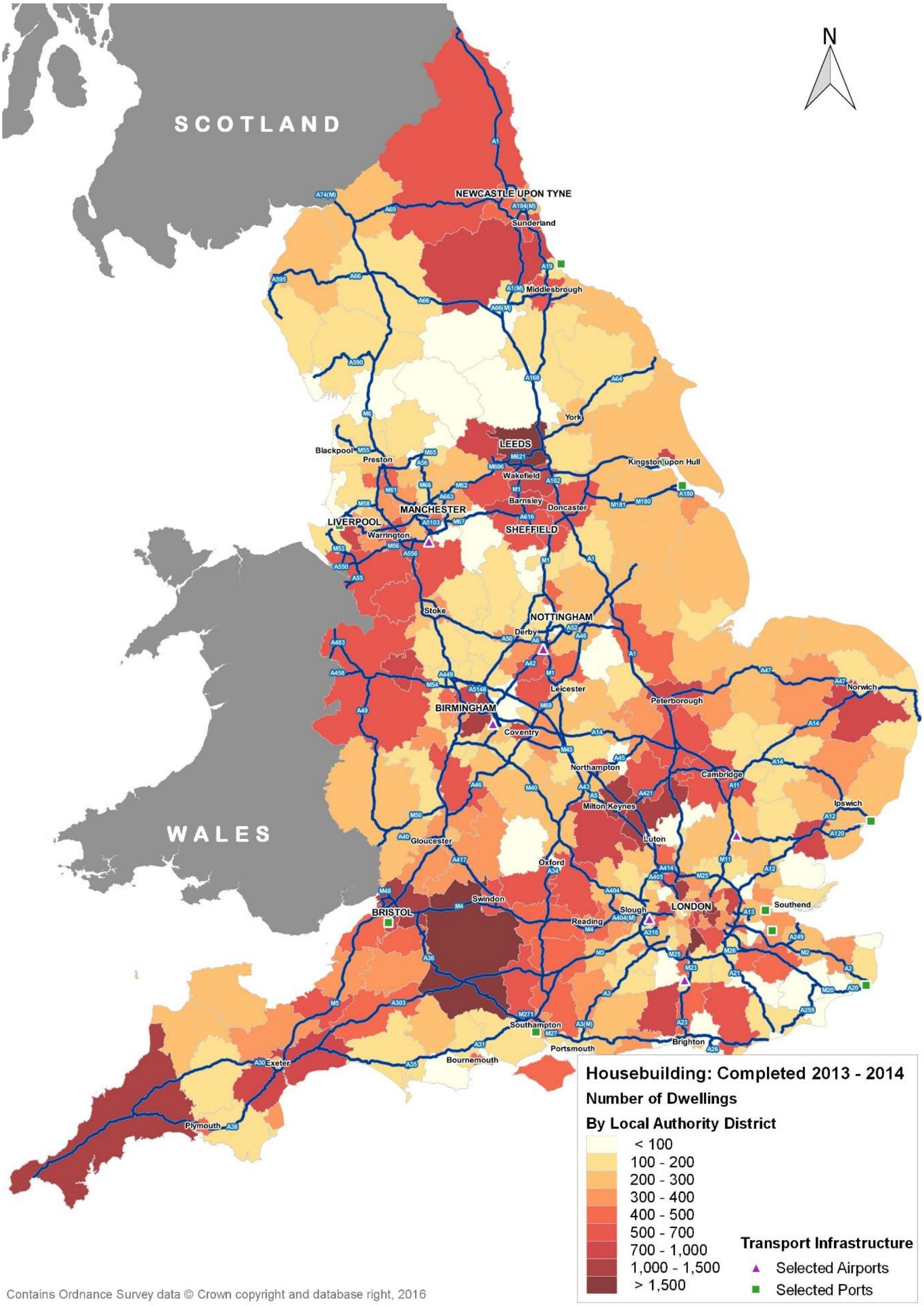
Source: ONS, Table KS101EW - Usual resident population from the 2011 Census.

Population density identifies where people live but is limited by presenting a snapshot of existing population. England's population is growing and there is a need for new housing. Housebuilding has been a key topic for several years with housebuilding experiencing sustained growth in the early 2000s, but hitting a trough in 2009 as the economic downturn affected the whole economy. There is recognition by policy makers and other commentators that England is facing a 'housebuilding crisis' with estimates of the number of new houses needed to meet demand of around 250,000 per annum. The lack of housebuilding has driven rising house prices and demographic trends with people moving out of expensive housing areas.

Despite a 'housebuilding crisis', many areas of England are building houses. Figure 3-3 presents the volume of housebuilding in England between 2013 and 2014. This shows areas that can be expected to see increased population increase and resultant road infrastructure pressures. Several of these areas of growth are in urban areas (e.g. Leeds and Birmingham) whilst some are in more rural areas (e.g. Wiltshire and areas of Northamptonshire) highlighting the desire for homes in wider growth areas.

Areas of predicted housebuilding growth could be areas of pressure on the SRN. Housing targets outlined in local plans provide evidence on the scale of this in the future but there is difficulty in meeting targets with economic conditions and planning regulations identified as key barriers to meeting housing requirements.

Figure 3-3 Housebuilding Completed (2013-2014)



Source: Table 253 Housebuilding: permanent dwellings started and completed, by tenure and district, 2013-14 (https://www.gov.uk/government/statistical-data-sets/live-tables-on-house-building)

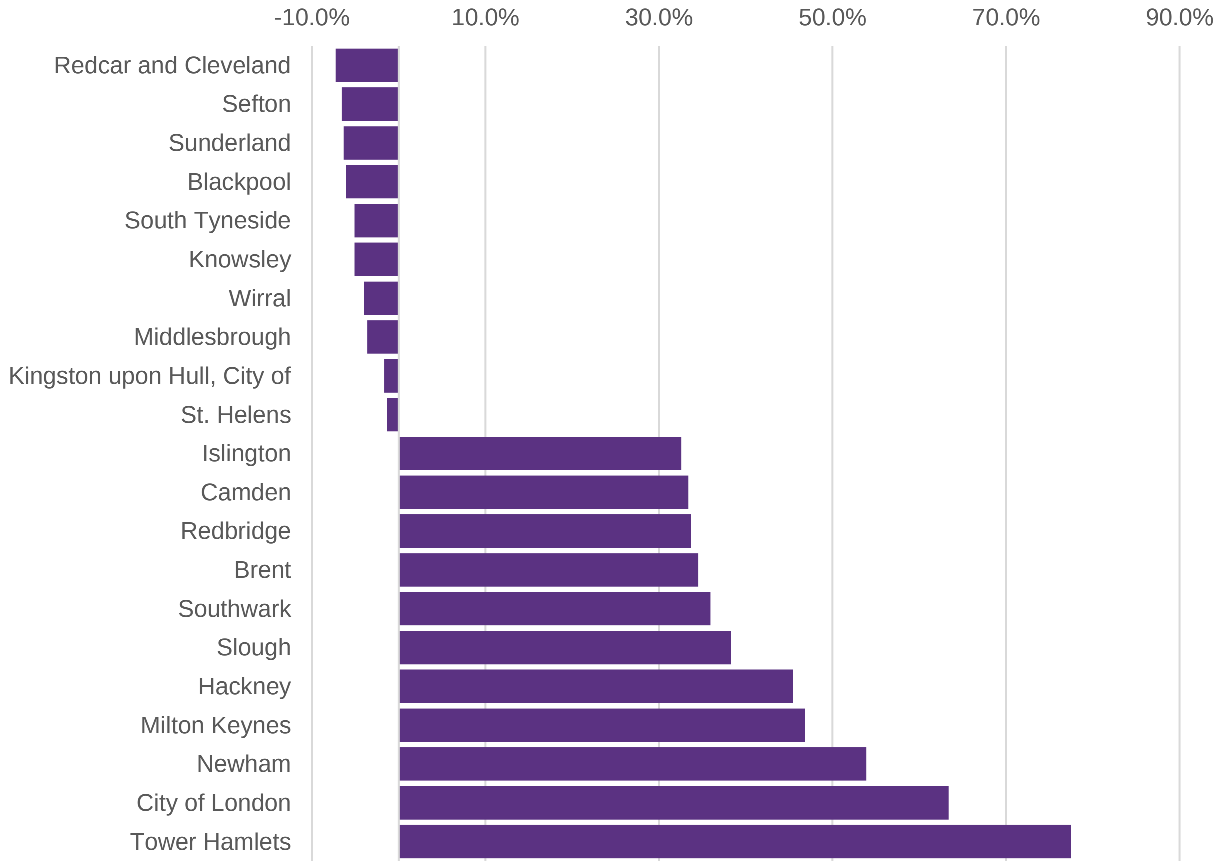
The SRN is a key determinant of where people choose to live and work, with the majority of the population living in proximity to the SRN[8]. Figure 3-5 shows population growth in the past 24 years. Population growth has been uneven with several areas in London, Cambridgeshire and Lincolnshire growing quickly whilst several urban areas in the North of England have seen population decline or little growth including Sunderland, Hull and parts of Merseyside.

Figure 3-5 shows that some areas have grown in the North, including York, Manchester, Warrington and North and East Yorkshire. Across the rest of England other areas that stand out for population growth include Bristol, Milton Keynes and Swindon. Several of these areas are also expected to see population growth in the future (see section 4) although this is not uniform. Warrington is an example of a place planning to grow its population, whilst York is seeking to check growth to protect the green belt, address the shortage of housing and balance future economic development and employment.

There are a number of causes of population change:

- High birth rates in cities are sometimes driven by higher birth rates from migrant populations.
- Increased immigration to England and especially to urban areas (e.g. core cities) as well as areas of seasonal employment (e.g. Lincolnshire) has driven population increases.
- Migration *within* England has seen population in areas like London grow with people moving to London to further their career or seek employment.
- Certain areas are experiencing out-migration of young people and other areas have seen an influx of older people following retirement leading to an ageing population

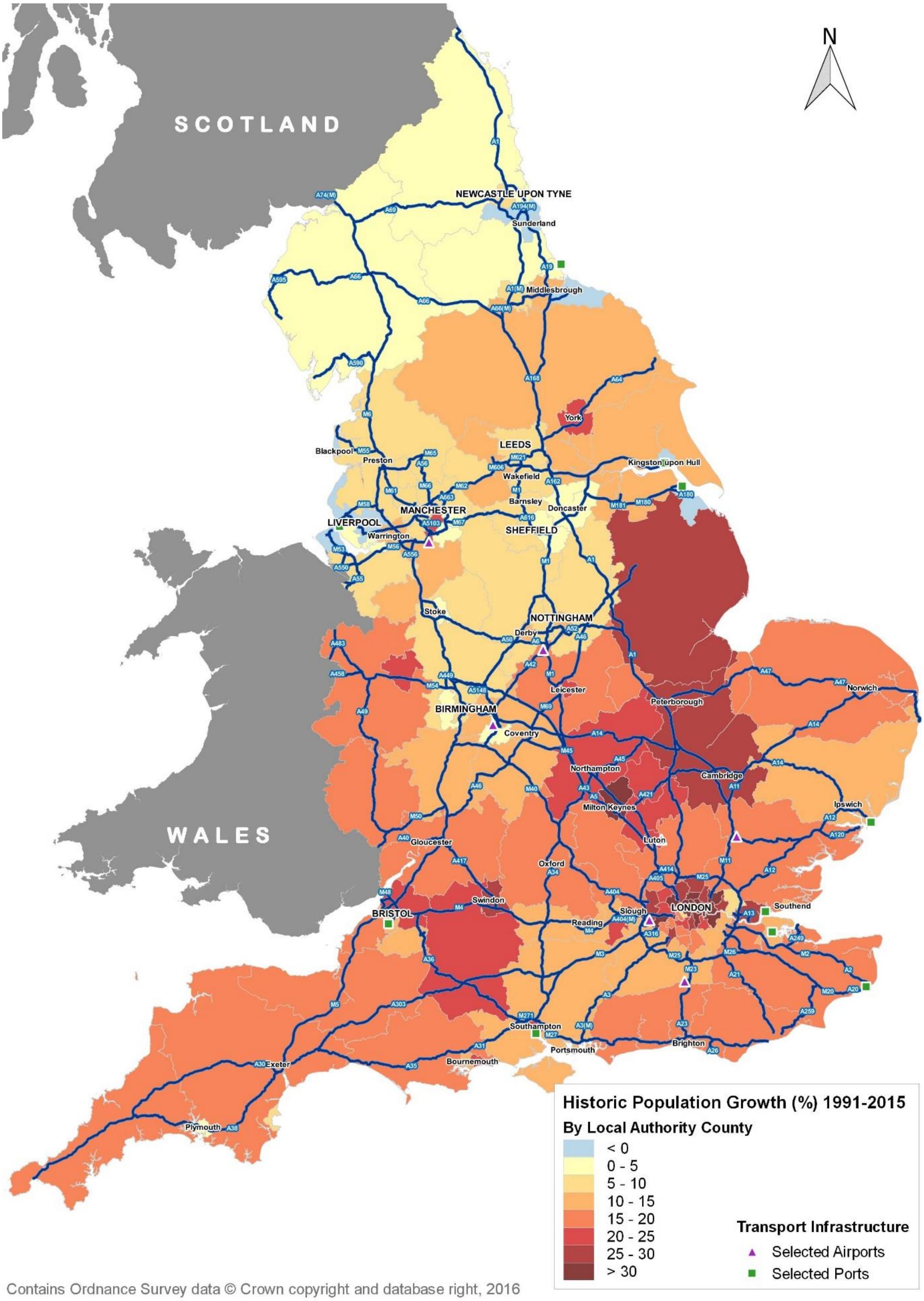
Figure 3-4 Top 10 and Bottom 10 Local Authorities for Population Growth (1991-2015)



Source: ONS Population Estimates (Atkins 2016)

[8] Commercial Development and the SRN, SEGP report 2016

Figure 3-5 Historical Population Growth (1991-2015)



Source: Historic local authority based population estimates with single year of age (https://www.nomisweb.co.uk/articles/934.aspx)

3.3. Deprivation

Deprivation can be quantitatively assessed using the English Indices of Deprivation 2015. These indices help to identify areas of poverty across 37 separate indicators which fit into seven distinct domains (which combine to produce the overall index – 100%):

- Income Deprivation (22.5%)
- Employment Deprivation (22.5%)
- Education, Skills and Training Deprivation (13.5%)
- Health Deprivation and Disability (13.5%)
- Crime (9.3%)
- Barriers to Housing and Services (9.3%)
- Living Environment Deprivation (9.3%)

The Indices of Deprivation 2015 provide a set of relative measures of deprivation for local areas across England and mapping can be used to identify where the SRN could potentially be an important feature in helping to address issues of deprivation.

Figure 3-6 overlays the SRN with the distribution of measured deprivation. The deprivation geography of England is complex. Many highly deprived areas are found in and around urban areas (e.g. core cities) although there are several rural and coastal areas of deprivation (West Midlands, East Yorkshire, parts of Lincolnshire, and in the south west across Devon and Cornwall). The SRN crosses and connects deprived and less deprived areas.

Linkages between the SRN and deprivation are complex. The SRN plays a role in impacting on all of the deprivation domains. However, there is no clear correlation between deprivation and access to the SRN. For example, two of the most deprived areas in England are:

- Oldham which is less than 5 minutes' drive from the SRN
- Jaywick near Clacton which is 25 minutes' drive from the SRN.

This indicates that there is not a simple correlation between SRN access and deprivation. Table 3-1 presents data on the most and least deprived areas in the country.

Table 3-1 Least and Most Deprived Local Authorities by Rank of local concentration

Most deprived Local Authorities	Least deprived Local Authorities
Blackpool	Vale of White Horse
Middlesbrough	Rutland
Knowsley	Chiltern
Great Yarmouth	Waverley
Kingston upon Hull, City of	Uttlesford
Thanet	South Cambridgeshire
Liverpool	Wokingham
Burnley	South Northamptonshire
North East Lincolnshire	Hart

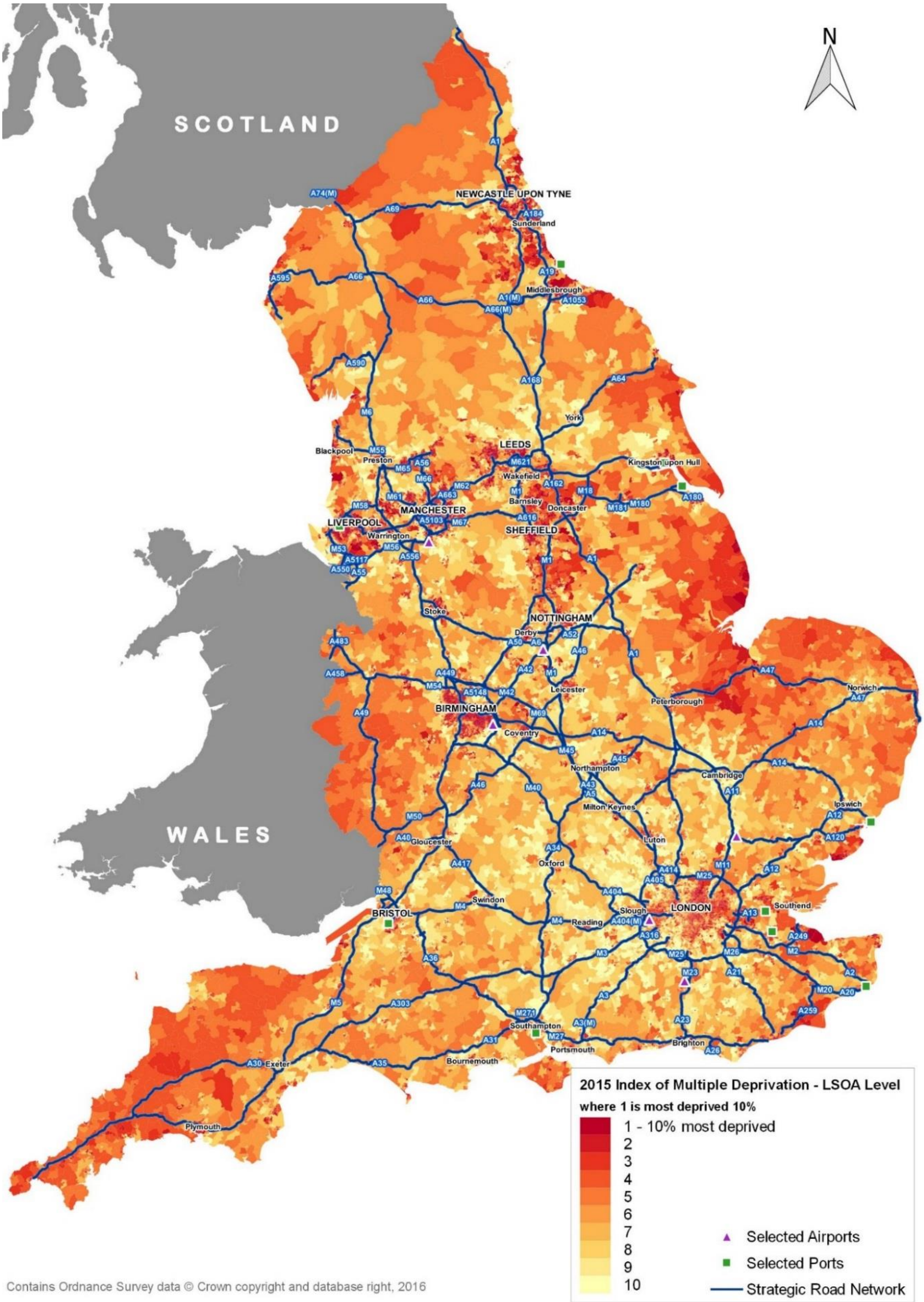
Source: IMD 2015

Improving access to the SRN could help to tackle deprivation but is not the only element: other factors are highly important in tackling deprivation including improving people's health, tackling skills problems and attracting new jobs. The transport network plays a key role in each of these aspects and the SRN is important for:

- Access to jobs, services and education;
- Social cohesion (e.g. family & friendships);
- Business connectivity; and
- Movement of goods.

Deprivation is usually explored as part of impact assessments for Highway England schemes. However, the links between deprivation and the SRN are not fully understood. Several further metrics could be explored including access to employment, the rural and urban deprivation component and the cost of travelling (e.g. cost of fuel and car ownership).

Figure 3-6 Deprivation Analysis



Source: English indices of deprivation 2015 (https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015)

3.4. Enterprise and Employment

This section examines the relationship between employment and economic activity and the SRN. Employment and economic centres have historically focused on proximity to:

- Resources (e.g. coal or food);
- Markets (e.g. concentrations of people);
- Workforce (e.g. accessible workforces);
- Transport routes (rivers, roads, rail); and
- Sources of innovation or technological developments (e.g. power stations).

These factors remain important but in modern times other factors have become important (e.g. access to broadband or concentrations of knowledge workers). As such, most employment is concentrated in city centres, business parks, other urban centres, enterprise zones or near to infrastructure (large industry, ports and airports). The rise of out of town office locations in the 1980s and 1990s has been replaced by reurbanisation as jobs have shifted to city centre locations. Businesses are also mobile and increased globalisation has led to firms relocating, expanding and spreading their operations across countries and borders.

A high proportion of people in England travel to work using a car or other vehicle (40.7%). Figure 3-7 shows the significant differences in car use between London and other regions (in some London Boroughs only 2% of residents use a car). Levels of car use are highest in the more rural regions, including the South West, East and East Midlands, whilst car use is lower in urban areas.

Figure 3-7 Travel to work using car or other vehicle (2011)

Source: ONS Census (2011)

3.4.1. Business Density

The table below helps understand the location of enterprise units[9] relative to the SRN. It shows the number of businesses located with 5km, 10km and 15km of the SRN. Across England 91% of businesses are within 15km of the SRN whilst 55% are within 5km. This reflects the coverage of the SRN in rural areas and limits of the SRN in accessing urban centres.

Table 3-2 Number of Enterprises in close proximity to the SRN

Buffer	% within proximity to SRN	Number of enterprises
5km	55.5%	1,224,015
10km	80.7%	1,779,730
15km	91.4%	2,015,402

Source: Highways England and ONS Business Counts (2014)

Roads are vital to the business community. The Confederation of British Industry (CBI) describes how roads are the "backbone for trade, helping to attract inward investment and supporting economic growth"[10] (CBI) and the Institute of Directors (IOD) states that "The UK is utterly dependent on road transport".[11]

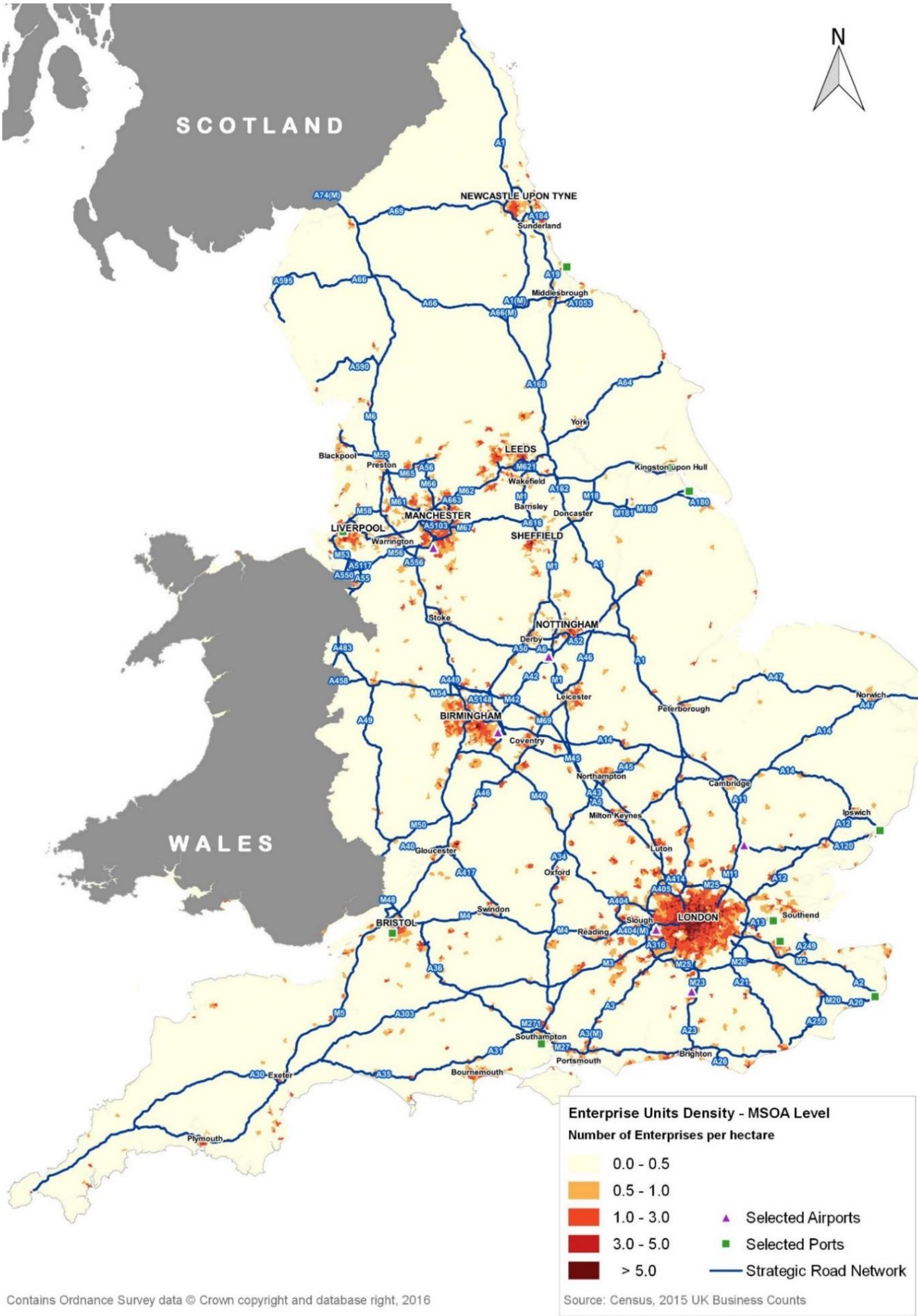
Almost all areas of major business density are connected by the SRN (Figure 3-8). There are key areas of business density in major cities, which are well connected by the SRN. However, there are a number of areas of business density scattered across England, which are not close to the SRN. These include areas of the South East Midlands, South Coast and towns north of Leeds. However, there is not a direct correlation between proximity to the SRN and use of the SRN. Many businesses in areas close to the SRN will not need to use the SRN. Conversely, many businesses in areas more distant from the SRN will have a strong need to use the SRN.

[9] Enterprises are defined in the Census as the smallest combination of legal units which have a certain degree of autonomy within an Enterprise Group.

[10] Leighton Jenkins | Assistant Director Policy | CBI Wales – Response to SENNED (2013)

[11] The Big Picture (IOD) 2014 - James Sproule, Chief Economist and Director of Policy at the IoD

Figure 3-8 Business Density



Source: UK Business Counts – Enterprises
(https://www.nomisweb.co.uk/query/construct/summary.asp?mode=construct&version=0&dataset=142)

Recent trends in the commercial office market indicate that a key determinant of location is quality of place and environment. Activity in the commercial office sector is therefore forecast to continue concentrating development in urban areas, in particular city centres and other major urban centres. Locational decisions are increasingly driven by human resource considerations with businesses choosing to locate in vibrant and attractive office locations, which are easily accessible by public and private transport, and provide cultural and leisure facilities for staff. This is driving a pull back to large town and city centre locations and away from car-dominated, poorly serviced out of town business parks.

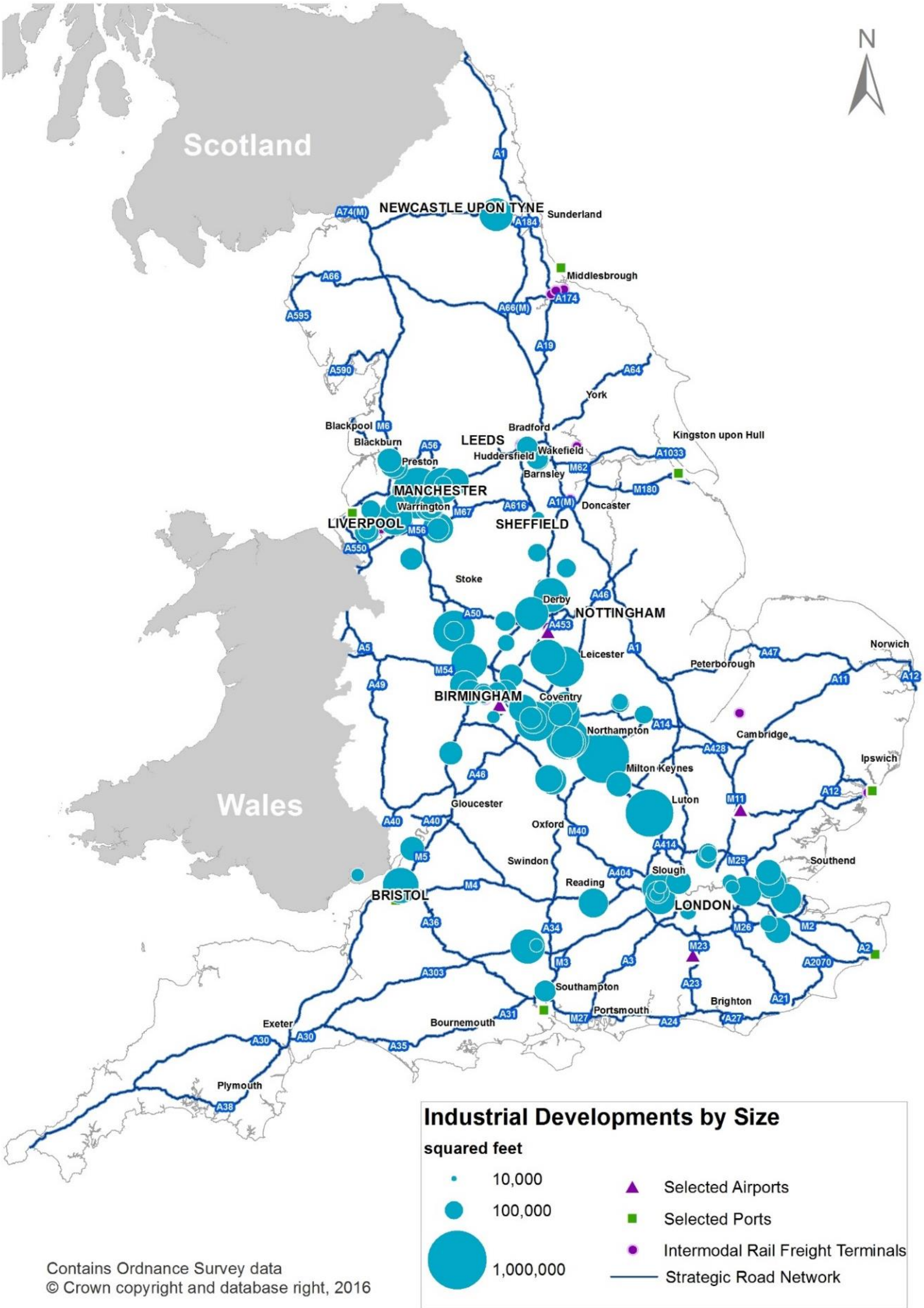
The following key points are identified as important for business location:[12]

- Improving economic conditions are resulting in rising employment and growing business confidence leading to an increased demand for office space;
- Market demand for office space is increasingly focused on large town and city centre locations, fuelled by knowledge based jobs clustering in central locations;
- High demand for new Grade A schemes; influenced by increase in on-shoring/north-shoring[13];
- Most successful business parks are highly accessible and established with a strong sector specialism and of a scale and critical mass to support a wider amenity offer; and
- Technological and infrastructure advancements support increasingly globalised businesses.

Figure 3-9 plots the distribution of major speculative industrial development that has taken place in England between April 2014 and April 2016. It demonstrates a clear relationship between industrial development and the SRN. Geographically, this shows that there is a South East to North West corridor (approximately Kent to Merseyside) where the largest developments are largely focused. This has implications on the SRN routes that are near to these developments, such as the M6, M25 and M1. Larger industrial developments are also more likely to be related to the warehousing and logistics sector which makes heavy use of the SRN.[14]

[12] Commercial Development and the SRN, 2016 report
[13] North shoring is when a southern company relocates to a more peripheral regional economy, such a decision is typically made to reduce costs
[14] Commercial Development and the SRN, 2016 report

Figure 3-9 Speculative Industrial Development & the SRN 2014-2016



Source: Cushman and Wakefield, 2016.

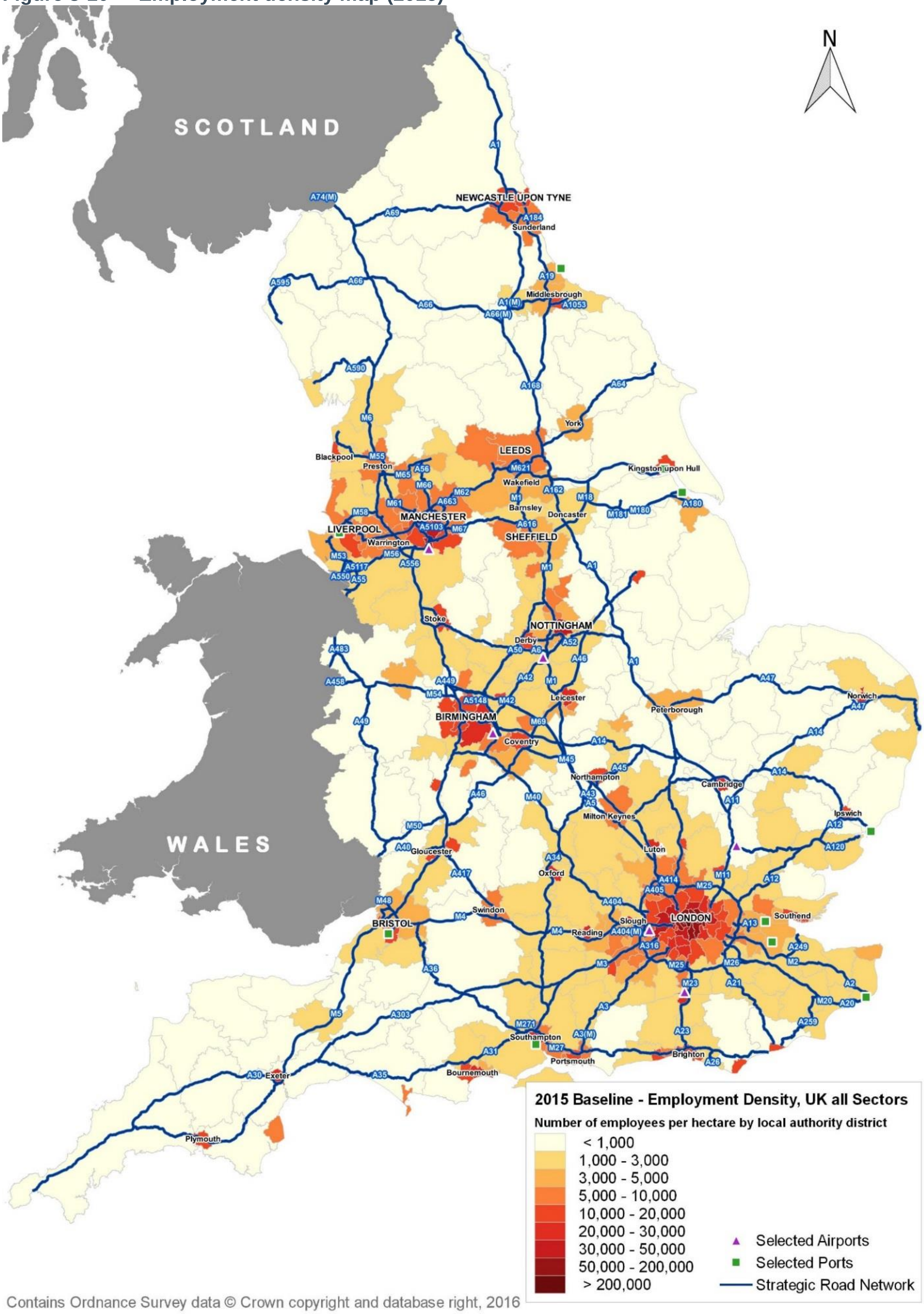
3.4.2. Employment Density

The SRN connects people to jobs. Many people, especially outside of London, travel to work by car (Census 2011). Almost all employment centres (as defined by employment density) are connected by the SRN (Figure 3-10). Key areas of employment density include the core cities, M62 corridor, M1 Leeds to Nottingham, Birmingham to Manchester and Nottingham, routes between London and Southampton, areas around Swindon, Milton Keynes, Birmingham and the Bristol city region. These are all located close to the SRN.

However, there are a number of areas of employment that are not close to the SRN. These include specific larger towns, such as Torbay and Weymouth on the South Coast, although access to these towns has been improved in recent years with the completion of road improvements by the local authorities. There are also other areas – including parts of the South East Midlands and East Anglia, which are located between routes on the SRN but are not directly served.

This does not imply that the SRN is not important to the operation of businesses in these locations. In many cases, the SRN is important for both employees travelling to work and for access to markets. Access to the SRN is important to firms in rural (often remote) locations to that deal with agricultural, raw materials or other large manufactured goods.

Figure 3-10 Employment density map (2015)



Source: Cambridge Econometrics Data

3.4.3. Productivity (GVA)

There is a strong relationship between productivity and connectivity. A 2014 study for the Department for Transport by Laird, Overman and Venables identified that:

"if all other drivers of growth were to increase by 10% and transport infrastructure were to stay constant, then realised growth in income would be just 9%, i.e. 1% point less than it otherwise would have been"

Productivity, as measured by GVA per worker, is a key component of current Government policy with economic scale and density (often agglomeration) central to productivity growth. Transport is a key factor for productivity growth through supporting agglomeration economies by supporting economic interactions between businesses, consumers and markets.

Figure 3-11 shows that GVA per worker on the whole is higher in the South of England compared to the North (as demonstrated in section 2.1.1). This is a critical issue for the future of the UK: in order to drive the success of the UK it is critical to improve productivity in the North and the Midlands, which is one of the main reasons behind the Northern Powerhouse and Midlands Engine agenda and ambitions to lift productivity across the country.

Transport plays a role in lifting productivity in areas of low productivity and strengthening areas of higher productivity. Better transport is key to productivity growth through supporting agglomeration economies by supporting economic interactions between businesses, consumers and markets by:

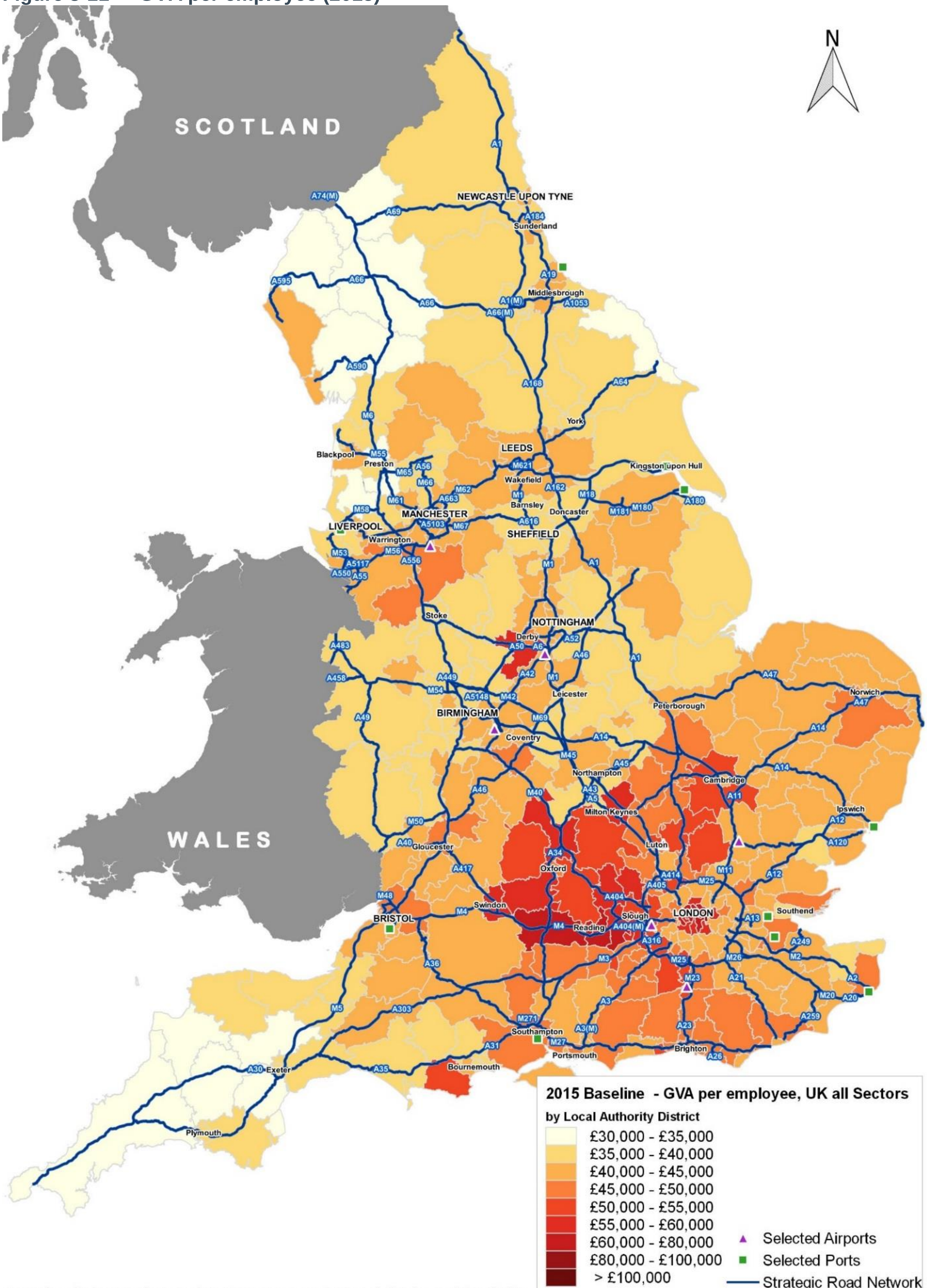
- Reducing distances between firms and market and increasing competition; and
- Supporting access to labour markets;

Transport fosters economic interaction that raises productivity. Effective connectivity is an essential component in attracting highly productive businesses, which require easy access to markets, supply chains and skilled workers. Good transport links are not sufficient in their own right: a number of factors influence productivity, including sector mix, investment, innovation and workforce skills. The drivers of productivity across England are therefore complex, but effective connectivity is essential.

Areas with good access to domestic and global markets and high quality skills generally have high productivity and business growth. Figure 3-11 shows that areas of highest productivity include Central London, the area west and north of London, the arc between Swindon and Cambridge, and hotspots near Derby and Bournemouth. Areas of lower productivity include the area north of Birmingham, the North East and far North West. The more peripheral areas, including Cornwall, Devon and Cumbria, have the lowest productivity. This demonstrates the effect of peripherality on economic performance. Conversely, the highest levels of productivity are along the M4 corridor, which benefits from easy access to Heathrow, and has therefore attracted global businesses.

Remote areas of low productivity are often characterised by a dependency on a sector mix with lower GVA per worker. However, the economies of these areas are based on sectors that rely on effective access to the SRN. For example, Cumbria, Cornwall and Devon have a strong dependence on the visitor economy, which requires effective access from the rest of the UK. Other sectors of the economy also require the SRN to connect with supply chains and national international markets, for example transport of seafood from Cornwall to the markets of major cities. Congestion and disruption on the SRN can therefore have significant impacts on the economies of these areas.

Figure 3-11 GVA per employee (2015)



Source: Cambridge Econometrics Data

3.5. Business Sectors Dependent on the SRN

This section explores the role of the SRN in meeting the needs of different parts of the economy. It draws on evidence on supply chain linkages between different parts of the economy and detailed research into the locational decisions in different sectors. It highlights the fundamental role of the SRN in the operation and competitiveness of particular sectors of the economy.

3.5.1. Economic Analysis

Cambridge Econometrics has determined the sectors of the economy that are the primary users of road transport services, based upon sectoral interdependencies in the UK Input-Output tables[15].

These tables capture the linkages between different actors in the economy, including the value of inputs of each sector of the economy (across 105 disaggregated sectors) into each other's sector. The Input-Output tables were used to assess the extent to which different sectors of the economy demand Land Transport Services (excluding rail)[16]. This was used as a proxy for demand for the SRN, based on the assumption that the vast majority of freight is moved by specialist hauliers, and that the SRN provides the key routes used by these hauliers.

The major users of the SRN were then identified as SRN dependent sectors. Table 3-3 below sets out each sector identified as a major user through the Input-Output analysis, and the rationale for their inclusion in this classification (i.e. why the data highlights them as being key users of the SRN).

Table 3-3 SRN Dependent Sectors

Sector	Rationale for inclusion
Land transport	Businesses in the land transport sector are the primary users of the SRN – they include specialist hauliers, postal and courier activities, as well as warehousing, storage and other support activities to land transportation.
Retail & wholesale trade	Many retail goods are moved along the SRN, both when moving from distribution centre to retail location and from distribution centre direct to consumer.
Primary materials	Primary materials include extraction of coal, petroleum, natural gas, metal ores and other mining & quarrying activity, reflecting the fact that large quantities of these goods are moved using the SRN.
Manufacturing – users of transport services	This sector, including manufacture of food, beverages, tobacco, wood & wood products, paper & paper products, rubber & plastic products and other non-metallic mineral products (such as construction materials) are included as they are substantial users of land transport services, with large quantities of the manufactured goods being moved along the SRN.
Manufacturing – reliant on other sectors which are users of transport services	This sector, which includes motor vehicles, includes sectors that take a substantial proportion of inputs from the manufacturing sectors (identified above) that are heavy users of the SRN. These firms are therefore indirectly dependent upon the SRN.
Construction	Construction is both a direct user of the SRN (in terms of moving vehicles used in construction) and heavily reliant on inputs of manufactured goods (such as non-metallic mineral products) which use the SRN.

Figure 3-12 and Figure 3-13 show the distribution of employment density and GVA per employee for these sectors. This shows employment and productivity concentrations including Birmingham, Derby, Leicester, London, Luton and Manchester. These are likely to be linked to concentrations of SRN-

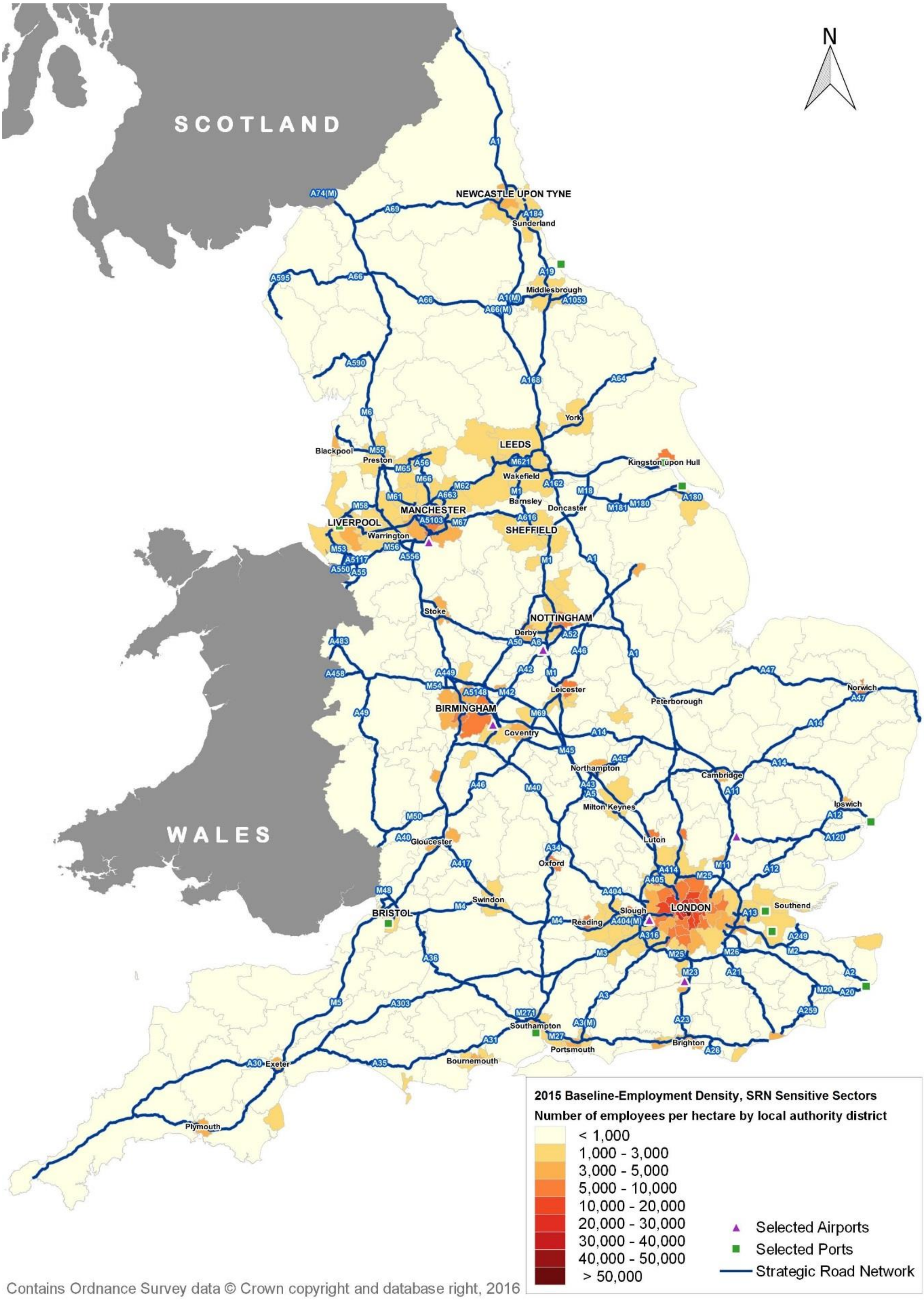
[15] See http://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/inputoutputsupplyandusetables
[16] SIC codes 49.3-5

dependent sectors clustered around areas of economic mass, in locations with access to a wide range of markets, and specific business clusters, for example:

- Car (e.g. Nissan in Sunderland) and train manufacturing (e.g. Bombardier in Derby);
- Aerospace and defence (e.g. BAe Systems in Preston and Hampshire); and
- Airport activities (around large international and regional airports).

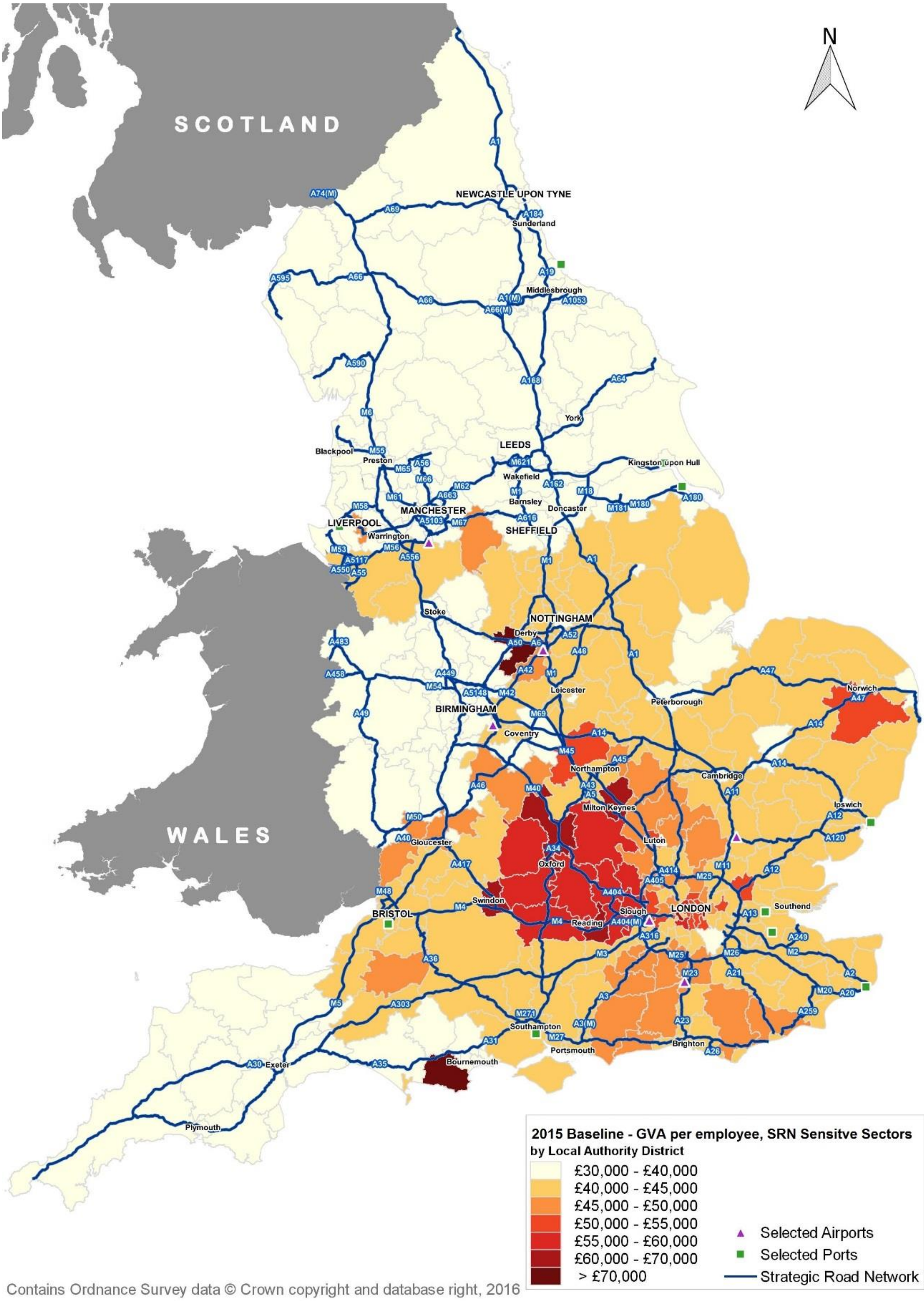
The maps show linkages to wider activities in transport sectors such as Motorsport Valley. Motorsport Valley is often referred to as the largest concentration of UK motorsport firms and is located in the Midlands and centre of England. The maps also highlight the logistics sector and key clusters for this industry in South/West Yorkshire, the M62 Corridor and Essex/Kent.

Figure 3-12 Employment Density. SRN Sensitive Sectors – 2015



Source: Cambridge Econometrics Data

Figure 3-13 GVA per employee. SRN Sensitive Sectors – 2015



Source: Cambridge Econometrics Data

3.5.2. Other Sectors

In addition to the transport sensitive sectors, consideration should be made to other sectors that rely on transport and particularly the road network. The section that follows provides a high level assessment of how the energy and retail & leisure sectors interact with the SRN.

3.5.2.1. Energy

The energy sector is reliant on the SRN to move people and materials. The UK imports nearly half its energy supply: oil, biofuels and coal are transported by boat, train and lorry to power stations. The renewable energy sub-sector is also dependent on the SRN with specialist companies involved in the transport of renewable energy equipment including offshore wind turbines and blades.

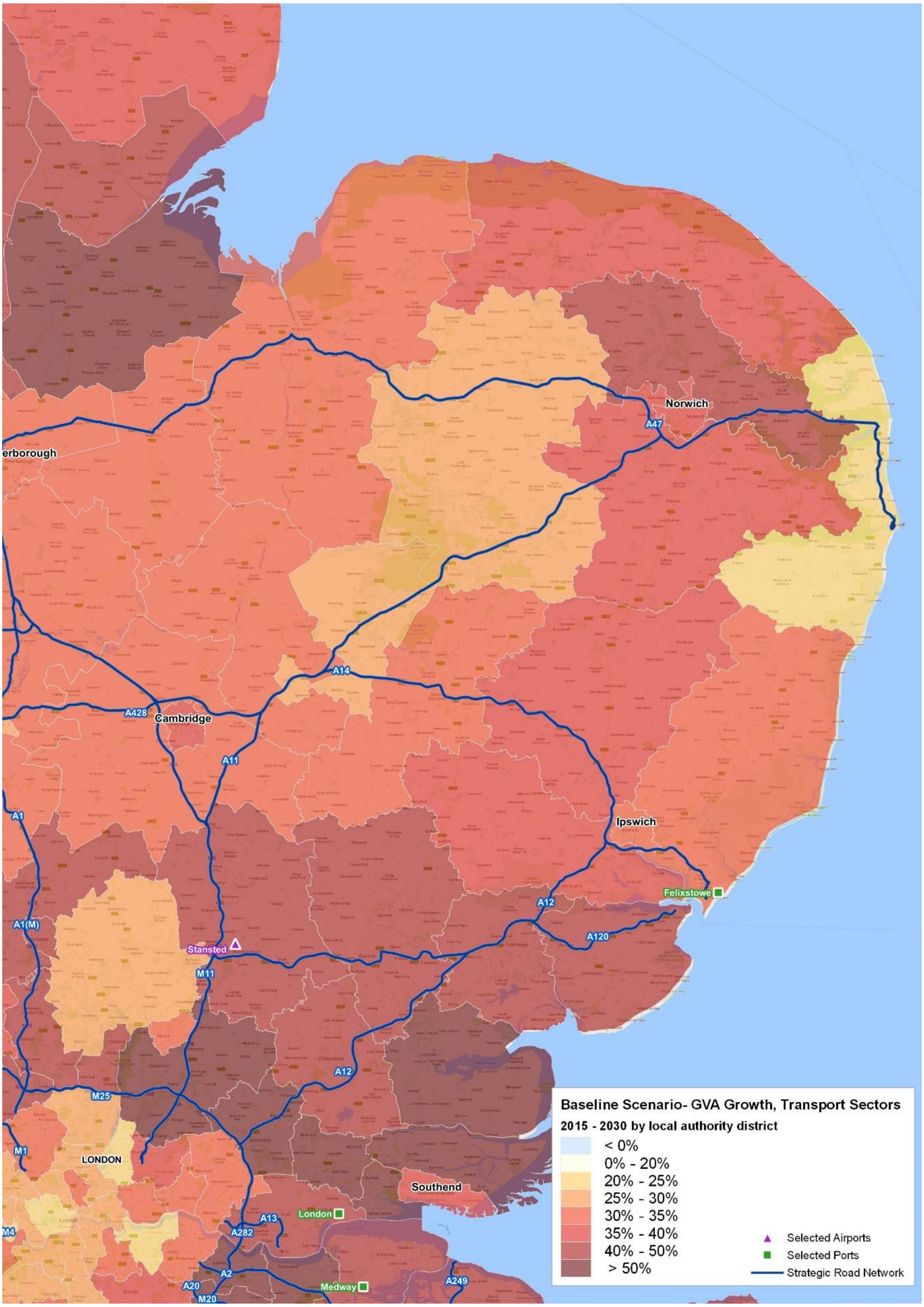
The UK energy system depends on effective access by the road network. The location of several power stations away from large urban areas (particularly nuclear power stations) means that staff working in the operation of the power stations use the road network to commute to work. Several power stations are also near to the SRN and depend on effective access to the SRN in their operations.

The UK Government is increasing its focus on cost-effective and efficient energy generation and supply. New nuclear energy generation in Somerset and Cumbria will be dependent on skilled workers living in these areas commuting to these locations. The M5 and M6/A66 are therefore likely to be key to how materials and people are transported.

There is little research evidence on the linkages between the energy network and transport. The construction phase for energy generating plants is lengthy and requires high levels of physical capital and labour inputs. These plants are often in more remote areas where local labour and product markets are not of sufficient size to support these requirements. Materials and workers therefore come from further afield and the SRN performs a vital function in supporting this movement of goods and people. As such, further work is required to understand how the energy sector will use the SRN and develop in the future, including how the network can enhance the economic competitiveness of this sector.

The relationship between the energy sector and the SRN is explored, for the East of England, in the figure on the following page. Figure 3-14 shows the forecast GVA growth across the East of England between 2015 and 2030. This covers an area that includes key energy assets (e.g. Sizewell B Power Station) and transport infrastructure (e.g. Port of Felixstowe). The forecasts indicate slight GVA growth for this area. However, GVA growth could change if a Sizewell C power station is planned and built. This would require a construction workforce, operating workforce and associated transport infrastructure and activity. The resulting GVA growth could therefore be greater and the SRN (A12 and A14) in this area could face challenges in supporting the needs of this energy project.

Figure 3-14 GVA Growth – SRN Dependent Sectors - East of England (2015-2030)



Source: Cambridge Econometrics

3.5.2.2. Retail and Leisure

The SRN plays an important role in the location decisions of major retail and leisure destinations as well as being important to providing access to these destinations. Out of town shopping centres and visitor economy assets are often accessed by car. Research by the National Trust suggests that more than seven out of ten tourism day trips and nearly eight out of ten holiday visits are made by car[17].

Within the retail sector there is an observed trend of retail and leisure occupiers wanting to cluster in sub-regional destinations that are highly accessible from a range of transport modes. The role of the SRN is to allow efficient movement of people and products to and from these destinations.

Research for the Strategic Economic Growth Plan has identified a range of drivers for retail and the SRN. These include the future importance of online shopping and how this impacts on journeys to retail centres and the number of delivery vehicles. The rise in demand for next/same day deliveries and returns of goods is rapidly changing the retail landscape and consequently demand for the SRN by the retail and distribution sector. The food and leisure offer within shopping centres is increasingly important to policy makers who are considering how transport hubs can also become retail destinations. Grand Central in Birmingham is one such example.

Leisure attractions are often concentrated where there is good accessibility, significant catchment populations and clusters with a critical mass of attractive retail, leisure or tourism destinations. The leisure and visitor economy offer is important to the national economy and reliant on the SRN. Table 3-4 highlights the proportion of visitors by residence and destination, showing large cross-regional visits that are likely to use the SRN. For example visitors to the Lake District (in the North West) are likely to use the M6 if coming from most parts of Britain. Although there are significant cross regional visits the majority of visitors to destinations originate within the same region, indicating the importance of local connections. Future research would help to better understand the factors influencing travel from further afield and if this could be increased by improved public transport or SRN provision in turn generating additional wealth.

Table 3-4 % of Visitors by Residence and Destination

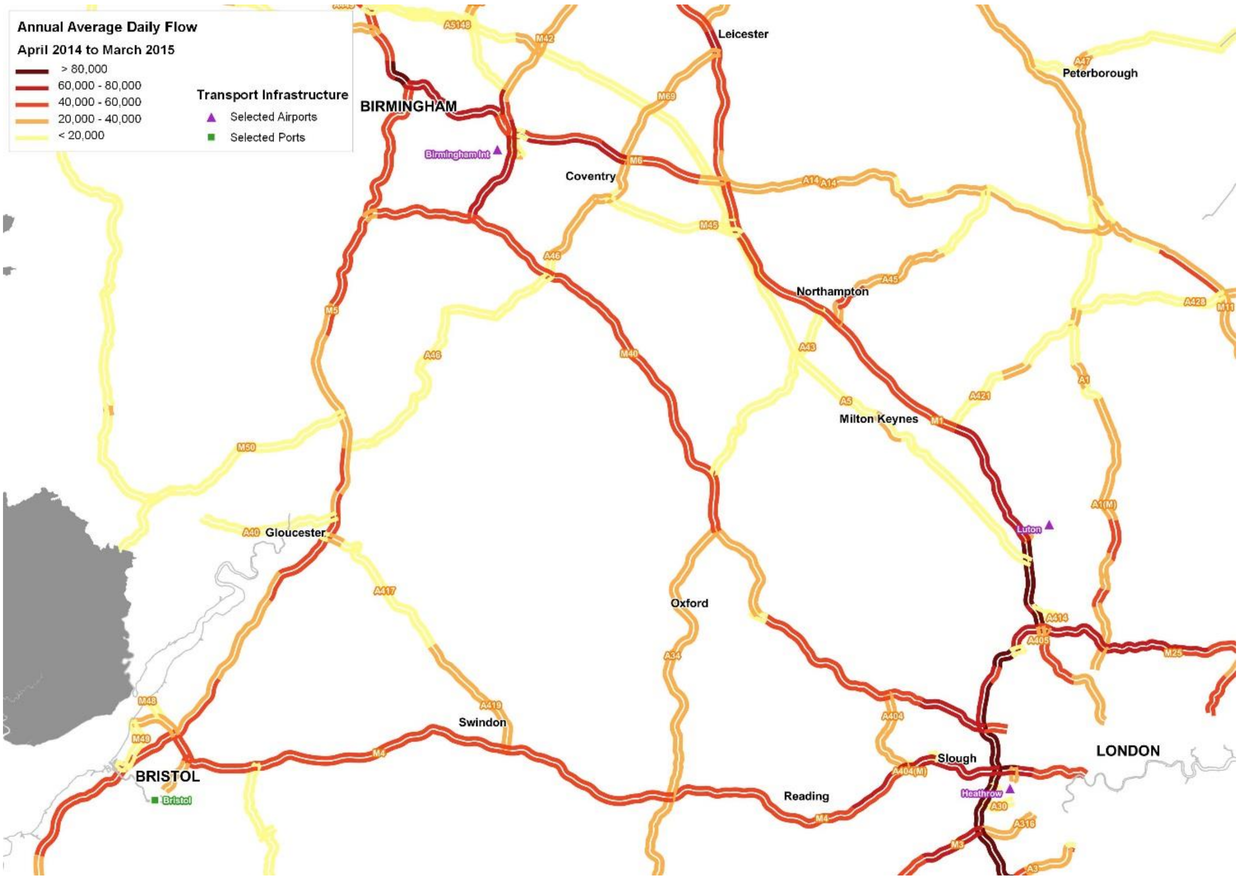
	Destination									
Region of Residence	**North East England**	**North West England**	**Yorkshire and The Humber**	**East Midlands**	**West Midlands**	**East of England**	**London**	**South East England**	**South West England**	**Northern Ireland**
North East England	69.5%	1.5%	2.7%	1.%	0.7%	0.5%	0.4%	0.8%	0.2%	7.4%
North West England	8.5%	79.3%	4.7%	2.0%	1.9%	1.4%	1.1%	0.8%	2.8%	1.5%
Yorkshire & The Humber	7.3%	4.8%	76.5%	6.1%	2.1%	3.5%	1.2%	1.1%	1.0%	12.4%
East Midlands	1.8%	2.3%	4.7%	70.2%	6.0%	5.0%	3.0%	1.3%	1.6%	18.0%
West Midlands	3.2%	3.5%	2.8%	6.1%	75.8%	1.2%	1.8%	2.2%	3.7%	0.7%
East of England	0.9%	0.7%	1.7%	4.6%	2.8%	75.1%	4.9%	4.9%	2.0%	18.2%
London	1.8%	2.0%	2.5%	3.6%	3.3%	7.1%	73.1%	14.1%	6.7%	13.1%
South East England	1.9%	1.1%	1.6%	3.6%	2.2%	4.7%	9.8%	70.2%	7.5%	14.2%
South West England	0.2%	0.9%	1.3%	1.2%	1.8%	1.2%	3.0%	3.4%	71.6%	0%

Source: Visit Britain UK

[17] National Trust evidence submission into Rural Tourism Submission for Wales.

Figure 3-15 highlights an area of the country where there are several tourism, retail and leisure attractions. The Cotswolds, to the east of the M5, are bound by the SRN. Several stretches of the SRN near to the Cotswolds have high average daily flows. Traffic has increased in the Cotswolds and its accessibility from Birmingham, Bristol and London has resulted in increased congestion, noise and visual disturbance.[18] Several of the routes near to and traversing the Cotswolds are busy throughout the year, with problems exacerbated during holiday periods.

Figure 3-15 Annual Average Daily Flows Bristol-Birmingham and London



Source: Highways England, HATRIS Data for April 2014 to March 2015. Received March 2016.

[18] http://www.cotswoldsaonb.org.uk/userfiles/position-statements/transport-2013.pdf

4. Economic Futures

4.1. Overview

This section assesses the demographic and economic future of England, highlighting key areas of growth and potential areas of importance for future analysis. It examines growth in population, economic activity and GVA in the whole economy, before then examining specific growth forecasts for SRN-sensitive sectors.

It should be highlighted the economic forecasts (GVA and employment) presented in this report are outputs from the Cambridge Econometrics local economic forecasting model. These forecasts represent only one illustration of scenarios of possible future economic change. These scenarios are strongly influenced by past trends and existing local structural factors, and do not take account of potential impact of policy or other market interventions.

4.2. Population Growth

As discussed in the previous chapter, 97% (51.3 million people) of England's population live within 15km of the SRN.[19] Area based population growth forecasts provide an indication of areas that are most likely to experience the strongest population growth. Connecting areas of future population growth with key employment locations is an important requirement of the SRN.

Key factors driving population growth include higher birth rates, rising life expectancy and increased migration. High population growth can place pressure on housing and services, including schools and healthcare. Areas with lower population growth (or population decline) can face challenges of reducing local tax base and increased pressure on services from increased proportions or numbers of older people.

Historic population growth shows that over the previous 25 years the population in and around key northern cities has declined (e.g. Newcastle, Liverpool, and Middlesbrough). In more recent years this trend has begun to reverse. Forecasts indicate this reversal in trend will continue with the urban areas forecast to have the highest growth rates. In some cases inward migration is a cause with people from outside the UK settling in cities, especially where housing is available. The long term trends for population change from migration are uncertain with limits on migration and free movement of people uncertain following the vote to leave the European Union.

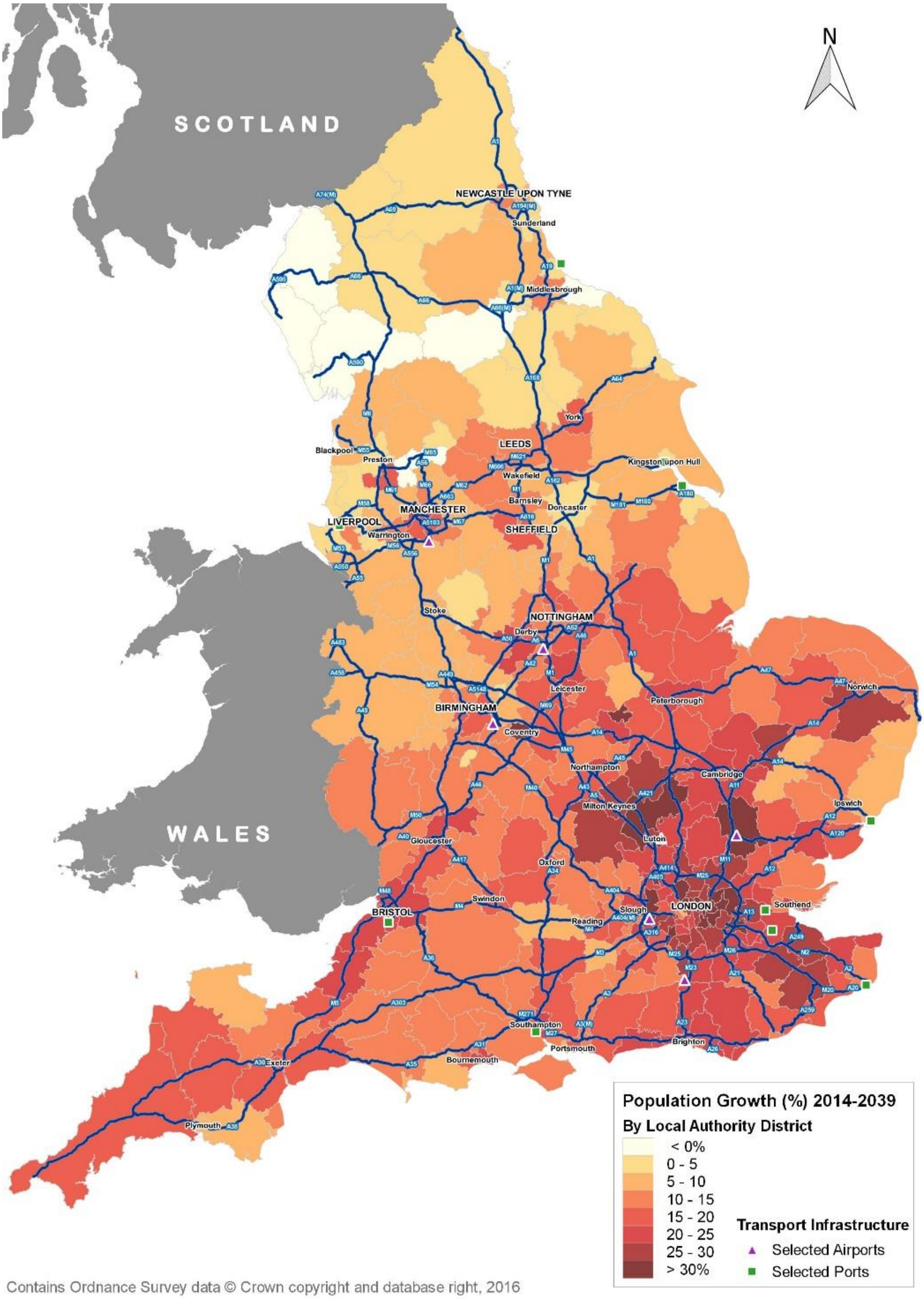
4.2.1. Population Growth and the SRN

Figure 4-1 shows the forecast pattern of future population growth. There are distinct patterns of population change: growth is strongest across the wider South East, East of England and South Midlands, with several areas of growth concentrated in urban areas in the South West, the Midlands and the North. Population is forecast to decline in some areas particularly rural parts of the North of England.

In the South, high growth is forecast in and around London, Kent, and north of London in Hertfordshire, Northamptonshire, Oxfordshire and Bedfordshire. The population in the South West and East Midlands has been growing strongly in recent years (see section 3.2). Growth is likely to continue in the South West, concentrated in the corridor between Somerset and Gloucester. The concentration in areas around the SRN is also evident in the Midlands around Birmingham, Coventry, Leicester and Nottingham. The corridor running north-east from the South West through Gloucester to Birmingham and Nottingham is forecast to experience significant population growth. Significant growth is also forecast in Cambridgeshire, Lincolnshire, Nottinghamshire and Leeds City Region.

[19] Based on 2011 Census data

Figure 4-1 Population growth (2014-2039)



Source: 2014SNPP Projected Population, 2014-based Subnational Population Projections (http://web.ons.gov.uk/ons/data/dataset-finder/-/q/dcDetails/Social/2014SNPP?p_auth=c4NIxraw&p_p_lifecycle=1&_FOFlow1_WAR_FOFlow1portlet_dataset_navigation=datasetCollectionDetails)

Areas with a high level of growth (>15%) and a significant base population are identified as key population growth areas. Parts of the network connecting these areas likely to be impacted by future growth are identified below. Key growth areas (and potentially impacted areas of the SRN) are:

Greater South East:[20]

- London
- Kent – London: M2, M20, A249
- Cambridge – London: M11, A11, A14
- Norwich area: A11, A47

South West:

- Cornwall and West Devon: A30, A38
- Exeter and East Devon: M5, A38, A30
- Taunton – Bristol – Gloucestershire: M5, M4

Central England:

- South East Midlands (including Oxford – Cambridge arc): M1, A5, A1, A428
- Birmingham and Coventry: M42, M6, A46
- Nottingham, Leicester and Derby: A50, A6, A52, A42, A46, A38, M1, M69
- Lincolnshire and eastern Nottinghamshire: A1, A46

North of England:

- Liverpool – Preston – Manchester: M6, M58, M60, M61, M62
- Leeds – Sheffield: M1, M62, M621

These areas indicate where the SRN could face increased demand in the future and where the SRN will need to support residential growth. It also highlights areas where wider infrastructure needs (e.g. schools or healthcare) could exert pressures on the SRN.

The drivers of population change are numerous with ageing population, social mobility, migration, affordability and access to jobs likely to be key influences on where people locate in the future. There is a predicted increase in the proportion of people aged 60 and over and this will have far reaching economic and social effects including use of services and housing. Areas of ageing population are (broadly) rural and coastal areas. There has been strong population growth in some coastal areas, notably Lincolnshire, and parts of Devon and Cornwall, driven by older people retiring to the coast.[21].

4.3. Future Employment and GVA Growth

This section presents evidence of future economic growth. It draws on detailed district level economic growth forecasts of GVA and employment, prepared by Cambridge Econometrics, to identify high growth areas and explores the role of the SRN in supporting the economy of England.

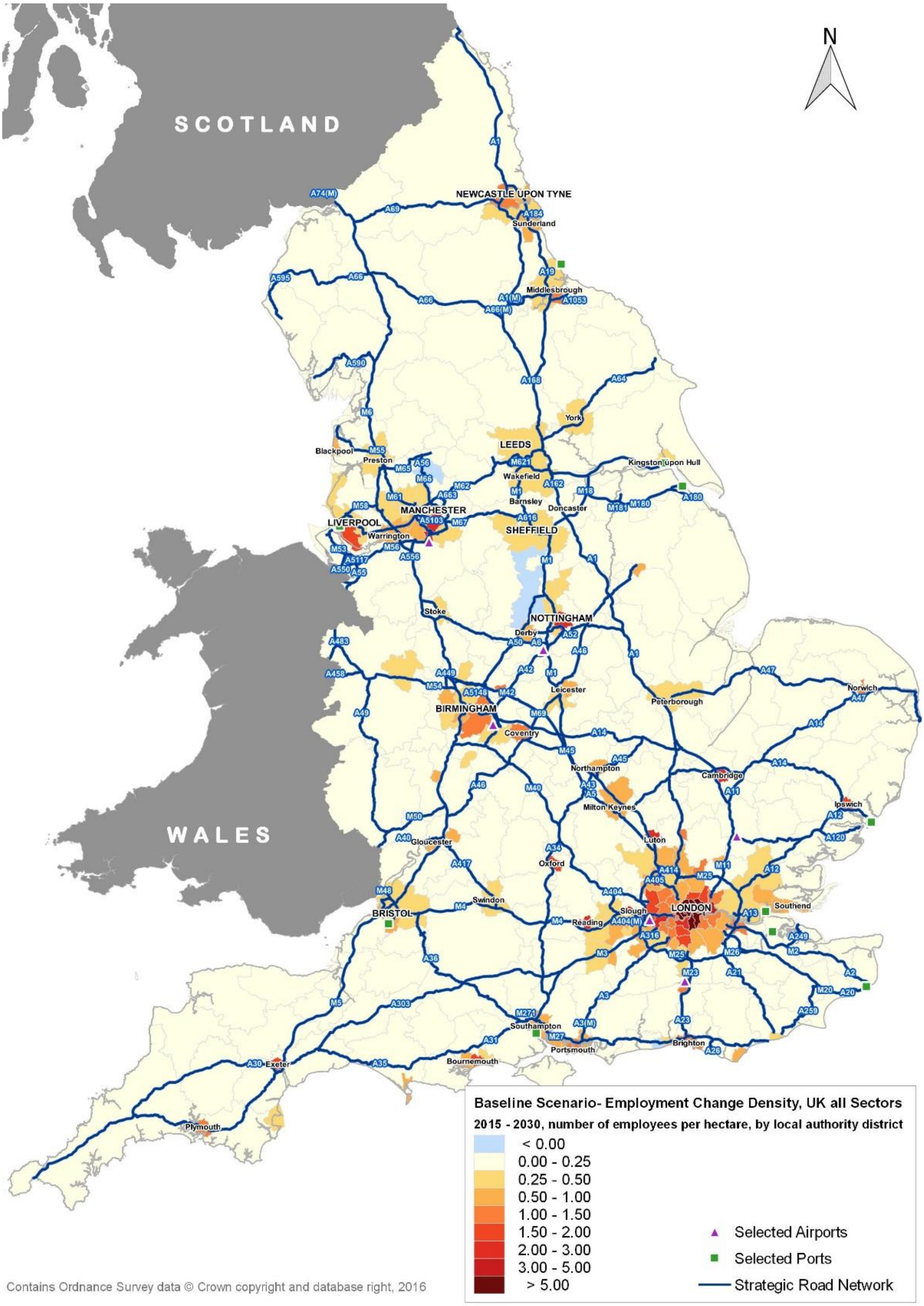
4.3.1. Employment Growth

An effective road network is critical in connecting businesses with their labour markets, and people to employment opportunities. Growth in city regions and inter-connectivity between them are key drivers of employment growth. Figure 4-2 shows the forecast increase in density of employment between 2015 and 2030 by mapping the change in the number of employees per hectare. It demonstrates that future employment growth will be concentrated in and around core cities and fast-growing centres such Oxford, Cambridge and York.

[20] Note: this is a broad order categorisation, it does not follow strict regional definitions or boundaries as a number of these corridors span regional borders.

[2121] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/514912/road-use-statistics.pdf

Figure 4-2 Change in Employment Density (2015-2030) Baseline Scenario - All Sectors [22]



Source: Atkins analysis of Cambridge Econometrics economic forecast data

[22] Econometric forecasts are to 2030 in contrast to population forecasts that are to 2039.

The map shows a strong relationship between employment density and the SRN, including routes radiating from the M25; the M1, M6 and M42 in the Midlands Engine; M5 in the West; the M62 belt connecting major cities in the Northern Powerhouse; and A1 and A19 in the North East. This confirms that concentrations of economic activity tend to be in close proximity to the SRN emphasising the enabling role of the network in supporting economic growth.

Forecasts indicate that growth is likely to be concentrated in Greater London and along routes to the west, north and south, in the major city regions, and in other hotspots such as Nottingham, Cambridge, Peterborough and York. Greater London and the South East, Birmingham, Leeds, Liverpool, Manchester, South Gloucestershire and Milton Keynes are forecast to have the highest increases in employment in terms of absolute change in the number of jobs created and in increased intensification of the number of workers per hectare (Table 4-1). This demonstrates that urbanisation and agglomeration of economic activity is a key driver of future employment growth and shows the importance of the SRN in serving and connecting concentrations of economic activity across England.

Table 4-1 shows that 25% of England's future employment growth will be concentrated in 15 locations[23]. The high representation of London boroughs and major cities demonstrates the role of large urban areas (in particular urban cores) in driving economic growth.

Table 4-1 Top 15 Employment Growth Districts 2015-2030

Top 15 Employment Growth areas	absolute change in employment 2015-2030 (number of jobs)	% of UK change
City of London	45,372	3%
Westminster	43,575	3%
Tower Hamlets	40,96	2%
Birmingham	32,317	2%
Camden	30,718	2%
Islington	29,401	2%
Leeds	26,386	2%
Cornwall UA	26,029	2%
Southwark	24,575	1%
Manchester	24,093	1%
Wiltshire UA	21,951	1%
Liverpool	20,930	1%
South Gloucestershire UA	20,416	1%
Hillingdon	19,931	1%
Milton Keynes UA	18,643	1%
top 15 total	**425,297**	
total England change	**1,726,895**	
top 15 as % of England total		**25%**

Source: Cambridge Econometrics Economic Forecasts 2016

Table 4-2 includes the top 15 employment growth areas outside Greater London. It shows that the highest employment growth is forecast in most (but not all) Core Cities, Cornwall, Wiltshire, Milton Keynes, Warrington, Peterborough and Shropshire. Even though they do not feature in the top 15 locations, Cambridge, Northampton, Norwich, Ipswich, York and coastal towns on the South coast are also have high forecast employment growth.

[23] Cambridge Econometrics economic forecasts produced for 326 local authority districts in England.

Table 4-2 Top 15 Employment Growth Districts outside Greater London 2015-2030

Top 15 Employment Growth areas outside Greater London	Absolute change in employment (total number of jobs)	% share of change in England
Birmingham	32,317	2%
Leeds	26,386	2%
Cornwall UA	26,029	2%
Manchester	24,093	1%
Wiltshire UA	21,951	1%
Liverpool	20,930	1%
South Gloucestershire UA	20,416	1%
Milton Keynes UA	18,643	1%
Nottingham UA	18,623	1%
Bristol, City of UA	16,496	1%
Newcastle upon Tyne	16,318	1%
Sheffield	12,855	1%
Warrington UA	12,837	1%
Peterborough UA	12,578	1%
Shropshire UA	12,222	1%
top 15 non-London total	292,694	17%
total England change	1,726,895	
top 15 as % of total UK		17%

Source: Cambridge Econometrics Economic Forecasts 2016

There forecasts provide evidence of economic activity spreading across a wider area around major urban agglomerations, particularly across the wider South where employment growth is strong in the Bristol to London corridor (Figure 4-3). There are a number of reasons for this spread of economic activity: although these can be location specific there are some common features. These include:

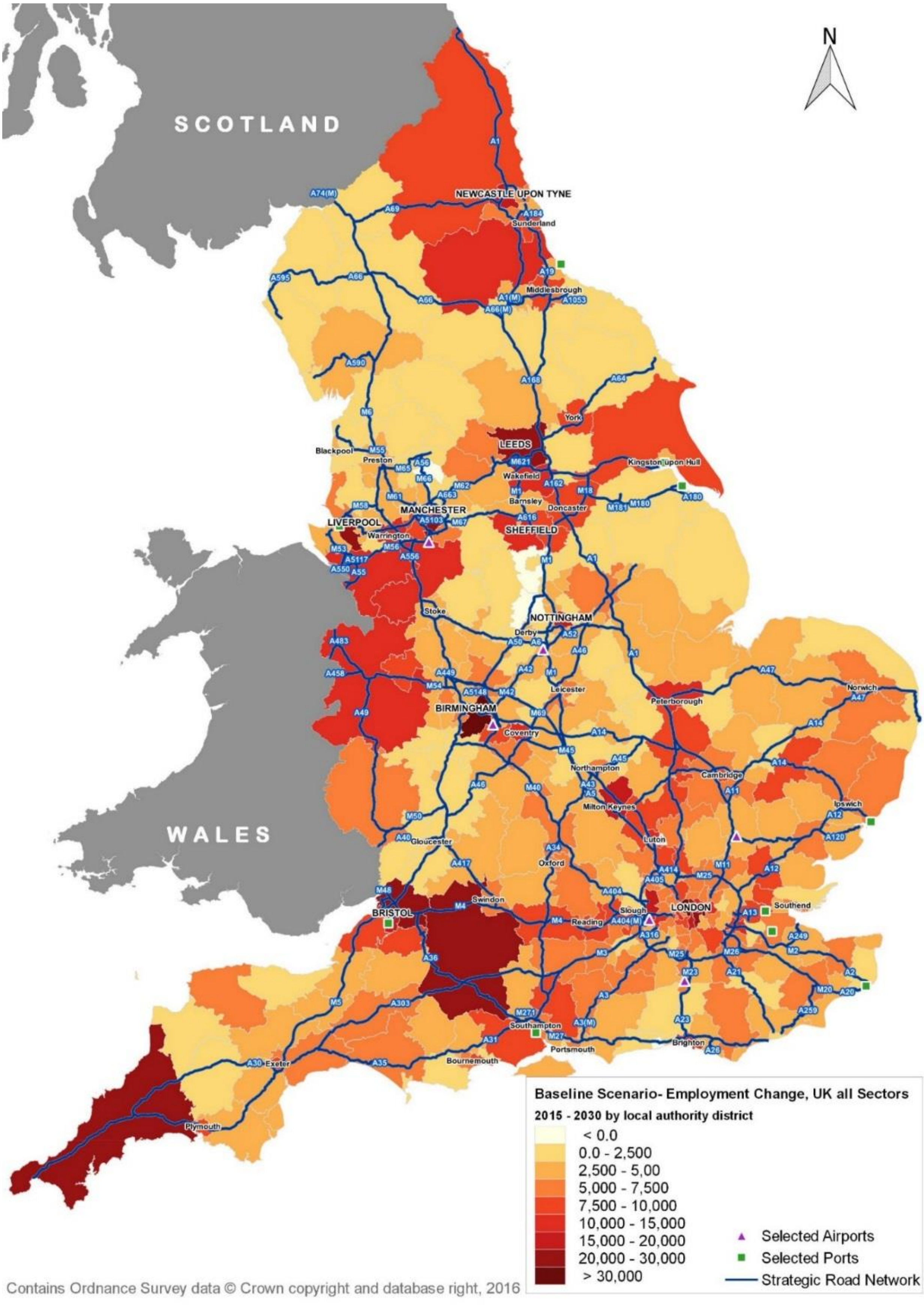
- Continued growth where economic dynamics are positive and supported by market forces;
- Increased local specialisation and clustering of economic activity outside the core cities but where there are specific locational advantages, e.g. being close to international gateways; and
- Spillover benefits of agglomeration through connectivity with centres of high economic mass and access to a large pool of skilled labour.

This spread is most evident across the South East on key corridors radiating from London. The Cambridge-Oxford arc, Shropshire, Wiltshire and Gloucestershire are examples of notable growth areas benefiting from proximity to core cities that have positive economic dynamics and are important areas for future employment growth. Employment growth in the North of England is less spread than in the South, however there is evidence of similar dynamics with areas that surround the core cities experiencing significant growth in employment. These include Cheshire (linked to growth in Greater Manchester) and Wakefield (as part of the Leeds City Region).

Access to high quality labour markets is an important determinant of business success. The development market analysis undertaken for the Strategic Economic Growth Plan highlights the trend of north-shoring and housing growth outside the major cities (mostly in the South) due to commercial and cost considerations. It will be important to ensure that future employment growth is matched by growth in a suitably skilled labour market to meet business needs. A potential area of future research would be to examine in more detail how forecast employment growth will be met by a skilled labour force with appropriate connectivity between jobs and labour markets. For example, employment growth across Cornwall is predicted to be relatively strong[24] and population growth is predicted to be moderately strong. However, if the growth in population is driven by an aging demographic, it will be necessary to consider if the labour supply will be sufficient to support predicted employment growth.

[24] Although it is recognised this growth is spread over a wider geographic area.

Figure 4-3 Employment Growth (2015-2030) Baseline Scenario - All Sectors



Source: Atkins analysis of Cambridge Econometrics economic forecast data

4.3.2. GVA and Productivity Growth

Economic output, as measured by GVA, is forecast to increase by 33% from 2015 to 2030. This means that economic output is expected to increase by c£450 billion over the 15 year period to c£1.8 trillion from the 2015 level of £1.3 trillion. This growth will be concentrated in the urban areas of England. It demonstrates that agglomeration economies and major urban conurbations will continue to be important drivers of growth in GVA and productivity.

Locations that have strong economic dynamics in place will continue to prosper and economic activity will intensify in these locations. Table 4-3 shows that growth in the major cities accounts for a significant proportion of GVA growth across England. The top 15 locations are forecast to account for 25% of total GVA growth across England. Eight of the top 15 locations within Greater London: these collectively account for 13% of the country's GVA growth to 2030. This will increase even more when the remaining districts of Greater London are added, demonstrating the continuing importance of London as a key driver of economic growth.

Table 4-3 Top 15 GVA Growth Districts 2015-2030

Top 15 GVA growth districts by value	Increase in total GVA (£m, 2015 prices)	% of England Growth
City of London	23,025	5%
Westminster	17,020	4%
Tower Hamlets	14,406	3%
Camden	8,450	2%
Birmingham	7,213	2%
Islington	7,118	2%
Leeds	6,376	1%
Southwark	5,882	1%
Manchester	5,083	1%
Bristol, City of UA	4,063	1%
Lambeth	3,989	1%
Wiltshire UA	3,845	1%
Milton Keynes UA	3,806	1%
Hammersmith and Fulham	3,598	1%
Sheffield	3,568	1%
Top 15 total	**117,442**	
England	**462,682**	
% of GVA growth in England		**25%**

Source: Cambridge Econometrics Economic Forecasts 2016

Table 4-4 includes the top 15 growth locations outside Greater London. Again, these are mainly located in city regions or areas neighbouring major cities (e.g. South Gloucestershire, Wiltshire and West Berkshire). Together these account for 12% of England's growth in GVA to 2030. Cornwall is an exception, partly due to it covering a large geographic area and therefore growth occurs over a wider area. However, Cornwall's contribution to GVA and employment growth is not negligible and, as shown in Figures A-2 and A-3, Cornwall is forecast to have high percentage growth. It is an important economic growth area for different reasons, more to do with local strengths as a visitor economy than urban agglomeration, nevertheless it is forecast to contribute significantly to future GVA growth.

Table 4-4 Top 15 GVA Growth Districts outside Greater London 2015-2030

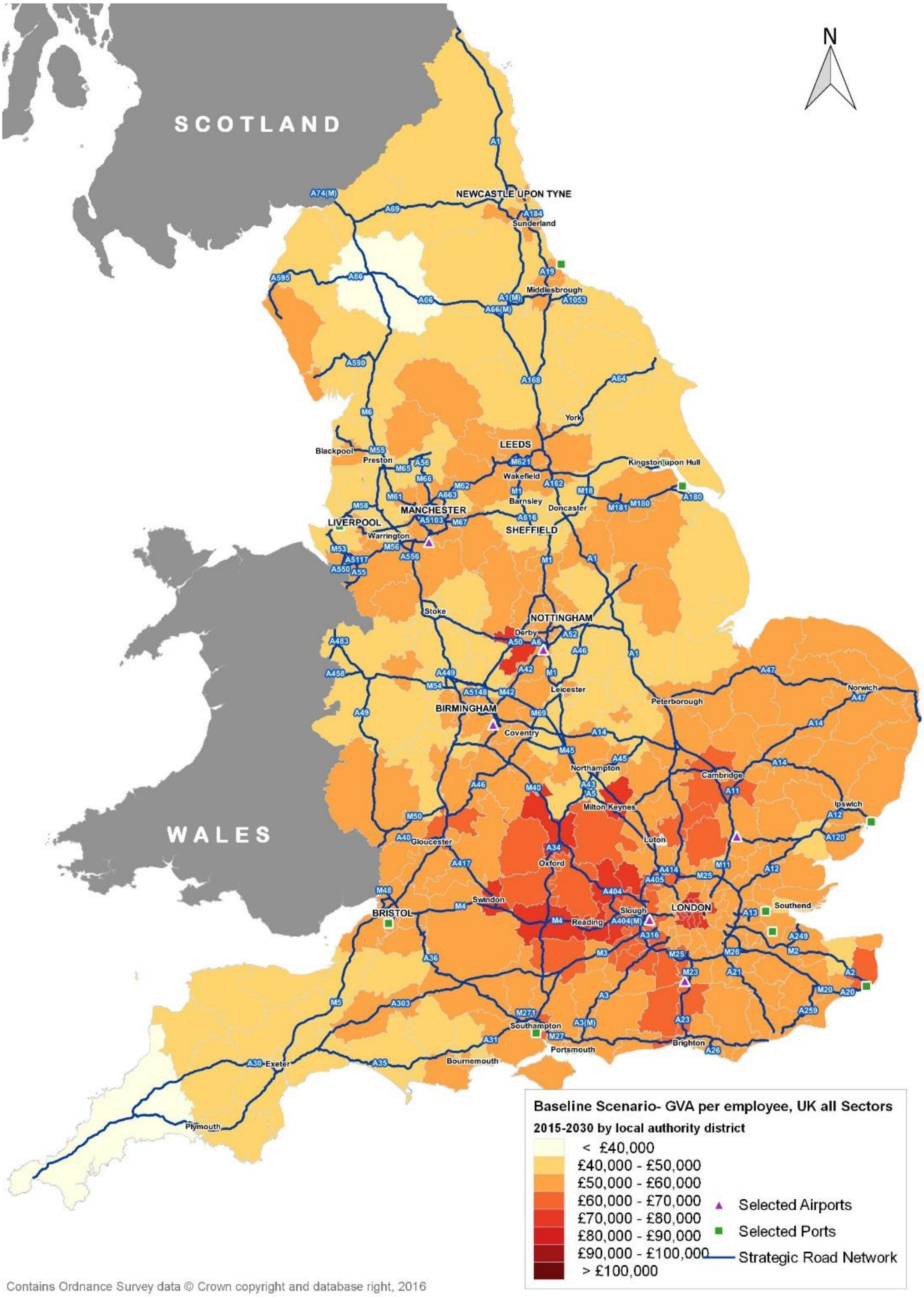
Top 15 GVA growth by value (outside Gtr London)	Increase in total GVA (£m, 2015 prices)	% of England Growth
Birmingham	7,213	1.6%
Leeds	6,376	1.4%
Manchester	5,083	1.1%
Bristol, City of UA	4,063	0.9%
Wiltshire UA	3,845	0.8%
Milton Keynes UA	3,806	0.8%
Sheffield	3,568	0.8%
Liverpool	3,452	0.7%
Cornwall UA	3,179	0.7%
Bradford	3,018	0.7%
Cheshire East UA	2,998	0.6%
South Gloucestershire UA	2,930	0.6%
Nottingham UA	2,747	0.6%
Swindon UA	2,625	0.6%
West Berkshire UA	2,571	0.6%
Top 15 total	**57,475**	
England	**462,682**	
% of GVA growth in England		**12%**

Source: Cambridge Econometrics Economic Forecasts 2016

Effective transport connectivity is an essential component in attracting highly productive businesses, which require easy access to markets, supply chains and skilled workers. A number of factors influence productivity, including sector mix, investment, innovation and workforce skills. International connectivity and access to global product and labour markets is an important factor in driving innovation and attracting investment. This is a key driver of GVA and employment growth in the area west and north of London, resulting in the continued growth of high value generating economic activity.

There is a strong relationship between connectivity and productivity in the economy. Intensification of business to business interaction leads to innovation, driving greater efficiencies and higher value business activities. Figure 4-4 shows forecast GVA per worker at local authority level, across England. This shows that differences between high productivity areas west and north of London, and low productivity in more peripheral areas, including Cornwall, Devon and Cumbria, will continue. It illustrates the effect of peripherality on economic performance. Conversely, the highest levels of productivity will be along the M4 corridor, which benefits from easy access to Heathrow.

Figure 4-4 GVA per employee 2030



Source: Atkins analysis of Cambridge Econometrics Economic forecast data

Property market analysis provides evidence of 'north-shoring' and relocation of higher value functions spreading across the area north and west of London and to Birmingham, Leeds, Liverpool, Manchester, Nottingham and Sheffield. This is a positive sign of an improving sector mix leading to higher productivity, wages and GVA growth across the country. Cambridge Econometrics forecasts support this analysis and show these locations to have high GVA and employment growth. Improvements in the network in parallel with wider policy support, investment in rail and local transport infrastructure, and expansion of the region's ports and airports will support productivity growth across the North and Midlands supporting the Northern Powerhouse and Midlands Engine concepts.

4.3.3. Summary

An effective road network is vital to the business community and therefore to employment growth. Businesses require effective connections to customers, supply chains and employees, and well-connected places tend to attract more businesses. Economic forecasts show that future growth will be concentrated around England's major cities (where the majority of the population is concentrated), including London, Birmingham, Bristol, Leeds, Liverpool, Manchester, Newcastle, Nottingham and Sheffield. There are other important hotspots in other cities and towns. These are England's most important agglomerations of business activity, which are characterised by both businesses serving local needs and specialist activities due to the competitive strengths of each location.

GVA growth increases are important for future SRN investment as this indicates higher growth in business and commuting related travel and in the movement of goods and services. Growth forecasts show a continued strengthening across the South. High value growth areas are concentrated around London and the South East with strong growth spreading across the wider region radiating out from London. The area north and west of London is a key area for GVA and productivity growth.

Analyses of economic growth forecasts demonstrate that the SRN is largely focused on the right corridors to serve future growth across England and that future investment should be focused on providing efficient connectivity between key growth clusters of urban agglomerations and connectivity between city regions to support economic growth. Growth in employment and GVA in peripheral regions would be enhanced by effective connections focused on particular needs of the local economy that reduce effective distance with urban agglomerations, improve access to international gateways and reduce journey times for tourists and leisure travellers.

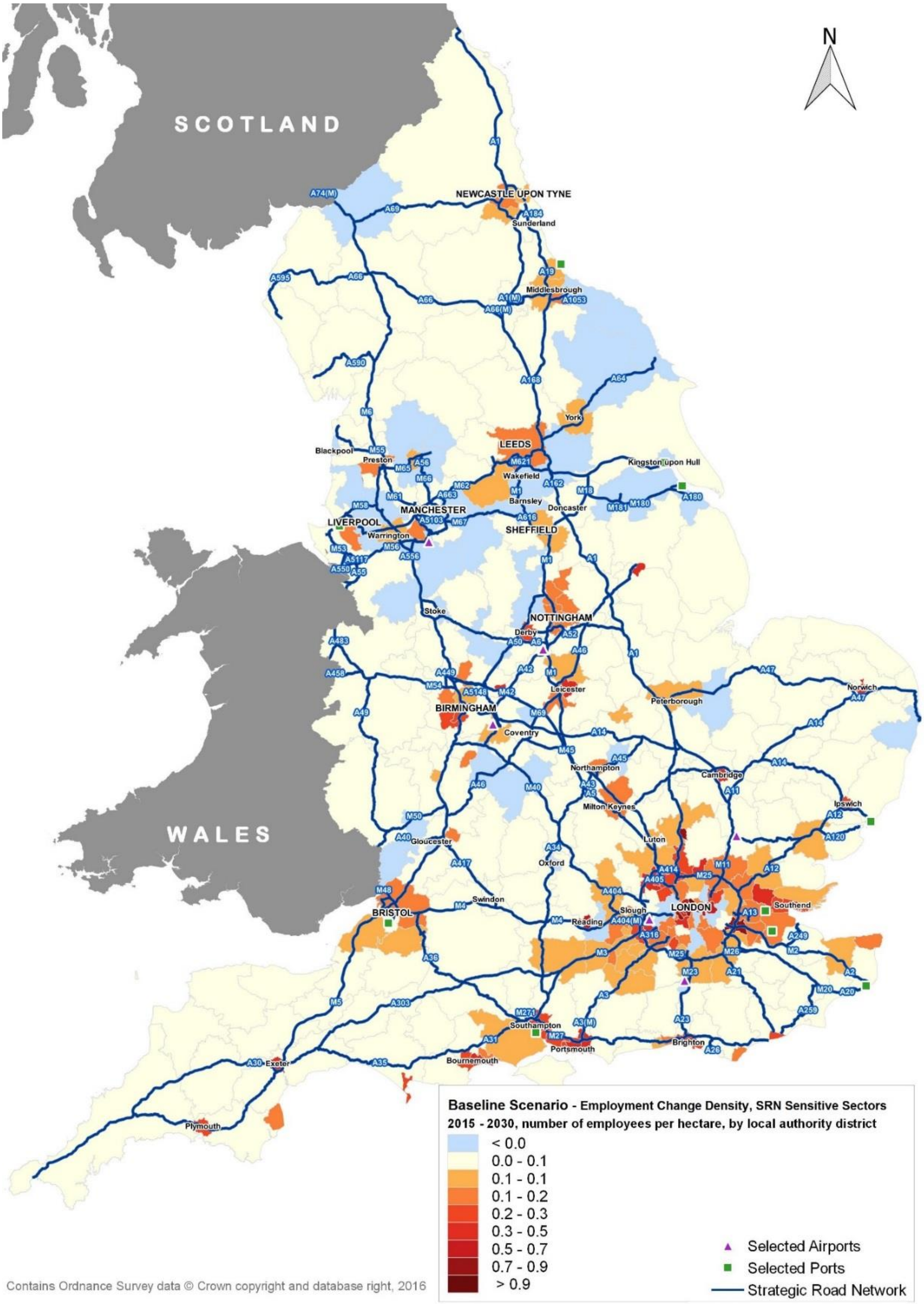
4.4. Future Growth in SRN Sensitive Sectors

This section presents forecasts in SRN-sensitive sectors. These were introduced in Section 3.5. The first part of this section discusses forecasts of employment growth, and the second part discusses GVA and productivity growth in these sectors.

4.4.1. Employment Growth in SRN Sensitive Sectors

Economic forecasts of SRN dependent sectors show that employment growth in these sectors will be increasingly concentrated around key nodes on the SRN and in close proximity to key cities. Figure 4-5 shows predicted change in employment density of SRN sensitive sectors across England. It shows that growth in SRN sensitive sectors will be concentrated on key corridors and nodes served by the SRN, including routes in the South East radiating from Greater London and around the city regions of Birmingham, Bristol, Leicester, Nottingham and Leeds. Other hotspots are Milton Keynes, Manchester, Liverpool, York, Middlesbrough, Newcastle and the southern coastal towns. Many areas are forecast to experience reductions in employment, indicating that future growth will be increasingly concentrated in key areas where there are locational advantages.

Figure 4-5 Change in Employment Density in SRN Sensitive Sectors 2015-2030



Source: Atkins analysis of Cambridge Econometrics economic forecast data

This demonstrates the importance of the network in providing high quality transport connectivity with centres of economic mass and ports and airports to the functioning of these sectors. South Gloucestershire is forecast to be an important growth area for SRN sensitive industries. It is the highest employment growth location and in the top ten locations for GVA growth. Greater London and the wider South East have high concentrations of SRN dependent businesses that provide goods and services to high density business and resident populations. Connectivity to the key ports and airports is critically important, for example south east of London through Dartford to London and Medway ports.

A notable pattern of future growth is that key growth locations are not concentred *within* core cities but are located *around* them. This reflects the locational advantages of having access to and being able to serve a range of markets. It enables businesses in these sectors to avoid high rents and input costs of city centre locations. Each SRN sensitive sector requires effective connectivity but the industrial and logistics sectors have a particularly strong dependence on the SRN, with good quality access to international gateways and domestic markets. Future employment in SRN sensitive sectors is likely to further concentrate in areas with good access to the SRN.

Patterns of future growth show the importance of manufacturing in the West Midlands, Derby, Sunderland and Swindon, logistics hubs along the M1, M6 and M62, and port-related employment in Southampton, Portsmouth and Liverpool. Table 4-5 includes the top 15 employment growth areas in terms of absolute change in employment numbers. It shows that growth in these sectors is not strongest in the major cities (in contrast to that for employment growth across all sectors of the economy). In the case of Greater London, areas on the M25 and to the east of London are the focus for growth. Leeds and Milton Keynes are the only cities that feature in the top 15. Areas around key ports and airports are forecast to have high employment growth highlighting the importance of international gateways as key drivers of future growth in SRN dependent industries.

Table 4-5 Top 15 SRN Sensitive Employment Growth Districts 2015-2030

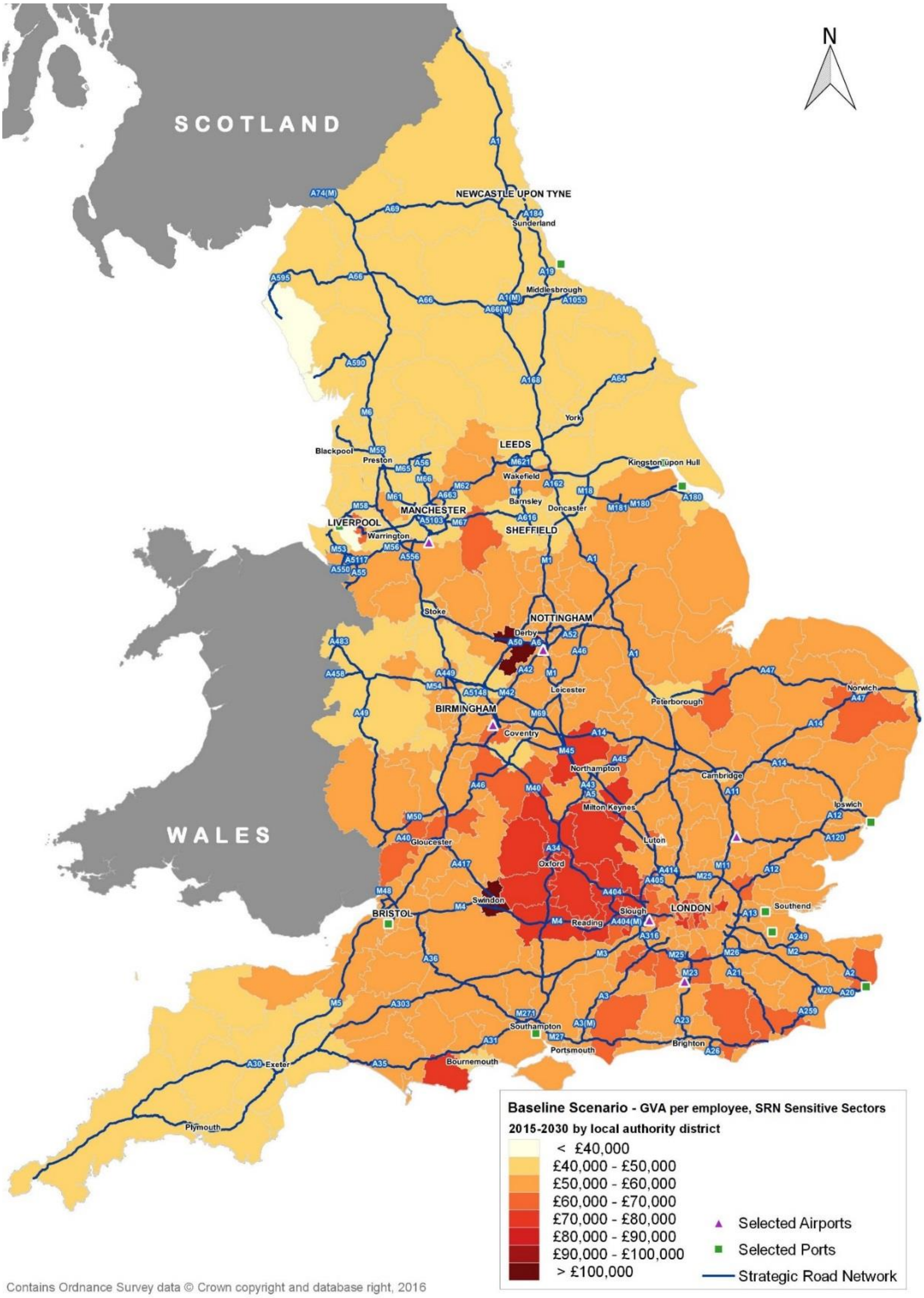
Top 15 Employment Growth areas	Change in employment (SRN sensitive sectors)	% of England change
South Gloucestershire UA	6351	1.9%
Leeds	5836	1.8%
Dartford	5386	1.6%
Basildon	4300	1.3%
Epping Forest	3916	1.2%
New Forest	3909	1.2%
Thurrock UA	3658	1.1%
Milton Keynes UA	3641	1.1%
Basingstoke and Deane	3211	1.0%
Leicester UA	3173	1.0%
Kirklees	3028	0.9%
East Devon	3019	0.9%
Portsmouth UA	2925	0.9%
Medway UA	2853	0.9%
Three Rivers	2848	0.9%
top 15 total	**58054**	
total SRN sectors change	**328021**	
top 15 as % of England total		**18%**

Source: Cambridge Econometrics Economic Forecasts 2016

4.4.2. GVA and Productivity Growth in SRN Sensitive Sectors

Figure 4-6 shows the forecast productivity in 2030 for SRN sensitive sectors.

Figure 4-6 GVA per Employee SRN Sensitive Sectors 2030



Source: Atkins analysis of Cambridge Econometrics Economic forecast data

The highest levels of productivity are in the area to the north and west of London. The M5, M40 and M42 corridors are also forecast to have high levels of productivity, including SRN dependent industries. This demonstrates the significant locational advantages of this area, with good reach and accessibility to the capital, Heathrow and a number of England's other major cities. There are notable hotspots of high productivity in Derby[25] and Swindon. Productivity is forecast to be significantly lower in the far South West and far North of England where peripherality is a challenge with long distances and journey times to markets. Productivity will also be lower in the West Midlands and urban areas in the North, indicating that other factors will also be important in driving performance.

GVA and productivity growth is highest where there are high value sectors that benefit from international connectivity, good access to major domestic markets and specialised business clusters. High growth is predicted where high value business clusters in logistics, advanced manufacturing and aerospace are located around the western and eastern edges of the M25, benefiting from close proximity to the country's main airports and ports and access to highly skilled labour.

The SRN is vital to the industrial and logistics markets. These industries have a high dependence on the SRN to transport goods and services to key markets generating a high frequency of trips that are often long distance. A primary purpose of the SRN is therefore to support these sectors and to provide capacity for growth.

Table 4-6 shows the top 15 highest GVA growth areas for SRN sensitive sectors.

Table 4-6 Top 15 SRN Sensitive GVA Growth Districts 2015-2030

Top 15 SRN sectors GVA growth by value	Increase in total GVA (£m, 2015 prices)	% of total SRN sectors growth
Birmingham	1,646	1.5%
Westminster[26]	1,451	1.3%
Leeds	1,425	1.3%
Swindon UA	1,161	1.1%
Milton Keynes UA	961	0.9%
Wiltshire UA	958	0.9%
Cornwall UA	881	0.8%
Bristol, City of UA	875	0.8%
Bradford	826	0.7%
South Gloucestershire UA	811	0.7%
Kirklees	809	0.7%
Cheshire East UA	758	0.7%
Camden	743	0.7%
Ealing	738	0.7%
Sheffield	737	0.7%
top 15 total	**14,780**	
total 6SRN change	**110,333**	
top 15 as % of total England		**13.4%**

Source: Cambridge Econometrics Economic Forecasts 2016

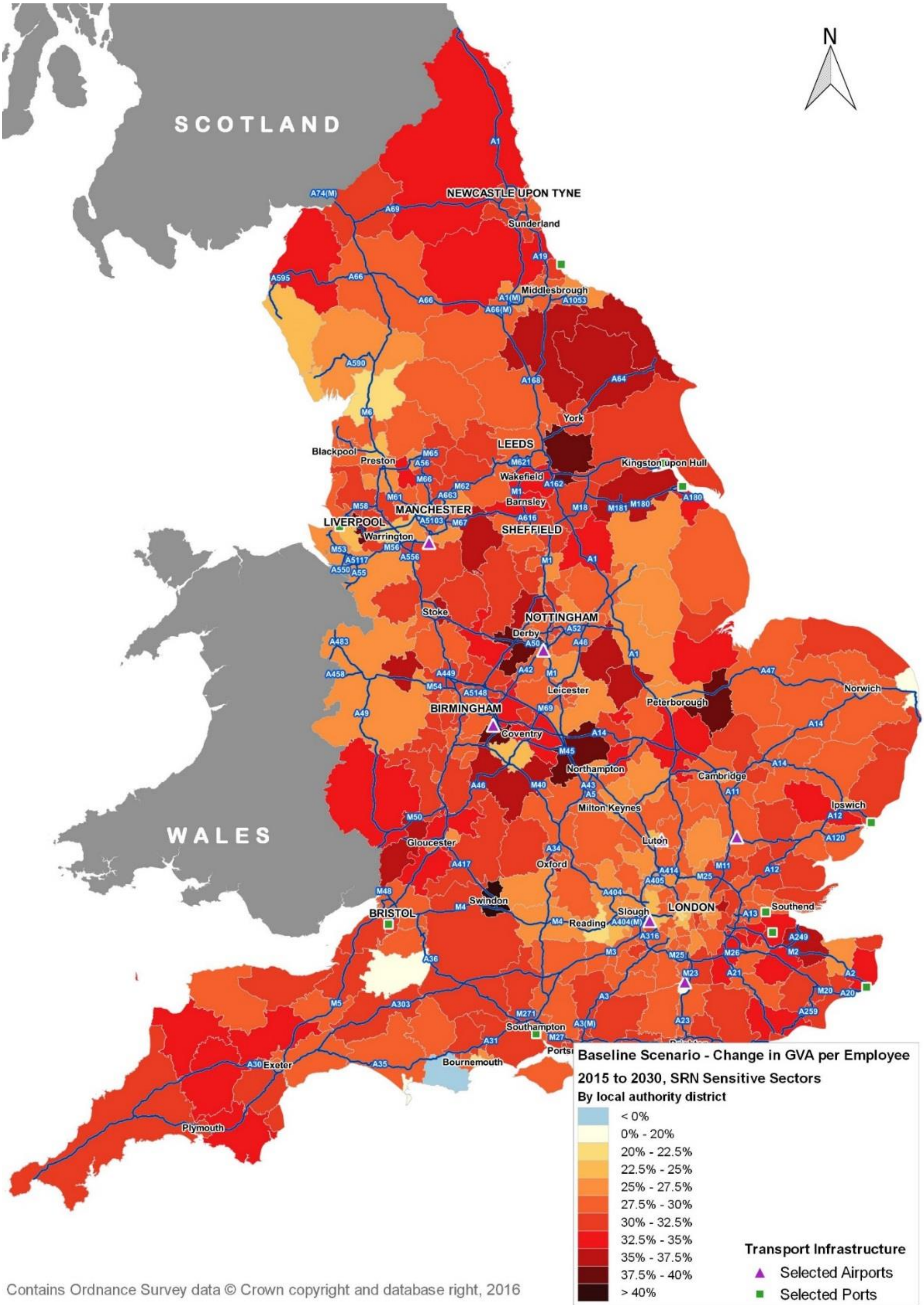
[25] Toyota and Bombardier are examples of major businesses located in Derby.
[26] The large growth in Westminster is likely to be due to the large presence of the retail industry (one of the SRN-dependent sectors) and Headquarters of organisations located in Central London.

Birmingham is predicted to have the highest growth in GVA demonstrating the importance of the Midlands as a growth area for manufacturing and logistics companies. Bradford, Kirklees, Leeds and Sheffield and are all in the top 15 locations demonstrating that this is a key area for growth in SRN dependent sectors. The appearance of London boroughs in this list indicates the economic strength of these areas and the relatively high proportion of SRN dependent sectors in their sector mix.

The SRN is vital to support business growth and spread of high value sectors that underpin improvements in productivity and spatial rebalancing of the economy. Productivity in key SRN sectors across large parts of the North is lower, reflecting lower value business activity. Peripherality, sector mix and distance from areas of high economic mass are key issues. However there is evidence of future productivity growth in the Midlands, Yorkshire and the North East suggesting the potential to rebalance the economy and reduce the productivity gap between these regions and the South.

Figure 4-7 shows the forecast change in productivity of SRN sensitive sectors across England. This shows a number of areas in the North and Midlands where productivity is forecast to grow at a faster rate than in the South. Notable areas are around Northampton, Solihull, Telford and South Derbyshire in the Midlands, and Selby and North Lincolnshire in the North. National infrastructure projects such as HS2 and predicted growth in Manchester Airport, Immingham, Tees and Liverpool Ports have the potential to drive productivity growth across the North. The SRN will need to support these expansion plans to drive economic growth in the North and sectoral and spatial rebalancing of the economy.

Figure 4-7 Change in Productivity in SRN Sensitive Sectors 2015-2030



Source: Atkins analysis of Cambridge Econometrics Economic forecast data

4.4.3. Summary

Growth in employment and GVA for SRN sensitive sectors is forecast to be strongest around areas that have good access to markets and international gateways. Businesses operating in these sectors tend to concentrate on key nodes on the SRN where they have good access to markets across the country, which is particularly evident in the industrial and logistics markets. Key growth areas are around the M25, particularly east to Dartford and Medway port; and the heart of England, north and west of London. The London – Bristol – Birmingham triangle is a high productivity area and an important location of future growth in SRN sensitive sectors.

The advanced manufacturing, aerospace and automotive sectors, together with specialised business clusters that are frequent users of the SRN, are key industries with strong growth dynamics where economic growth will be driven by gains in productivity. Particular hotspots are around Derby, Swindon, West Midlands and Sunderland, and port-related activity in Southampton, Portsmouth and Liverpool. Derby has a high concentration of businesses in advanced transport manufacturing (including rail, aerospace and automotive) and has particularly strong growth potential. Motorsport Valley also has a strong concentration of businesses in the advanced automotive sector with strong growth potential.

GVA and employment growth is predicted to strengthen in areas where it is currently strong, across London and the South East, and west of London. However, in contrast to growth across all sectors of the economy, there is a wider spread of growth in the SRN sensitive sectors. West Yorkshire, around Leeds and Sheffield; and the South West around Bristol, Wiltshire and Gloucestershire will be important growth areas for SRN dependent industries.

Future growth forecasts provide support for spatial rebalancing of the economy. A number of areas across the Midlands and the North have strong growth dynamics with productivity predicted to grow at a higher rate than the South. Future investment in the network targeted in the right locations could support productivity growth across regions with low productivity and help balance productivity growth across wider areas of the economy.

4.5. Economic Growth Areas

Table 4-7 provides a summary of important areas of economic growth identified through analysis of economic and population data. Each area represents a cluster where economic growth dynamics are strong and future growth will impact on the SRN. The table identifies key routes that could be identified by growth in each area. It does not aim to identify exact links or locations with specific congestion issues.

The SRN is integral to location decisions and the functioning of key business sectors that are dependent on the road network. It plays a critical role in serving and connecting urban agglomerations and international gateways. The above analysis shows that the SRN is largely in the right places to serve locations of high economic growth and is largely focused on the right corridors to serve future growth in sectors that are particularly dependent on the SRN. There are a number of primary users of the SRN – manufacturing and primary materials are examples – that are concentrated in locations for historical reasons or for access to raw materials and for specific needs of the manufacturing process. It is important the SRN serves the needs of these sectors to support their future growth.

The prevalence of congestion in each area suggests that traffic conditions on the network could be a constraint on economic growth. However, there are number of RIS1 schemes addressing congestion and capacity issues within important growth areas. The challenge is for the SRN to provide sufficient capacity and quality to support future economic growth.

The following table summarises findings from the preceding analysis. A key economic growth area is defined as having strong population and economic growth dynamics, proximity to international gateways and a high concentration of SRN dependent sectors. Congestion in these areas is indicative of the need for interventions to support economic growth. Highways England is already addressing issues on parts of the network identified through current or planned RIS1 investments. This could form the basis for directing more detailed future research into investigating the extent to which RIS1 and future RIS programmes support economic growth across the country.

Table 4-7 Key Economic Growth Areas

Key Growth Areas	Roads impacted	Population Growth – is it a high population growth area?	GVA and Employ-ment – Is it an area of strong economic growth?	SRN sensitive sectors – Is it a key location for SRN sensitive sectors?	International Gateway – is there a significant port or airport in or close to the area?	High Congestion / Delays – Is congestion an issue?	RIS 1 Scheme – Is a there a RIS1 scheme in the area?
Greater London and the South East: Routes radiating from London • East of London – Dartford, Medway • Surrey, Sussex, Kent to London • North of London	M25, A12, A13, M2 M20, M26, A21, M23, A23, M1	Yes	Yes	Yes	Yes	Yes	Yes
North and West of London: • Berkshire, Oxfordshire, Buckinghamshire	M4, M3, A404, A34, A303	Yes	Yes	Yes	Yes	Yes	Yes
Bristol, Swindon, Gloucester, Wiltshire	M5, M4, A417/ A419	Yes	Yes	Yes	Yes	Yes	No
Oxford–Cambridge arc – Luton, Milton Keynes, Peterborough	M40 A34, M1 A5, A41, A421 A428	Yes	Yes	Yes	Yes	Yes	Yes
Birmingham, Leicester, Derby, Nottingham and Coventry	M6 A6 A50 A42, A52, A46, A38	Yes	Yes	Yes	Yes	Yes	Yes
Manchester, Liverpool, Warrington, Leeds, Sheffield, York, West Yorkshire and Cheshire	M62, M621, M1, M58, M56, , M60, A5103, M6, A1, A64	Yes	Yes	Yes	Yes	Yes	Yes
Newcastle, Sunderland, Middlesbrough	A1, A19, A66, A69	No	Yes	Yes	Yes	Yes	Yes
Portsmouth and Southampton	A3, A34, M3, M27, M271	Yes	Yes	Yes	Yes	Yes	Yes
Cornwall - Devon	A38, A30, M5, A303	Yes	Yes	Yes	No	Yes	Yes

5. Conclusions

The SRN supports economic growth through four key mechanisms:

- Improving productivity, through improving efficiency, facilitating agglomeration economies and increasing competition;
- Increasing domestic and international trade;
- Facilitating investment by businesses and developers, as well as supporting inward investment; and
- Supporting employment growth through better access to employment opportunities.

The SRN is a key factor in location decisions of firms and workers and therefore plays a critical role in supporting the location of economic activity. The data and maps presented in this report indicate that the SRN is a key determinant in shaping the pattern of economic activity across the country – particularly for certain sectors. A primary purpose of the SRN is therefore to support these and related sectors and to tackle the barriers to growth caused by the transport system.

Urbanisation and growth in city regions are key drivers of population and economic growth. Analysis of employment density, business density and trends in the commercial property market support the focus on England's main city regions as the primary location for future growth. Current trends indicate that employers and employees increasingly prefer city centre locations for office-based activities. Market demand for office space is focused on large town and city centre locations, fuelled by knowledge based jobs clustering in central locations. Activity in the office sector is forecast to continue concentrating developments in urban areas, in particular city centre locations. The SRN has a limited role in supporting movement within city centres. However as jobs concentrate in city centres, the growth of wider city regions means that the SRN plays a key role in connecting different parts of the city region, for both business and commuting trips. There is also a strong interdependency between the SRN and the local road network in reinforcing the roles of each in supporting economic growth.

Future employment growth will be concentrated in and around core cities and other growing centres. The top 15 districts are forecast to contain 25% of total employment and GVA growth across England, indicating a concentration of economic activity in key locations. This shows a strong relationship between employment density and the SRN, including routes radiating from the M25, M1, M6 and M42 in the Midlands, M5 in the West, the M62 belt connecting major cities in the Northern Powerhouse, and A1 and A19 in the North East. London and the South East are the most prosperous regions in England and are forecast to be the highest growth areas in terms of economic contribution.

Economic data indicates a strong relationship between productivity and international connectivity. GVA and productivity growth is forecast to be highest where there are high value industries and business sectors that benefit from international connectivity, good access to the major domestic markets and specialised business clusters. High growth is predicted where high value business clusters in logistics, advanced manufacturing and aerospace are located. The corridors radiating north, west and east from the M25 benefit from close proximity to the country's main airports and ports, and access to highly skilled labour. Economic forecasts indicate these areas will continue to generate productivity and employment growth in the future and are therefore important for future economic growth.

The SRN is vital to support business growth and spread of high value sectors that underpin improvements in productivity and spatial rebalancing of the economy. Productivity in key SRN sectors across large parts of the North of England is lower, reflecting lower value business activity. Peripherality, sector mix, and distance from areas of high economic mass are key issues. However there is evidence of future productivity growth in the Midlands and the North, suggesting the potential to rebalance the economy and reduce the productivity gap between these regions and the South.

Illustrative scenarios of future economic growth support recent Government initiatives aimed at encouraging the spatial rebalancing of the economy. A number of areas across the Midlands and the North have strong growth dynamics with productivity predicted to grow at a higher rate than in the South. Future investment in the network targeted in the right locations could potentially support productivity growth across regions with low productivity and help balance productivity growth across wider areas of the economy.

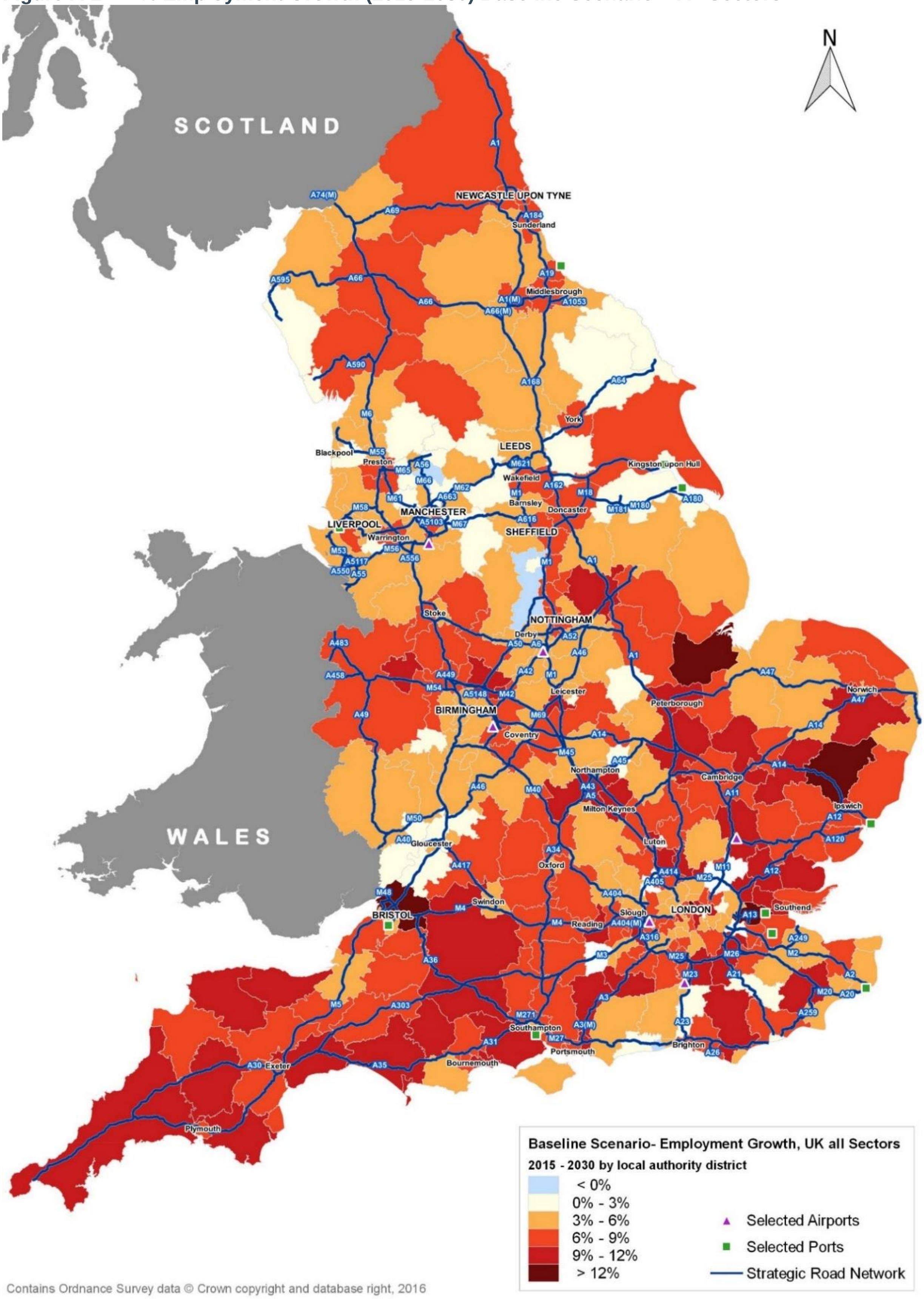
Economic forecasts for sectors dependent on the SRN show that concentrations of growth are clustered around the SRN and international gateways. A notable pattern of future growth in SRN dependent sectors is that key growth locations are not concentred within core cities *themselves* but are located *around* them. This reflects the locational advantages of having access to and being able to serve a range of markets. It demonstrates the importance of the network in providing high quality transport connectivity with centres of economic mass and ports and airports to the functioning of these sectors.

There are signs of growth spreading across a wider area around major urban agglomerations, particularly across the South, where employment growth is strong along the Bristol to London corridor. There are a number of reasons for this spread of economic activity and although these can be location-specific there are some common features. These include continued growth where economic dynamics are positive and supported by market forces; increased local specialisation and clustering of economic activity outside of the core cities but where there are locational advantages of being in proximity to international gateways and high quality transport links; and spillover benefits of agglomeration through connectivity with centres of high economic mass and access to a large pool of skilled labour.

Analyses of economic growth forecasts demonstrate that the SRN is largely focused on the right corridors to serve future growth across England. Future investment should be focused on providing efficient connectivity between key growth clusters of urban agglomerations and connectivity between city regions to support economic growth. Growth in employment and GVA in peripheral regions would be enhanced by effective connections that reduce effective distance with urban agglomerations, improve access to international gateways and reduce journey times for tourists and leisure travellers.

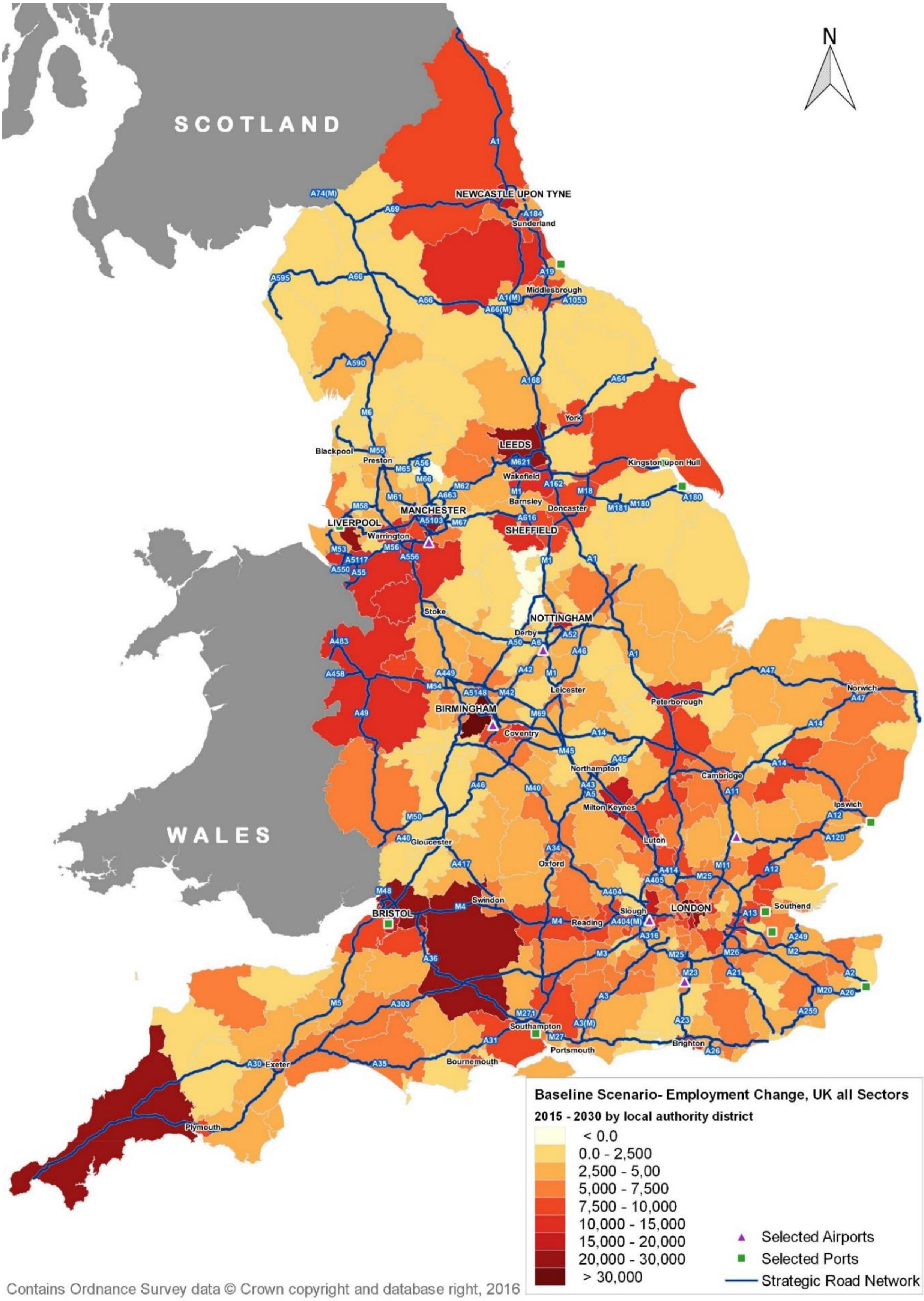
Appendix A. Growth Forecast Maps

Figure A-1 % Employment Growth (2015-2030) Baseline Scenario – All Sectors



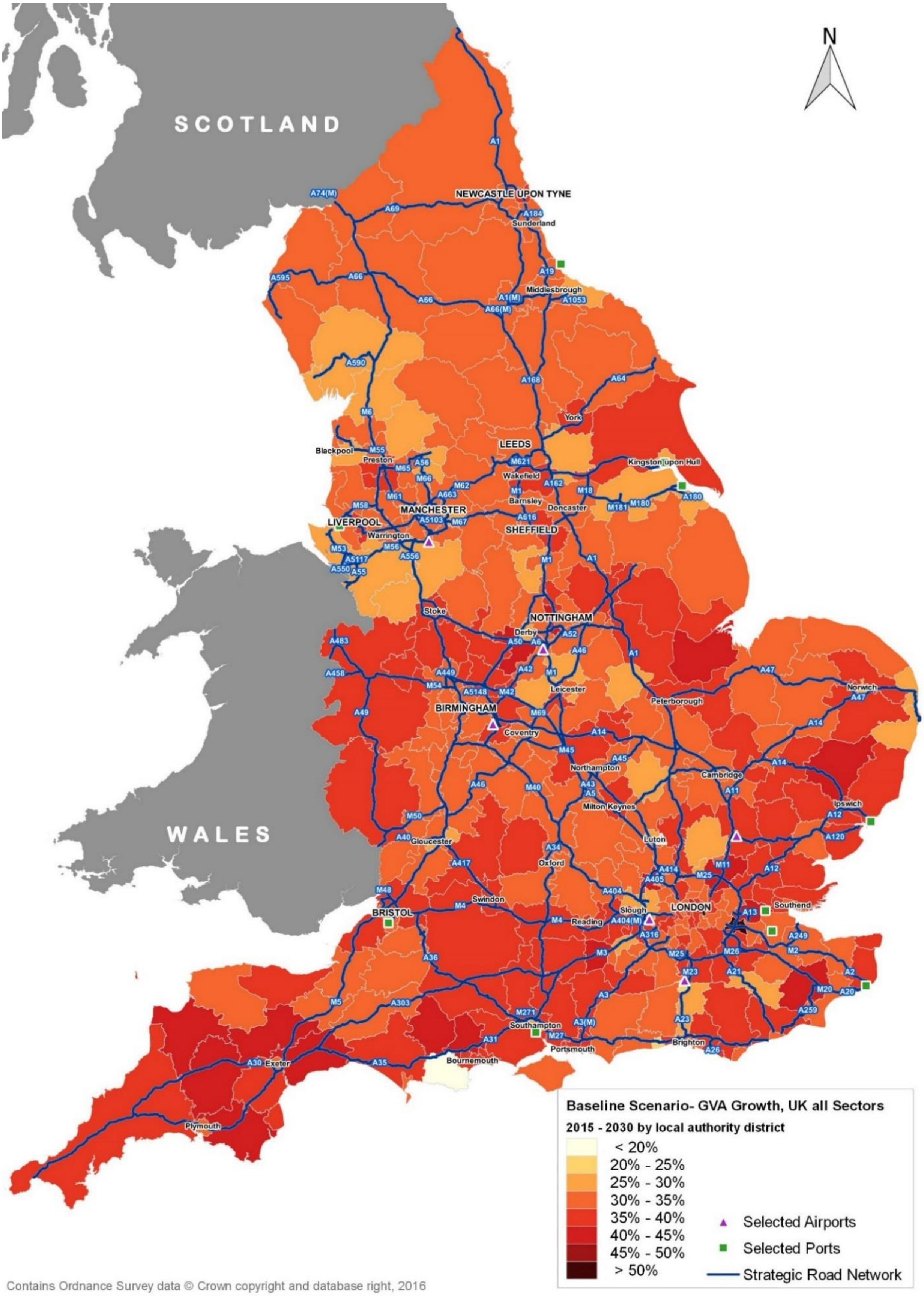
Source: Atkins analysis of Cambridge Econometrics Economic forecast data

Figure A-2 Employment Growth (2015-2030) Baseline Scenario- All Sectors



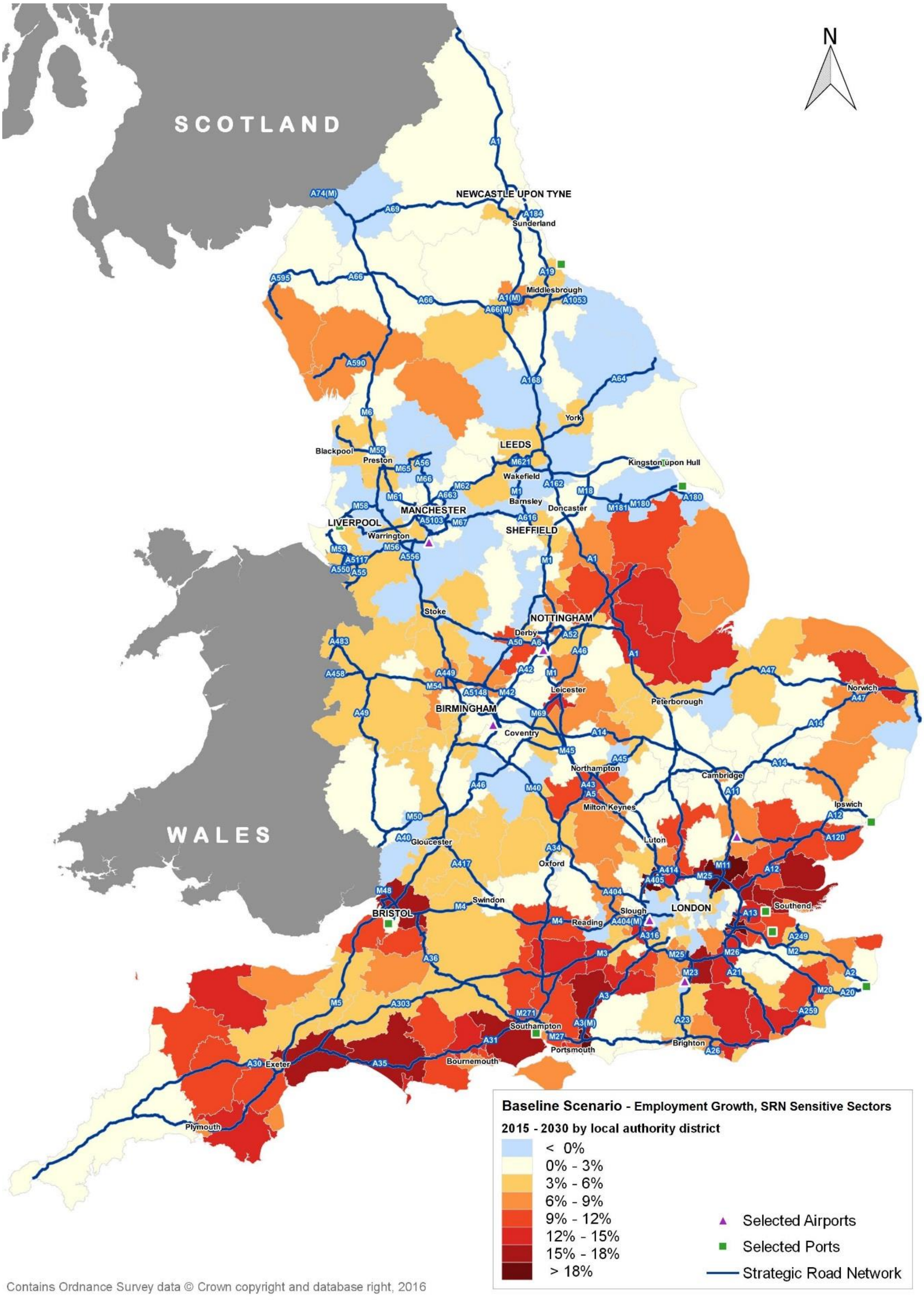
Source: Atkins analysis of Cambridge Econometrics Economic forecast data

Figure A-3 % GVA Growth (2015-2030) – All Sectors



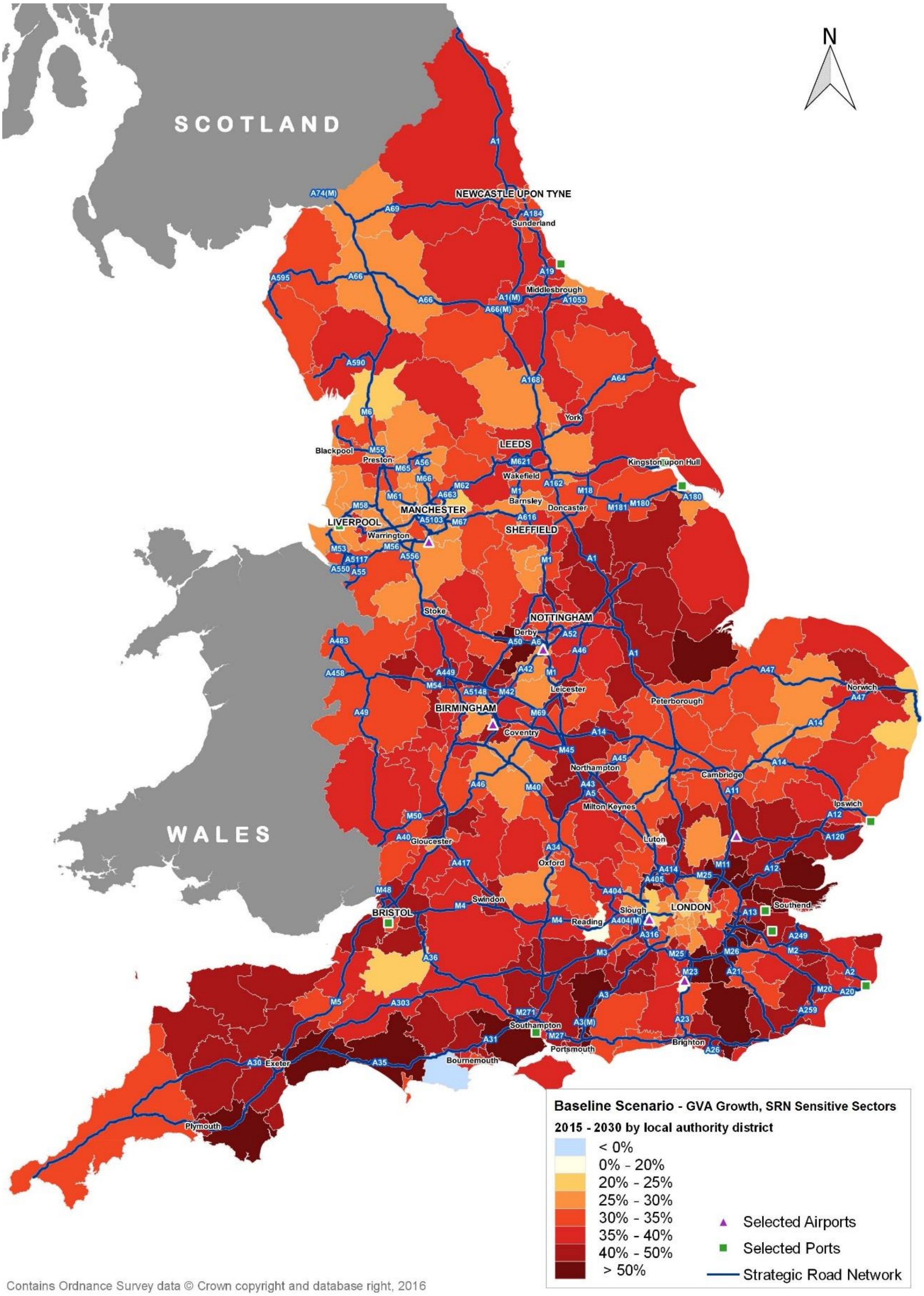
Source: Atkins analysis of Cambridge Econometrics Economic forecast data

Figure A-4 % Employment Growth (2015-2030) – SRN Sensitive Sectors



Source: Cambridge Econometrics Economic Forecasts 2016

Figure A-5 % GVA Growth (2015-2030) – SRN Sensitive Sectors



Source: Cambridge Econometrics Economic Forecasts 2016

Appendix B. SRN Dependent Sectors

Category	SIC07 Sector(s)
Land transport	49 Land transport
Warehousing and storage	52.1 Warehousing and storage
Support activities for transportation	52.2 Support activities for transportation
Postal and courier activities	53 Postal and courier activities
Retail & wholesale trade	45 Wholesale And Retail Trade And Repair Of Motor Vehicles And Motorcycles
	46 Wholesale Trade, Except Of Motor Vehicles And Motorcycles
	47 Retail Trade, Except Of Motor Vehicles And Motorcycles
Primary materials	05 Mining of coal and lignite
	06 Extraction of crude petroleum and natural gas
	07 Mining of metal ores
	08 Other mining and quarrying
	09 Mining support service activities
Manufacturing – users of transport services	10 Manufacture of food products
	11 Manufacture of beverages
	12 Manufacture of tobacco products
	16 Manufacture of wood and of products of wood and cork
	17 Manufacture of paper and paper products
	22 Manufacture of rubber and plastic products
	23 Manufacture of other non-metallic mineral products
Manufacturing – reliant on other sectors which are users of transport services	29 Manufacture of motor vehicles, trailers and semi-trailers
Business services	58 Publishing activities
	59 Motion picture, video and television programme production, sound recording and music publishing activities
	60 Programming and broadcasting activities
	61 Telecommunications
	62 Computer programming, consultancy and related activities
	63 Information service activities
	64 Financial service activities, except insurance and pension funding
	65 Insurance, reinsurance and pension funding, except compulsory social security

Category	SIC07 Sector(s)
	66 Activities auxiliary to financial services and insurance activities
	68 Real estate activities
	69 Legal and accounting activities
	70 Activities of head offices; management consultancy activities
	71 Architectural and engineering activities
	72 Scientific research and development
	73 Advertising and market research
	74 Other professional, scientific and technical activities
	75 Veterinary activities
	77 Rental and leasing activities
	78 Employment activities
	79 Travel agency, tour operator and other reservation service and related activities
	80 Security and investigation activities
	81 Services to buildings and landscape activities
	82 Office administrative, office support and other business support activities
Construction	41 Construction of buildings
	42 Civil engineering
	43 Specialised construction activities

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NATIONAL INFRASTRUCTURE ASSESSMENT

NATIONAL
INFRASTRUCTURE
COMMISSION

July 2018

IMAGE CREDITS:
Solar Farm, Abingdon – Belectric
Prince of Wales bridge – Highways England
Pudding Mill sewage pump station - Lyall, Bills & Young Architects

Contents

The Commission

The National Infrastructure Commission was established in 2015 to provide independent, impartial advice on the UK's long term infrastructure needs.

As of July 2018, the Commission's members are:

Sir John Armitt CBE (Chair) published an independent review on long-term infrastructure planning in the UK in September 2013, which resulted in the National Infrastructure Commission. Sir John is chairman of the National Express Group and the City & Guilds Group and sits on the boards of the Berkeley Group and Expo 2020.

Dame Kate Barker sits on the boards of Taylor Wimpey plc and Man Group plc. She is also chair of trustees for the British Coal Staff Superannuation Scheme. She has previously served as an external member of the Bank of England's Monetary Policy Committee (2001-2010).

Professor Sir Tim Besley CBE is School Professor of Economics and Political Science and W. Arthur Lewis Professor of Development Economics at the LSE. He has previously served as an external member of the Bank of England Monetary Policy Committee (2006-2009).

Professor David Fisk CB is Emeritus Professor at the Centre for Systems Engineering and Innovation at Imperial College London. He has served as Chief Scientist across several Government departments including Environment and Transport, and as a member of the Gas and Electricity Markets Authority.

Andy Green holds several Chairman, Non-Executive Director and advisory roles, linked by his passion for how technology transforms business and people's daily lives. This includes chairing IG Group, a global leader in online trading and Digital Catapult, an initiative to help grow the UK digital economy.

Professor Sadie Morgan is a founding director of the Stirling Prize winning architecture practice dRMM. She is also chair of the Independent Design Panel for High Speed Two, is deputy chair of the Thames Estuary 2050 Growth Commission and a Mayor's design advocate for the Greater London Authority.

Julia Prescot is co founder and Chief Strategy Officer of Meridiam, and sits on the Executive Committee of Meridiam SAS. She has been involved in long term infrastructure development and investment in the UK, Europe, North America and Africa.

Bridget Rosewell OBE is a director, policy maker and economist. She has served as Chief Economic Adviser to the Greater London Authority (2002-2012) and worked extensively on infrastructure business cases. She is a director of Network Rail.

Foreword

The infrastructure we have now, and the infrastructure we plan to build, will support and sustain us for decades to come. Our quality of life, and our success as an economy in the future, will depend on our infrastructure's ability to respond to future challenges. This will rely on decisions taken now.

Providing the right infrastructure for the future does not just entail delivering the running water, roads and rail that traditionally spring to mind, although these are important. The UK needs fast, reliable internet connections. It needs low cost energy and transport that doesn't harm the planet. It needs to make cities liveable for the growing urban population. It needs to reduce the plastic waste that can end up in our oceans. It needs water supply and flood defences that can respond to the risk of extreme floods and drought. All this needs to be done in a way that is well designed, and affordable for the government and the public.

Over the last 50 years, the UK has seen an endless cycle of delays, prevarication and uncertainty. These have been driven in part by short term considerations, and the lack of a cross-sectoral approach to infrastructure. This approach has limited growth, undermined job certainty, and restricted innovation. And too often the UK has ended up playing catch up. This will not do for the challenges ahead.

In the National Infrastructure Assessment, the first of its kind, the Commission has been able to look across infrastructure sectors, and come to independent conclusions based on the best available evidence. The Assessment sets out a clear, long term strategy for the UK's economic infrastructure from 2020 to 2050, providing long term clarity for industry and the supply chain.

The Commission's interim report, published in October 2017, identified three headline challenges for the UK's infrastructure: congestion, capacity and carbon. The Assessment's recommendations to government tackle congestion by prioritising devolved, stable, long-term funding for urban infrastructure in cities. The recommendations will improve the capacity of our water supply and digital infrastructure. And they will reduce our carbon emissions by leading the move to an energy system that is powered mainly be renewable energy sources such as solar and wind.

However, this is not all: the recommendations will also improve our quality of life by reducing air pollution, protecting our homes from floods, and making cities better places to live. The cost of driving will fall substantially if people can switch to electric vehicles. And they will help the environment by reducing waste that ends up in our landfills, incinerators and oceans.

Over the course of preparing this Assessment, the Commission has consulted and listened to the public, industry, academics, local and national government. Our analysis and proposals will not satisfy everyone. But the recommendations represent our considered view of how we can best create infrastructure which enables a fair, productive and green society for the whole country.

Ensuring that the Commission's recommendations can deliver the benefits we think they can, will require politicians across all parties to build a consensus. We welcome the funding guidelines that government has set for the Commission's recommendations, and have made our recommendations in line with it. We have also taken into account existing government commitments for road, rail and aviation, as well as all of our previous recommendations. We look forward to the government adopting our programme of recommendations as policy, and committing to invest in our infrastructure over the coming years.

I would like to take this opportunity to thank my fellow Commissioners and the excellent team at the Commission secretariat, in particular its Chief Economist, James Richardson, who has led the development of this Assessment from start to finish. I would also like to thank everyone who has contributed to our work over the last two years. We look forward to the response from government and the wider community.

Sir John Armitt CBE
Chair, National Infrastructure Commission

In brief

The first National Infrastructure Assessment sets out the Commission's plan of action for the country's infrastructure over the next 10-30 years. Infrastructure can inspire confidence and growth. But long term projects require a long-term vision, lasting plans, and stable funding. The UK must take decisive action.

The Commission's recommendations represent a significant programme of upgrades to the nation's infrastructure. But they are not an unaffordable wish list. They have been costed in line with the government's guideline for investment in infrastructure. And they are affordable for households and businesses.

The Commission was set up to address the lack of a long term infrastructure strategy, siloed decision making in infrastructure sectors, fragile political consensus and short termism. The Commission has addressed these issues by taking a long term, cross-sectoral approach, with in-depth analysis and wide consultation.

The government has committed to respond to the Commission's recommendations and to adopt agreed recommendations as government policy.

The recommendations set out a pathway for the UK's economic infrastructure:

- nationwide full fibre broadband by 2033
- half of the UK's power provided by renewables by 2030
- three quarters of plastic packaging recycled by 2030
- £43 billion of stable long term transport funding for regional cities
- preparing for 100 per cent electric vehicle sales by 2030
- ensuring resilience to extreme drought
- a national standard of flood resilience for all communities by 2050.

Alongside these, better design and more efficient funding and financing can save money, reduce risk, add value and create a legacy that looks good and works well.

These recommendations will equip the UK with the infrastructure it most needs. The Commission will continue to work to build consensus. It will hold government to account for the implementation of its recommendations. And it will continue to work on the nation's most pressing infrastructure issues.

Executive summary

The UK must take decisive action to have world leading infrastructure. Infrastructure can inspire confidence and growth. But long term projects require a long term vision, lasting plans, and stable funding.

Too often, the delivery of the UK's major infrastructure projects has been slow and uncertain. Airport expansion in the south east is the best known, but not the only, example. The Mersey Gateway Bridge, which opened in October 2017, was proposed in 1994. Crossrail, due to open this year, was originally proposed in 1974. Consequently, much of the country's infrastructure has not kept pace with population growth, demand and advances in technology. The UK must stop running to stand still.

The National Infrastructure Commission was set up to address the problems with long term infrastructure planning in the UK. This first National Infrastructure Assessment builds on the analysis in the Commission's interim report, *Congestion, Capacity, Carbon: Priorities for national infrastructure*, to set out a long term vision for high quality, good value, sustainable economic infrastructure for the UK, and a clear plan to achieve it.

Its core proposals include:

- **nationwide full fibre broadband by 2033**
- **half of the UK's power provided by renewables by 2030**
- **three quarters of plastic packaging recycled by 2030**
- **£43 billion of stable long term transport funding for regional cities**
- **preparing for 100 per cent electric vehicle sales by 2030**
- **ensuring resilience to extreme drought through additional supply and demand reduction**
- **a national standard of flood resilience for all communities by 2050.**

It also highlights the most important future challenges. Heating must no longer be provided by natural gas, a fossil fuel. The UK must prepare for connected and autonomous vehicles. These need more time for evidence or technology to develop. The Assessment sets out the actions needed to enable robust decisions to be taken in future.

The National Infrastructure Assessment

The Commission is required to carry out an overall assessment of the UK's infrastructure requirements once every 5 years. This is the first of those assessments. It covers all the key sectors of economic infrastructure, setting out recommendations for transport, energy, water and waste water, flood resilience, digital connectivity, and solid waste, from now until 2050. The Commission's remit also includes the potential interactions between its infrastructure recommendations and housing, but not housing supply in general. The Assessment is guided by the Commission's objectives to support sustainable economic growth across all regions of the UK, improve competitiveness and improve quality of life. More information can be found in the Commission's **framework document**.

Thinking long term

By 2050, the UK's population and economy will have grown significantly. This will place substantial pressures on infrastructure. And meeting the challenge of climate change will require a transformation in energy, waste and transport by 2050. Even so, the effects of climate change will still be felt, with higher average temperatures and increased risk of drought and flooding. The UK's infrastructure will need to adapt to these pressures. The Assessment provides a long term strategy for how to do this. More information can be found in the Commission's four papers on **the environment and climate change**, **economic growth**, **population change and demography**, and **technological change**.

How has the Commission come to these conclusions?

The strategies have been developed considering the responses to the Commission's consultation in **Congestion, Capacity, Carbon: Priorities for national infrastructure,** working closely with experts and other independent organisations, seeking diverse views across sectors and regions, asking the public for their views (via a social research programme), and through the Commission's own internal analysis and modelling. More information and consultants' reports can be found on the Commission's **website**.

How much will this all cost?

Government has given the Commission a long term funding guideline for its recommendations (the 'fiscal remit'). Where infrastructure is funded by the private sector, and the costs of any recommendations will ultimately be met by consumers, the Commission is also required to provide a transparent assessment of the overall impact on bills. These are set out in Chapter 7. More information on the Commission's fiscal and economic remit can be found in the Commission's **remit letter**.

The Commission's recommendations represent a major long term programme of investment in the UK's infrastructure. The programme includes substantial funding for major schemes such as Crossrail 2 and Northern Powerhouse Rail, as well as to support the delivery of enhanced digital networks and flood protection. The Assessment has been made in the light of existing infrastructure plans and investment. However, this is not an unaffordable wish list, but has been carefully designed to be consistent with the government's long term funding guideline for public investment in infrastructure. Where infrastructure is funded by the private sector, a transparent assessment is provided of costs and savings for each recommendation to ensure that consumer costs are manageable and proportionate to the benefits the infrastructure provides.

The recommendations in this Assessment have all been guided by the objectives set for the Commission by government to: support sustainable economic growth across all regions of the UK; improve competitiveness; and improve quality of life. They have been designed to stand the test of time, and to be robust to a variety of scenarios. Together they comprise an ambitious plan to modernise and enhance the UK's economic infrastructure.

The Assessment's recommendations do not simply comprise a list of projects for the government to build; good infrastructure requires long term planning, stable funding structures and good design. The Commission has also been able to consider interdependencies between sectors: urban infrastructure planning needs to be integrated with housing; the energy system needs to be prepared for an increase in electric vehicle ownership; and digital connectivity on the roads could be necessary for connected and autonomous vehicles.

Further detail on the Commission's analysis is set out in the technical annexes published alongside this report, the Commission's interim report and background papers, and the 31 reports commissioned for the Assessment, available on the Commission's website. Annex C sets out a list of these supplementary documents.

Good infrastructure is essential to the country's future growth and prosperity. Infrastructure is a key pillar of the government's Industrial Strategy. Now is the time to deliver. This Assessment is the plan of action.

Building a digital society

Data and digital connectivity will increasingly drive the country's economic growth, competitiveness, and quality of life. Digital communication makes it easier for customers and suppliers to find each other and exchange goods and services. In future, innovations such as artificial intelligence and the internet of things will bring new applications that rely on digital connectivity, from driverless cars to increased use of virtual reality. Some health services are already moving online, providing better access to specialist services, and reducing the need for patients to sit in waiting rooms where they risk further infection.

The UK already has a strong digital economy underpinned by an extensive broadband network. But the superfast broadband programme that delivered this is coming to an end. While current digital connectivity is enough for current needs, demand for data is rapidly increasing; superfast broadband may not be sufficient for the future.

The Commission's judgement is that the government should act now to deliver full fibre across the country; in the Commission's social research, 86 per cent of people agreed that all parts of the UK should have equal access to broadband. Full fibre broadband is the likely next step in digital connectivity. It is more reliable and cheaper to maintain than today's part copper, part fibre broadband connections. But it will take at least a decade to build nationally. Government needs to make a decision on full fibre now to avoid the risk of the UK being left behind in years to come. Full fibre will deliver benefits compared to current broadband even if the expected demand growth does not materialise. Enhanced digital connectivity will also facilitate the development of smart infrastructure: infrastructure with digital connections, enabling more efficient management and maintenance.

To encourage full fibre rollout, the government should put in place a national broadband plan by the end of 2018. Ofcom should provide certainty to commercial investors and encourage further private sector delivery of full fibre. With this certainty from government and Ofcom, most urban areas are likely to receive full fibre just through the promotion of market competition. However, full fibre will still need to be subsidised in some areas where commercial players are unlikely to deliver it. This should begin with the locations least likely to receive broadband commercially. With these plans in place, nationwide full fibre connectivity should be available no later than 2033.

Low cost, low carbon

The UK can and should have low cost and low carbon electricity, heat and waste. Ten years ago, it seemed almost impossible that the UK would be able to be powered mainly by renewable energy in an affordable and reliable way. But there has been a quiet revolution going on in this area. There is ample scope to build on this success in years to come. Highly renewable, clean, and low cost energy and waste systems increasingly appear to be achievable.

Furthermore, such a system need not lead to higher bills. Today, consumers pay an average of £1,850 per year for the energy they use, including fuel and equipment for heating and hot water, electricity and transport fuel costs. The same services could be delivered at the same cost (in today's prices) in 2050 by a low carbon energy system. But this will only be possible if the right decisions are taken now.

Sustaining progress on reducing emissions requires government to show ambition. The crucial first step is to enable an increasing deployment of renewables. The Commission's modelling has shown that a highly renewable generation mix is a low cost option for the energy system. The cost would be comparable to building further nuclear power plants after Hinkley Point C, and cheaper than implementing carbon capture and storage with the existing system. The electricity system should be running off at least 50 per cent renewable generation by 2030, as part of a transition to a highly renewable generation mix. Government should not agree support for more than one nuclear power station beyond Hinkley Point C before 2025.

But there are some changes that will need to be made to enable the increase in renewables. It will require increased system flexibility, in line with the recommendations in the Commission's *Smart Power* report. The Commission favours the use of existing market mechanisms – contracts for difference and the capacity market – where possible, to avoid creating more uncertainty, but incremental improvements could be made. All renewables should be able to compete; there is no longer a case for any bilateral deals, including for tidal.

Even with emissions almost eliminated from power generation, the UK cannot achieve its emissions targets while relying on natural gas, a fossil fuel, for heating. Delivering a low cost, low carbon heating system is the major outstanding challenge. But the electricity system represented just such a challenge ten years ago. There are actions that the UK can and should take now.

As a first step, improving the energy efficiency of the UK's buildings will mitigate some of the emissions from heat. In the meantime, the evidence base must be built up to make decisions on heat in future. The safety case for using hydrogen as a replacement for natural gas should be established, followed by trials for hydrogen at a community scale and alongside carbon capture and storage. At the same time, further data on the performance of heat pumps in the UK should be collected and used to support decisions.

In the waste sector, too, there are lower cost, lower carbon options especially for food waste and plastics. There is public support for greater recycling, but frustration with the complexity of the process.

It is cheaper to collect food waste separately and process it in anaerobic digesters, rather than send it to energy from waste plants (incinerators). Seventy nine per cent of people who do not currently use a food waste bin would be prepared to use one if it were provided by their local council. More plastics should be recycled, including by restricting the use of hard-to-recycle plastic packaging by 2025. Better packaging design, clearer labelling, fewer hard to recycle plastics, and tougher recycling targets (of 65 per cent of municipal waste and 75 per cent of plastic packaging by 2030) could all reduce residual waste and mitigate the need to build additional infrastructure.

Revolutionising road transport

By 2050, road transport will be unrecognizable from today. Cars and vans will be electric, and increasingly autonomous. Electric, connected and autonomous vehicles will change the nature of the transport debate in the UK.

Electric vehicles are easier to drive, quieter and less polluting than conventional cars and will soon have the same range and be cheaper to buy and maintain. Once this happens, their take up could increase rapidly. Given their benefits for the environment, this is something government should encourage. A key way to do this is by ensuring that charging an electric vehicle is as easy as refilling a conventional vehicle, or even easier.

The government needs to provide the right environment to support and encourage the switch to electric vehicles. To catalyse this, consumers need to feel confident that they can charge their electric vehicles en route across the country. A core network of fast or rapid chargers should be installed in visible locations across the UK. Government should subsidise charger installation where the private sector will not build them, starting in the locations least likely to be delivered commercially. However, the majority should be built by the private sector. Government should enable commercial investors to build charge points throughout the country, including by requiring local authorities to free up 5 per cent of their parking spaces for electric vehicle charge points by 2020, and 25 per cent by 2025.

The energy system will also need to be prepared for an increase in demand for electricity as the transition to electric vehicles gains traction. Whilst fast and rapid chargers will be needed to tackle range anxiety, most charging should be slow and smart. Done in the right way, using smart charging, electric vehicles can lower electricity system costs: the system will be able to operate closer to full capacity over the course of the day, as electric vehicles can charge primarily at night, increasing network efficiency. And with electric vehicles providing a source of flexible demand, the need for other kinds of flexibility such as battery storage or fossil fuels will be reduced.

In the longer term, connected and autonomous vehicles will bring even greater changes to the UK's roads. They will improve safety, and could allow more people to use personal transport and free up driving time for work or leisure. They may even encourage a shift towards increased vehicle sharing and reduced car ownership. Traffic lights and stop signs may become unnecessary, speed limits could be higher, and the use of road space could be automatically and constantly changing according to need. But, with road and rail projects lasting for decades, government needs to start taking the potential future impacts into account now as it makes investment plans.

A framework should be developed to assess potential impacts, even though these are inevitably uncertain. An initial framework should be put together before the next five year planning cycle for rail and major roads begins in the early 2020s.

Transport and housing for thriving city regions

Cities can be great places to live, with excellent public transport systems, well-designed public spaces for leisure and social activities, and flourishing, well-connected businesses. They are also engines of economic growth. However, as urban populations increase, many cities are becoming full and congested, and this is inhibiting economic development and reducing quality of life.

The UK has a programme of major strategic transport projects in the pipeline, including a large programme to improve major roads, HS2 and Northern Powerhouse Rail. In planning for the next wave of major investment, attention must be turned to cities. The UK is unusual in that many of its large cities outside of the capital are less productive than the national average. Transport alone cannot drive growth, but the UK should make sure that urban transport enables it.

For all their benefits, neither electric nor connected and autonomous vehicles will solve the problems of urban transport; rather they are likely to increase the number of drivers on the roads. Government and cities need to act now to ensure that space in cities is used effectively, with room allocated for fast, frequent public transport systems, well-connected and affordable housing, and pleasant public spaces. This will require a new approach to governance, strategy and funding.

To deliver thriving cities, metro mayors and other city leaders should develop integrated strategies for transport, employment and housing. Housing and infrastructure should be planned together: new housing requires new infrastructure. These integrated strategies should be backed up by stable, substantial, devolved funding. And for the cities that face the most severe capacity constraints, and with the most potential for growth, there should be additional funding to support major upgrade programmes, which would be agreed between the cities and central government.

Development of regional cities should be in addition to, rather than instead of, continuing to invest in London, whose growth brings benefits across the UK. The Commission will continue to work with government and cities to develop the next wave of infrastructure upgrades across the country.

Reducing the risks of drought and flooding

Climate change will continue to make extreme weather events such as floods and drought more likely in future years, and cities, towns and villages must be resilient. Decisive policy action is needed to mitigate these risks.

About 5 million properties in the UK are currently at risk of flooding. Protection from floods in the UK over the past years has too often been reactive rather than proactive. Ideally, no one should be exposed to flooding. Flooding has severe impacts on quality of life, particularly mental health.

A long term strategy for flood protection would allow a nationwide standard of resilience to flooding, with catchment based plans. These plans should evaluate the full range of options including traditional flood defences, 'green infrastructure' (whether natural flood management or sustainable drainage systems), individual property measures and spatial planning. In the Commission's social research, 59 per cent of people agreed that everyone should have the same standard of flood resilience, even though some properties cost more to protect.

The Commission believe that a national standard should be set for resilience to flooding with an annual likelihood of 0.5 per cent by 2050, where feasible. Over longer time periods, higher standards might be achievable. Densely populated areas, where the consequences of flooding are potentially much more serious, should be resilient to flooding with a likelihood of only 0.1 per cent a year by 2050. The Environment Agency should update plans for all catchments and coastal cells in England before the end of 2023.

A reliable water supply is usually taken for granted in UK. But despite its reputation for rain, the country faces a real and growing risk of water shortages, especially in the south east of England. Action is needed to address these challenges, but conflicting incentives, limited cooperation between water companies and a short term focus mean that insufficient progress has been made. In the event of a serious drought, the nation faces an unacceptably high risk of severe supply limitations; homes and businesses could even be completely cut off.

The Commission has published a standalone report, *Preparing for a drier future: England's water infrastructure needs*, which sets out a twin-track approach to manage water supply and demand. The government, working with Ofwat and water companies, needs to ensure the capacity of the water supply system in England is increased to boost the country's resilience to drought whilst also managing demand and reducing leakage. This can be achieved through: delivering a national water transfer network and additional water supply (for example reservoirs or water re use) by the 2030s; and halving leakage by 2050, together with greater smart metering.

Choosing and designing infrastructure

For government and relevant industries to take decisive action on their infrastructure projects, they need to have confidence that their decision making is as good as possible. Long term decisions inevitably carry risk, but these risks need to be taken, and uncertainty managed as much as possible. Decision making can be improved through robust analysis of the performance of existing infrastructure and recognising the value of good design in infrastructure.

Not everything can be reduced to numbers, but there should be an effective methodology to measure the quality of the UK's current infrastructure to reliably inform assessments of future needs. The assessment of the potential value of new projects could be more effective if there were better data on how past projects have performed. All government departments and agencies should therefore collect and publish costs and benefits estimates and outturns for major infrastructure projects. This would lead to increased scrutiny of costs and benefits estimates, improving quality.

Good design can save money, reduce risks, add value, deliver more projects on time and create infrastructure that looks good and works well for everyone. All nationally significant infrastructure projects should have a board level design champion, and use a design panel to maximise the value provided by the infrastructure. The Commission, advised by a national infrastructure design group, will publish a set of design principles to inform this.

Funding and financing

While the Commission's recommendations comprise an ambitious programme of investment, this is not an unaffordable wish list. A crucial factor in the development of this Assessment has been the fiscal remit set by government. This provides a long term funding guideline for public investment in infrastructure of 1.0 to 1.2 per cent of GDP, including existing government funding commitments such as HS2.

Where infrastructure is funded by the private sector, and the costs of any recommendations will ultimately be met directly by consumers, the Commission has also provided a transparent assessment of the overall impact on bills. Where recommendations have net costs, the Commission believes that these are manageable and good value relative to the benefits the infrastructure provides.

The recommendations in this Assessment, and the implications for public expenditure and for bills, reflect the judgement of the Commission. In reaching its conclusions, the Commission has drawn on a wide range of evidence. Uncertainty is inevitable given the timescales for infrastructure investment, and so the Commission has also sought to understand how robust its decisions are to uncertainty, seeking solutions that will stand the test of time.

The recommendations are an affordable and deliverable strategy to modernise and strengthen the UK's infrastructure networks. Nevertheless, it is important that these recommendations are paid for at least cost. Part of this comes from improvements in design and delivery. Part comes from ensuring that infrastructure is financed in the best way possible.

These recommendations will require a combination of public and private financing. Financing itself is not in short supply. However, state financing institutions can help to encourage private investment and catalyse activity in new markets. The European Investment Bank does some of this, but there is a risk that access may be lost following the UK's exit from the EU. A UK infrastructure finance institution, focussed on specific objectives, should be established if access to the European Investment Bank ceases after the UK exits the EU.

There is also a need for a better understanding of the costs and benefits of private financing and traditional procurement in the delivery of publicly funded infrastructure. The Commission has developed an analytical framework to be used in the evaluation of the costs and benefits of financing options for new and existing projects, which will enable greater certainty about the costs and benefits of the use of private financing for public sector projects.

Over the Assessment's timeframe, changes to the way road users pay to use roads are inevitable. In particular, fuel duty revenues will continue to decline with the impending shift to electric vehicles. This presents a huge opportunity to design a system that improves on current road taxation by being fairer, more sustainable, more effective at reducing the negative impacts of driving, and attracting greater public support. For years, experts have proposed road pricing, only for it to be opposed by the public. The Commission intends to engage stakeholders and the public on this topic to identify a new approach that works for the future of transport. Reforming how road use is paid for has been discussed for decades, but the issue is becoming more and more pressing and cannot be avoided forever.

Local funding mechanisms can help to ensure that local infrastructure is funded in a way that is fair, efficient and sufficient to meet local needs. The current system for gathering contributions from developers is complex, but raises more revenue than previous attempts. But the system could be improved still further. More funding mechanisms should also be made available to Local Authorities to enable them to capture a greater share of the uplift in land value that can occur with infrastructure investment. This should include making it easier to raise business rate supplements for up to one third of scheme costs, and giving local authorities powers to levy zonal precepts on council tax where public investments in infrastructure drive up surrounding property values.

Next steps

The Commission has outlined an ambitious set of recommendations. As the first Assessment, it could never solve everything. The Commission has therefore focused on key priorities to equip the UK with the infrastructure it needs. These recommendations will enable the UK to have a thriving digital economy, a low cost, low carbon energy and waste network, clean air, successful cities, and resilience to extreme weather. But the Commission cannot achieve this alone. Government, regulators, industry, citizens and others will all need to contribute to making this vision a reality. Over the coming months, the Commission will work to build consensus around its recommendations.

Infrastructure delivery depends on the availability of the right skills, the approach to construction and project management, the depth of the supply base, and the capability of government and other infrastructure owners and operators to act as an intelligent client. These are the responsibility of the Infrastructure and Projects Authority which advises on infrastructure delivery. The UK's exit from the EU will impact the UK's skills base and supply chain. There should be a strategic approach to manage this.

As its initial next step, the government has committed to lay the Assessment before Parliament, and to respond to the Assessment within six months (with a final deadline of a year). Its response will set out which recommendations it has agreed to, any further work required to take forward the recommendations, and alternative proposals for any recommendations it has not agreed.

The Commission will monitor progress in delivering government endorsed recommendations, and will report on this in its Annual Monitoring Reports.

The second Assessment, expected around 2023, will build on the recommendations in this report, as well as covering new ground.

Northern Ireland, Scotland and Wales

The Commission's remit covers six infrastructure sectors. As summarised in the table below, in four of six sectors covered by the Commission, there is substantial devolution to the devolved governments. Only energy in Great Britain and digital communications in the UK do not entail significant devolution.

The Commission's role is to advise the UK government. But the Commission works with both the UK government and the devolved administrations where responsibilities interact.

Sector covered by the Commission	Devolved administration responsibility		
	Scotland	Northern Ireland	Wales
Transport	Largely devolved	Devolved responsibility	Devolved, aside from rail
Energy	Not devolved, aside from energy efficiency	Devolved, aside from nuclear	Not devolved aside from energy efficiency
Water and sewerage	Devolved responsibility	Devolved responsibility	Devolved responsibility
Flood risk	Devolved responsibility	Devolved responsibility	Devolved responsibility
Digital	Not devolved	Not devolved	Not devolved
Waste	Devolved responsibility	Devolved responsibility	Devolved responsibility

Table 1: Devolved administration responsibilities, by infrastructure sector

1. BUILDING A DIGITAL SOCIETY

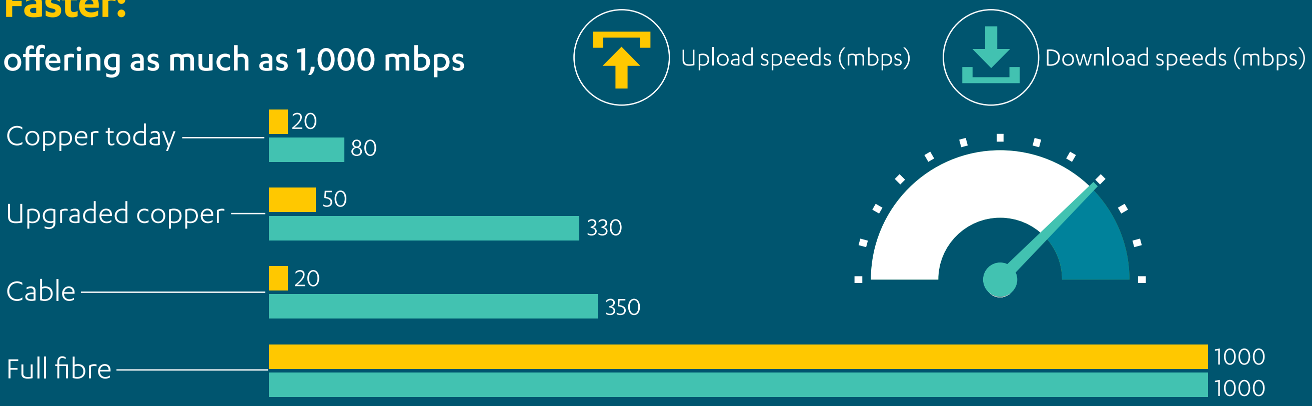
A FULL FIBRE FUTURE

Digital services are increasingly important for growth, infrastructure, and quality of life.

The superfast broadband programme is coming to an end and full fibre is the next step

Faster:

offering as much as 1,000 mbps



More reliable:

fibre has 5 times fewer faults than copper connections

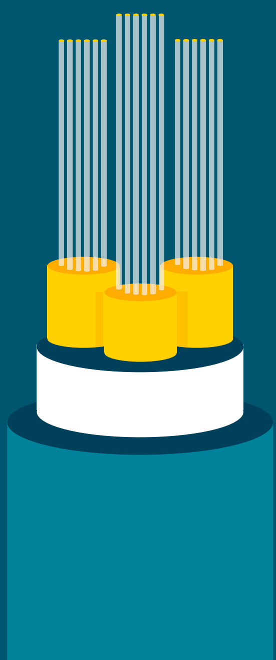
Cheaper to run:

Fibre would save up to £5bn in operating costs over 30 years

The benefits will take time, as full fibre speeds are not yet needed, but delivery will take 10-20 years

Investment must start now

to avoid being left behind



Competition is the best way to get full fibre and the market is already starting to deliver - companies are planning to make full fibre available to up to 14 million premises by 2025

But government support will be needed in rural areas

THE COMMISSION RECOMMENDS:

- A government strategy to deliver nationwide full fibre by 2033
- Ofcom should promote network competition to drive the commercial roll-out of full fibre
- Government support in rural areas starting by 2020
- Measures aimed at cutting the costs of delivery
- Allow for copper switch off by 2025

Sources: DCMS, Ofcom, Prism and Tactis, Frontier Economics

Digital connectivity is now an essential utility, as central to the UK's society and economy as electricity or water supply. Demand for data, and therefore the speed, reliability and capacity of broadband connections, is growing rapidly. Demand is likely to continue to increase as businesses, homes and infrastructure become smarter. So it is important that quality broadband is available throughout the country. Full fibre can provide this for the future.

The UK already has a strong digital economy underpinned by an extensive superfast broadband network.[1] There is room for improvement on mobile coverage and rural connectivity but, in general, the UK's digital connectivity meets the needs of today's consumers.[2] The UK compares well internationally for superfast broadband availability, but trails behind other countries such as Spain and Sweden for full fibre availability.[3]

The UK must now prepare for the future. The superfast broadband programme is coming to an end, with 98 per cent of UK premises on track to receive superfast broadband.[4] A guaranteed minimum broadband service will be available to remaining premises by 2020 but provides only a basic service for today's needs.[5]

The Commission's judgement is that a national full fibre rollout programme should be put in place. This will provide fast, reliable broadband, improve connectivity in rural areas, and support 4G and 5G mobile coverage. However, it will take at least a decade to build.[6]

The successful delivery of full fibre will require:

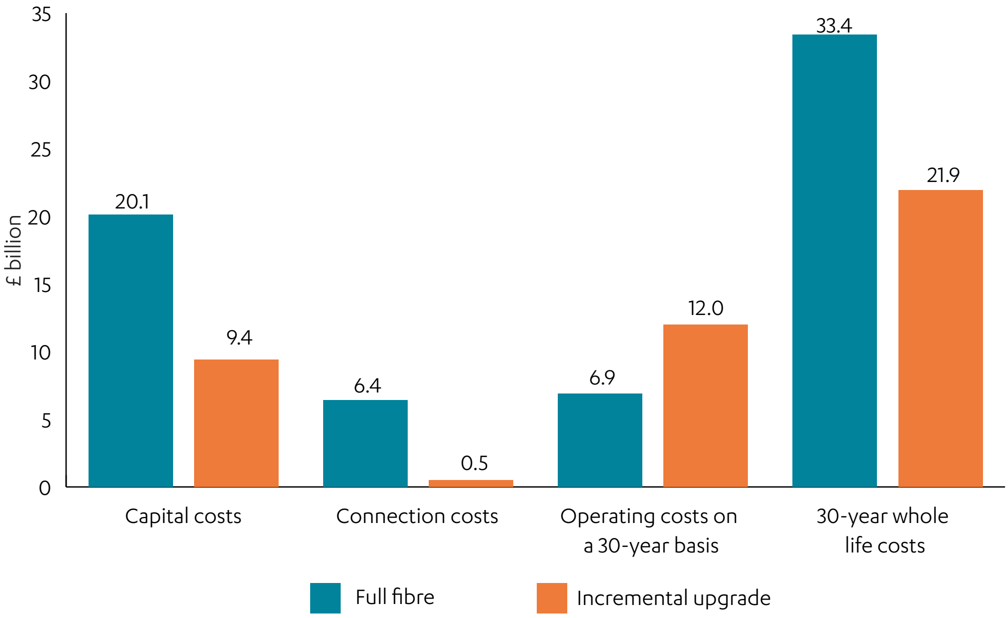
- a nationwide plan to deliver full fibre to all businesses and homes by 2033, with approaches tailored to the needs of different areas
- making the most of fibre deployment to support improved mobile coverage
- allowing for copper switch-off
- tackling the barriers that delay deployment and increase costs.

The Commission has previously examined the infrastructure needed to support 5G mobile in its report *Connected Future*[7] and the Assessment does not re-examine this. The Commission is also carrying out a review of economic regulation, which will report in spring 2019.

Full fibre for the future

The UK faces a choice between continuing to upgrade the existing copper network, or replacing what is left of it with fibre optics. Full fibre, a connection without any copper, is the best available broadband technology on the horizon. It can provide consistent, gigabit speeds, which are less affected by rain and flooding, uses less energy, costs less to maintain and has no long term foreseeable capacity constraints.[8,9,10,11] Nationwide full fibre would also provide the foundation for 5G mobile connectivity and could improve 4G coverage in harder to reach places.[12]

Choosing to make this investment is not a risk-free decision. In countries with widespread full fibre, take-up of higher bandwidth services is often low.[13] Analysis produced for the Commission estimates that, over a 30 year period, building and maintaining a full fibre network would cost £33.4 billion.[14] This is estimated to be approximately £11.5 billion more than incrementally upgrading the existing infrastructure.[15] But a further incremental upgrade now may still require full fibre in the long term. Figure 1.1 shows the breakdown of costs.

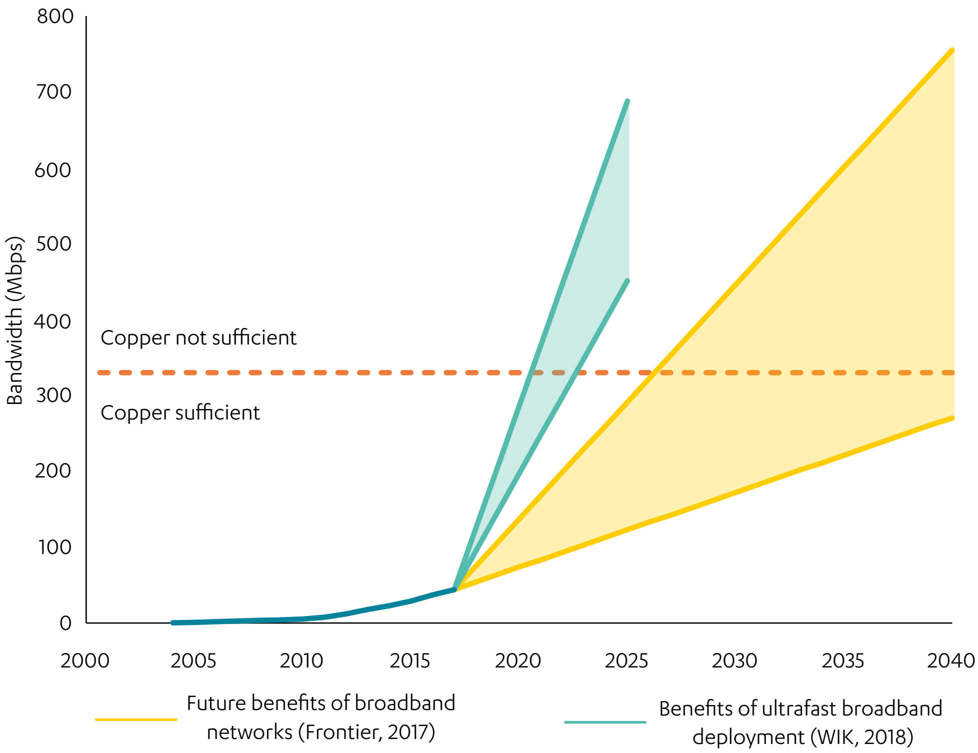


Note: present value in 2020

Figure 1.1: Estimated costs of deploying full fibre versus upgrading the existing copper/cable infrastructure[16]

The two alternatives to fibre are G.fast (a copper based technology), and cable (which uses shielding to reduce the electromagnetic interference that affects copper). G.fast might be an appropriate interim solution in some areas, but it is ultimately subject to many of the same limitations as copper. Unlike fibre, speeds on copper lines drop significantly over longer distances.[17] Existing cable networks can be upgraded to compete more effectively with fibre over the long term.[18] But Virgin Media, the UK's main cable provider, is increasingly rolling out fibre as it expands its network into new areas, partly because deploying and maintaining new cable is more expensive than full fibre.[19] Full fibre also has the potential to deliver much higher upload and download speeds.[20]

Total data demand, based on the time spent on the internet, has risen drastically over the last few years.[21] This is because people are online for more of the day and because the amount of data used at any one time is increasing, requiring higher bandwidth. Figure 1.2 compares projections of bandwidth demand, produced for the Commission and for Ofcom, the regulator, and the level at which a copper network becomes insufficient to meet demand. It is not clear when, or if, bandwidth demand will outstrip the capacity of the existing copper network. But it is possible that bandwidth demand could exceed the capabilities of a copper network within the 10-20 year horizon required to roll out a full fibre network.



Note: the dotted line is the theoretical maximum 'up to speed' on a copper upgrade.

Figure 1.2: Historic average UK broadband bandwidth and forecasted future bandwidth demand[22]

However, despite the possibility that demand does not materialise, the Commission's judgement is that investment in full fibre is a risk worth taking. Past investments in digital infrastructure have supported significant economic growth. The rollout of broadband infrastructure in OECD countries from 1997 to 2007 increased annual per capita growth by 0.9 to 1.5 percentage points for a 10 percentage point increase in broadband penetration.[23]

Potential drivers of future bandwidth demand

Demand increases to meet supply: History shows that as consumers' bandwidth increases, sites and applications adapt to make use of faster speeds. Video is the main driver of bandwidth demand. When BBC iPlayer launched in 2007 it required 0.5 megabits per second (Mbps) to watch programmes on demand.[24] Today, the minimum is the same, but iPlayer now offers a range of more sophisticated services that require much faster speeds, including 20 Mbps for Ultra HD programmes such as Blue Planet, and 36 Mbps for live events such as the World Cup.[25]

Virtual reality: If the use of virtual (and/or augmented) reality increases for entertainment, simulations, or communication, this will require better, faster broadband connections.[26]

Internet of things: Innovations in the network of infrastructure and appliances with digital connections will continue to increase the amount of data being transferred regularly through both the broadband and mobile networks.[27]

Connected and autonomous vehicles: Connected vehicles are expected to transmit large amounts of data at high speeds to other connected vehicles and/or road infrastructure. This is likely to require reliable 5G connectivity on roads, which will need to be underpinned by fibre.[28]

Furthermore, a full fibre network still provides several benefits relative to a copper network upgrade. These include operational savings, which would start being realised straight away and could amount to £5.1 billion between 2020 and 2050 (see figure 1.1). Full fibre suffers five times fewer faults than copper-based networks.[29] While not large enough to justify the investment in itself, these savings will continue beyond this timeframe.

A long term strategy for nationwide full fibre

Network operators are beginning to build new full fibre networks across the UK. However, only 4 per cent of UK premises have access to full fibre.[30]

Delivering a new national full fibre infrastructure network will take at least a decade.[31] Other estimates suggest the programme could be closer to 20 years.[32] If the UK wants to avoid the risk of not having the infrastructure needed to support an increasing demand for data in the future, it will need to start investing soon, even if this is ahead of demand at present.

Transitioning to full fibre from copper is a substantial infrastructure upgrade, and it will be difficult for the market to deliver in the absence of a clear government strategy. Commercial investors will need clarity on government's decision to back full fibre to give them the confidence to invest.

Government must therefore define and deliver the country's full fibre broadband strategy. It should be responsible for the plan, and ensure that Ofcom has the necessary powers to implement and deliver it.

A nationwide strategy

Recent announcements by network operators already total 14 million premises expected to receive a full fibre connection by 2025,[33] but in reality this number will be lower as the networks will overlap. Therefore, while some areas will receive multiple full fibre networks on a commercial basis, many homes and businesses, particularly in rural areas, will not receive full fibre at all. The government has set a target date of 2033 for national coverage, but should now set out a clear strategy to achieve this, giving commercial investors the confidence they need.

A nationwide broadband plan must reflect the differing economics of delivering full fibre in different areas of the country. Government should promote competition in areas where it is commercially viable for multiple network operators to build and operate full fibre networks. However, some geographic areas are not commercially viable at all, and in others there is only likely to be a commercial case for one network (for example smaller towns and villages). A key part of government's plan must be to ensure that the places that would not otherwise receive full fibre get the connectivity they need.

Incentivising competition

Competing fibre networks should be encouraged wherever they are feasible. Without infrastructure competition, the existing provider has poor incentives to build new fibre networks, as this undermines its existing copper based services. New entrants do not have existing customers to lose, so they have greater incentives to build. Competition will force the incumbent to build new networks commercially and at a competitive price.[34]

Infrastructure competition has been shown to drive investment in both new and existing broadband networks.[35,36] It has been a key driver of widespread fibre rollout in South Korea and Japan, which have over 95 per cent full fibre availability.[37] There is a strong correlation between cable coverage and full fibre availability internationally.[38]

The UK should therefore stick to a competitive model for commercial investors to deliver full fibre. This will require significant financing and it is essential that investors have confidence that if their business plans are successful, they will be able to make a fair return without the government reneging after the fact. The market must have the freedom to set the price for new services, subject, as now, to regulation of the basic service level. Within a competitive model consumers will have a choice of whether to pay any premium for full fibre. The market will drive full fibre deployment, and government should not intervene by restricting overbuild of new or existing networks, unless it constitutes anticompetitive behaviour.

This requires:

- a clear commitment from government and Ofcom to promote a competitive market wherever possible, with a stable regulatory regime

- a commitment to deregulate in geographic areas where competition is effective
- a commitment to ensuring telecoms providers can make a 'fair bet' for the risks they are taking in building new infrastructure, recognising the long term benefits of the infrastructure
- Ofcom continuing to ensure all providers can access Openreach's ducts and poles on a fair and efficient basis.[39]

Reaching rural and remote areas

The Commission has concluded that nowhere should miss out on the benefits of full fibre. The Commission's social research found that 86 per cent of people agreed that all parts of the UK should have equal access to broadband.[40] In the past, the UK had the ambition and foresight to connect the whole country to electricity, water and transport networks. The benefits today are obvious. The same ambition is needed now for digital infrastructure.

The capacity constraint of the existing copper network is a particularly critical issue for rural areas with long copper lines. The performance of copper is severely affected by distance, and cannot be upgraded without replacing large parts with fibre, effectively rendering full fibre as the only viable infrastructure upgrade option for most rural areas.[41] In the most remote areas, alternative technologies such as the use of mobile connectivity, fixed wireless or satellite might be more cost effective. Full fibre could also help to improve mobile coverage in hard to reach areas. Mobile 'cells', which transmit and receive data to and from mobile devices, connect to fixed fibre through which they are linked to the global internet.

Without full fibre, rural areas and some deprived communities where full fibre may not be commercially viable will risk falling behind. But everyone stands to gain from ubiquitous connectivity if it enables public services to use digital technology to become more efficient. For example, some health services are already moving online, which can provide better access to specialist services, reduce the need for patients to sit in waiting rooms where they risk further infection, and reduce costs for the NHS.[42] Savings from online provision in rural areas are likely to be particularly large, where the costs of providing traditional services are higher in sparsely populated areas.

The Commission recommends a taxpayer-subsidised infrastructure delivery scheme to uncommercial areas, along the lines of the successful Broadband Delivery UK programme, which directly subsidised up to 50 per cent of the capital expenditure for installing superfast broadband in rural areas. A taxpayer subsidy can take advantage of competitive dynamics, with different companies bidding for tenders. In the short term, this can have positive implications for how quickly and cheaply the infrastructure is deployed. In the longer term, it also enables the costs and performance of subsidised delivery in one region to be measured against others.

Unlike the 'Broadband Delivery UK' programme, government should focus initially on the areas least likely to receive full fibre broadband commercially, and which are also most likely to experience unreliable broadband through long distances of copper cables. Communities within these areas should be eligible to get their full fibre sooner if they volunteer to help build their network at community level, as for example Broadband for the Rural North have done.[43]

However, a reasonable cost threshold will be necessary: the most expensive premises can cost above £45,000.[44] This threshold should be high enough for the programme to cover the vast majority of premises. The few premises which are above the cost threshold should be able to use the subsidy to fund their own solution. The guaranteed minimum broadband service will act as a safety net.[45]

Completing a nationwide rollout

In some areas of the country, only one fibre operator is commercially viable. It is uncertain whether fibre operators will rush to invest with the aim of becoming the monopoly provider or choose to avoid areas that cannot support multiple networks. In these areas, there is a choice between a targeted solution or relying on the combination of competition and eventual direct government support where the private sector doesn't deliver.

A targeted solution might meet the particular challenge, but would require the government to identify and define the boundaries of these areas upfront. This would rely upon uncertain and evolving assumptions. Changes in the cost of deployment and consumer demand could extend the area where competition is commercially viable, rendering any targeted solution out of date and potentially costly.

Given the pace of innovation in the industry, the potential for significant changes in consumer demand, and the long timescales over which any targeted solution would have to operate, the Commission believes that the boundaries should be allowed to reveal themselves over time. Providing government support for the hardest to reach areas first will allow the market to drive investment in the first instance. The part-subsidy scheme can then be extended in phases to areas that remain unserved, meeting market driven rollout 'in the middle'. If this results in support for provision in areas that are commercially viable, but for only one provider, the taxpayer contribution can be reinvested or refunded through clawback mechanisms.

Improving mobile connectivity

The Commission was asked in March 2016 to advise government on the steps the UK should take to become a world leader in the deployment of 5G mobile networks, and take early advantage of the applications 5G could enable. The Commission published its report, *Connected Future*, in December 2016.

The Commission's central finding was that mobile connectivity has become a necessity. It recommended that government ensures services are available wherever people live, work and travel, and that the UK's roads, railways and city centres are ready for 5G.

The government and Ofcom have made some progress; the Department for Digital, Culture, Media and Sport has bolstered its telecoms capabilities and Ofcom has improved its coverage metrics to reflect actual user experience. Ofcom is also currently consulting on new coverage obligations, tied to the 700 MHz spectrum auction, to improve geographic coverage, particularly in rural areas.[46] However, government has made particularly poor progress on road and rail connectivity. It must accelerate its work to ensure 5G-ready infrastructure is available across the UK's motorways and major rail lines by 2025 at the latest.

The Assessment does not reopen the Commission's earlier mobile recommendations. The focus of the Assessment has been on fibre deployment for both fixed and mobile connectivity. Fibre is the necessary underpinning infrastructure for mobile connectivity. Full fibre policies have the potential to improve 4G coverage in hard to reach towns, villages and hamlets. It could also help deliver 5G further, more quickly and cheaply.

Mobile coverage is particularly poor in rural areas; 15 per cent of rural geographic areas cannot receive 4G coverage by any operator, compared to less than 1 per cent of urban areas. The Church of England recently agreed to using its church spires to improve mobile coverage. Two thirds of Anglican churches are in rural areas, situated in the heart of villages with tall spires, ideal for mobile cells. A full fibre connection to the highest point in a local village, whether or not that is the church, could allow mobile cells to be easily installed, improving connectivity in that local area.

Looking ahead, there is an option to preempt where 5G cells might need fibre. Subsidised full fibre rollout could include these locations. This includes lampposts and public buildings. Lampposts could be ideal sites for 5G cells, as well as WiFi and 4G cells today. They have access to power, are high up and evenly spaced out. But they do not automatically have fibre and will not receive it without coordination.

5G is a certain part of the future but what the 5G network will look like is uncertain. It is therefore a gamble to modify full fibre deployment based on any current 5G assumptions. Further evidence is needed to decide whether 5G obligations should be included with full fibre subsidies. The onus should be on wireless infrastructure operators to supply evidence and recommendations to the government.

Allowing for copper switch-off

Copper switch-off should be a key part of the long term national full fibre plan. Running a copper network adjacent to a fibre network will add significantly to overall costs. Switching off the copper network is ultimately a commercial decision for Openreach, the existing operator, but does require some government intervention to allow them to make the decision.

The transition plan will need to include protection for potentially vulnerable consumers. Some consumers will not want fibre but will receive it anyway. Openreach should not be able to charge customers extra that had no need for the upgrade.

Removing policy barriers

Tackling the barriers that delay deployment and increase costs must be an integral part of the UK's national full fibre broadband plan. Government has set up a Barriers Busting Task Force. This is a good first step and should continue to be prioritised. The Commission has identified four key objectives.

Give digital infrastructure operators the same rights as utilities: The process for obtaining rights of way on private land, known as 'wayleaves', should be simplified and standardised, through a notification regime similar to those used for other utilities. All new developments should have full fibre and telecoms duct capacity from the outset, as for other utilities such as electricity and water.

Prioritise digital connectivity at a local level: As recommended in *Connected Future*, local government should designate an individual 'digital champion' with responsibility for engaging with telecoms providers. The digital champion in each local planning authority should be responsible for coordinating and facilitating digital infrastructure deployment in their area, acting as the single point of contact for all telecoms providers, and assisting them in delivering better connectivity for the local area. Digital champions should prioritise:

- reforming and streamlining the process around permissions for street works, reducing the variability across the country and removing inefficient delays
- improving the accessibility of their publicly owned assets, making it easier and cheaper for operators to deploy digital infrastructure in the local area.

Increase infrastructure sharing to push full fibre rollout further: Access to Openreach's ducts and poles allows alternative operators to deploy fibre more quickly and cheaply. They no longer need to dig their own trenches, which can make up to 60 per cent of total deployment costs.[47] This increases the areas of the country where full fibre can be rolled out commercially. The success of this policy should be monitored by levels of usage to ensure that Openreach's infrastructure is accessible in practice. There may not be benefits from duplicating in-building fibre connections, which are costly and disruptive to install. Countries such as Spain, Portugal and France mandate that in-building fibre is accessible to all operators.[48] Ofcom should consider whether such policies should be applied in the UK.

Making use of other existing infrastructure can also reduce deployment costs. For example, using aerial fibre along existing electricity poles may push some premises below a reasonable cost threshold in rural areas. Infrastructure re-use should therefore be explored before premises are ruled out for being too costly.

Ensuring planning is fit for 5G deployment. The next generation of mobile will require a large number of small cells raising planning issues such as access to street furniture (eg lampposts). This will require collaboration between network operators and local authorities to ensure planning and other permissions are handled swiftly and in a coordinated way. The UK will not get the mobile infrastructure it needs if each individual cell requires separate planning permission. Planning policy, legislation for code powers, and guidelines for deployment at street level will need to be addressed before dense site deployment can take place. The Commission made recommendations on 5G in *Connected Future*.[49]

The Commission recommends that government should set out a nationwide full fibre connectivity plan by spring 2019, including proposals for connecting rural and remote communities. This should ensure that full fibre connectivity is available to 15 million homes and businesses by 2025, 25 million by 2030 with full coverage by 2033. To achieve these targets:

- **Ofcom should promote network competition to drive the commercial rollout of full fibre, by deregulating where competition is effective and guaranteeing a fair bet on risky investments before regulating any uncompetitive areas.**
- **Government should part subsidise rollout to rural and remote communities, beginning by 2020, starting with the hardest to reach areas and community self-build.**
- **Government and Ofcom should allow for copper switch-off by 2025.**
- **Government and Ofcom should take action to cut the cost of full fibre deployment including:**
  - **Government should ensure the processes for obtaining wayleaves and connecting new builds are the same for digital infrastructure as other utilities by 2019.**
  - **Local government should designate 'digital champions' to improve telecoms processes such as street work permissions and access to publicly owned assets.**
  - **Ofcom should monitor the accessibility of Openreach's duct and pole infrastructure by levels of usage.**

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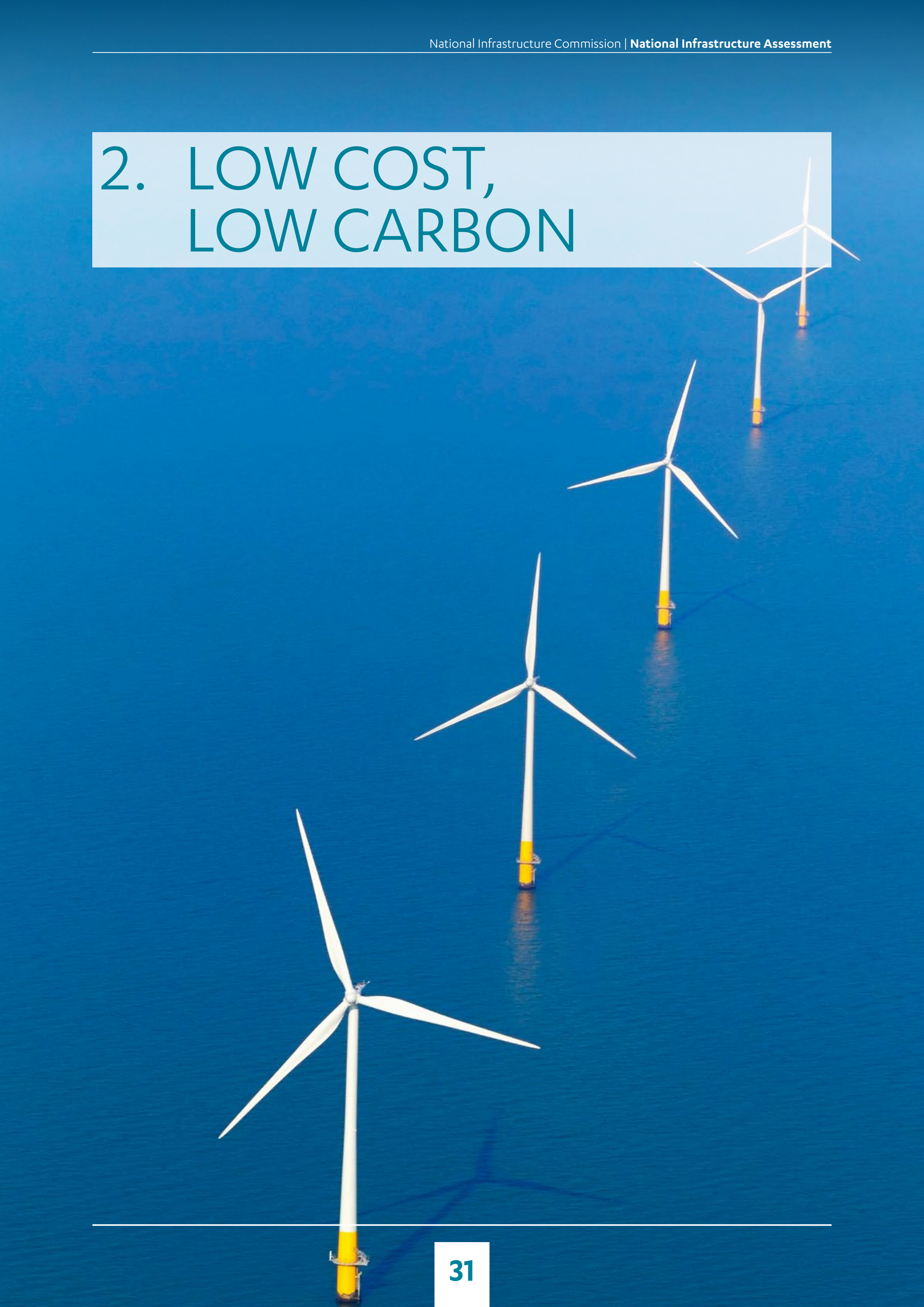


2. LOW COST, LOW CARBON

LOW CARBON INFRASTRUCTURE AT NO EXTRA COST

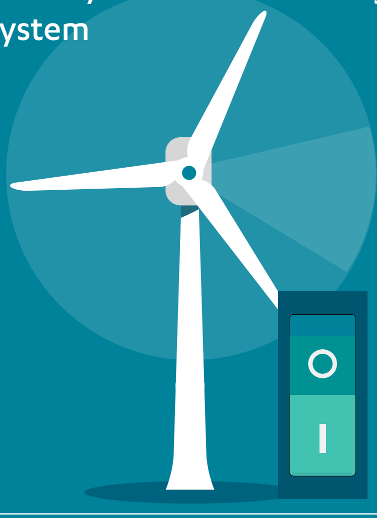
Reducing emissions has often appeared costly and difficult, but this is no longer the case, if the right decisions are taken now

Today, consumers pay an average of

£1,850

per year for electricity, heating, hot water and petrol or diesel

The same services could be delivered at the same cost in 2050 by a low carbon energy system



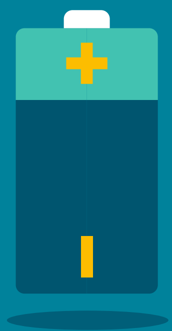
The Commission estimates that an electricity system powered mainly by renewables would cost no more than relying on new nuclear power plants

Renewables need more flexibility to balance variations in weather, but are cheaper to build

Sources of flexibility are getting cheaper: battery prices have fallen

80%

since 2010



Burning natural gas for heating and hot water is not a long-term option:

22%

of UK's greenhouse gas emissions come from heating

THE COMMISSION RECOMMENDS:

- At least 50% renewable electricity generation by 2030
- No more than 1 more contract for new nuclear before 2025
- Pilots to test hydrogen and heat pumps as low carbon heating options
- Buildings which require less energy to heat

Sources: BEIS, DfT, ESC, ONS, Commission calculations, Aurora Energy Research, McKinsey, Element Energy and E4tech

INCINERATING LESS, RECYCLING MORE

England needs to do as well as Wales – a world leader – at recycling

PEOPLE ARE WILLING TO DO THEIR BIT:

50%

would pay £30 a year for more recyclable packaging

79%

of people would be willing to separate their food waste

BUT THEY FIND THE CURRENT SYSTEM TOO COMPLICATED

Higher recycling, especially of plastics, could:

Save £6.2 billion from 2020 to 2050

Avoid the need to build 20 additional incinerators

Reduce greenhouse gas emissions

THE COMMISSION RECOMMENDS:

- Recycling targets: 65% of all waste, 75% of plastic packaging, by 2030
- Clearer labelling: recyclable or not recyclable
- Restricting use of hard to recycle plastics, by 2025
- Separate food waste collection, by 2025

Sources: Anthesis, Ipsos MORI

The UK can have low cost, low carbon electricity, heat and waste. Ten years ago, it seemed almost impossible for the UK to transition to being powered mainly by renewable energy sources such as solar and wind power in an affordable and secure way. Now the same focus needs to be applied to deliver a value for money approach to reducing emissions from heat. Low cost, low carbon energy and waste systems are now possible, and should be delivered.

The UK is legally bound to reduce its greenhouse gas emissions by at least 80 per cent from 1990 levels by 2050. Today, around 70 per cent of emissions come from electricity, buildings, travel and waste.[1]

Reducing emissions has often appeared costly and difficult, but this is no longer the case. Today consumers pay an average of £1,850 per year for the energy they use, including electricity, transport fuel, and fuel and equipment for heating and hot water.[2] The Commission's analysis shows that the same services could be delivered at the same cost (in today's prices) in 2050 by a low carbon energy system.[3] But this will only be possible if the right decisions are taken now.

The Commission's modelling has shown that delivering a low carbon electricity system for 2050 powered mainly by renewables is a low cost option, cost comparable to building further nuclear power plants after Hinkley Point C. The Commission's modelling also shows that continuing to use fossil fuels with the addition of carbon capture and storage is unlikely to form part of a cost competitive generation mix.

Reducing the waste sent to energy from waste plants (incinerators) by recycling more plastic and converting more food waste into biogas can also help reduce overall emissions. But even with emissions almost eliminated from power generation and waste, the UK cannot achieve its emissions targets without transitioning away from using natural gas, a fossil fuel, for heating. The UK must now address this problem. In the short term, improving the energy efficiency of the UK's buildings will reduce demand for heat and mitigate some of the emissions. In the longer term, it will also reduce the costs associated with delivering low carbon heat infrastructure.

The successful delivery of a low cost, low carbon energy and waste system requires:

- a flexible electricity system and new generation, primarily through renewables
- determining the best way to deliver low carbon heat in the UK

- **buildings which require less energy to heat**
- **encouraging more recycling, and less waste incineration.**

A lower cost, low carbon energy system

Reducing carbon dioxide emissions from the power sector no longer needs to be considered expensive. The Commission's analysis suggests that, across electricity, heat and transport, switching to and using low carbon alternatives does not need to lead to higher costs for consumers in the long term. The need to replace fossil fuels is driving a shift away from technologies, many over 100 years old, that society has become locked into, but which are now beginning to be replaced by more efficient alternatives.

Today, consumers pay an average of £1,850 per year for the energy they use, including electricity, transport fuel, and fuel and equipment for heating and hot water.[4] The Commission's analysis shows that the same services could be delivered at the same cost (in today's prices) in 2050 by a low carbon energy system.[5]

Heating is currently predominantly fuelled by natural gas, a fossil fuel. Transitioning to a low carbon alternative (the two main options are electrified heat, using heat pumps; and hydrogen fuelled heat) will add to household bills. But these extra costs can be outweighed by switching to use electricity rather than petrol or diesel for transport. The cost of supplying low carbon electricity is falling.

These estimates are inevitably uncertain. Savings will only be possible if the right decisions are taken. In particular, these estimates assume investment in cost-effective energy efficiency measures.

The Commission's cost estimates:

- assume a typical household, consuming the same quantities of energy services today and in 2050
- include the costs of electric vehicle charging infrastructure and home heating appliances (boilers, heat pumps) as well as the costs of energy and fuel
- exclude potential savings on the cost of cars and car maintenance from the switch to electric vehicles, and the one-off costs of energy efficiency measures
- exclude tax – there would be further savings for households from today's tax system (since petrol and diesel are heavily taxed) but these savings would have to be made up elsewhere by the Exchequer
- average the projected costs of predominantly hydrogen and predominantly heat pump scenarios for low carbon heat

- assume continued technology development for existing technologies (eg battery storage) but do not take into account potential new technologies.

Full details are set out in the technical annex: *Energy and fuel bills today and in 2050*.

Renewables have become cost competitive

It is now possible to conceive of a low cost electricity system that is principally powered by renewable energy sources. The Commission's analysis has shown that the estimated average cost of the electricity system as a whole between 2030 and 2050 is broadly comparable between investing heavily in nuclear power stations or investing heavily in renewables (there is very little prospect of new nuclear, beyond Hinkley Point C, coming on system before 2030). Figure 2.1 shows slightly lower average costs for a scenario with 90 per cent renewable and less than 10 per cent nuclear compared to a scenario with 40 per cent renewable and around 40 per cent nuclear, regardless of whether heat is predominantly electrified using heat pumps or provided through low carbon hydrogen in the future. The higher cost of managing the variable nature of many renewables ('balancing') is offset by the lower capital cost, which translates into lower costs in the wholesale market.

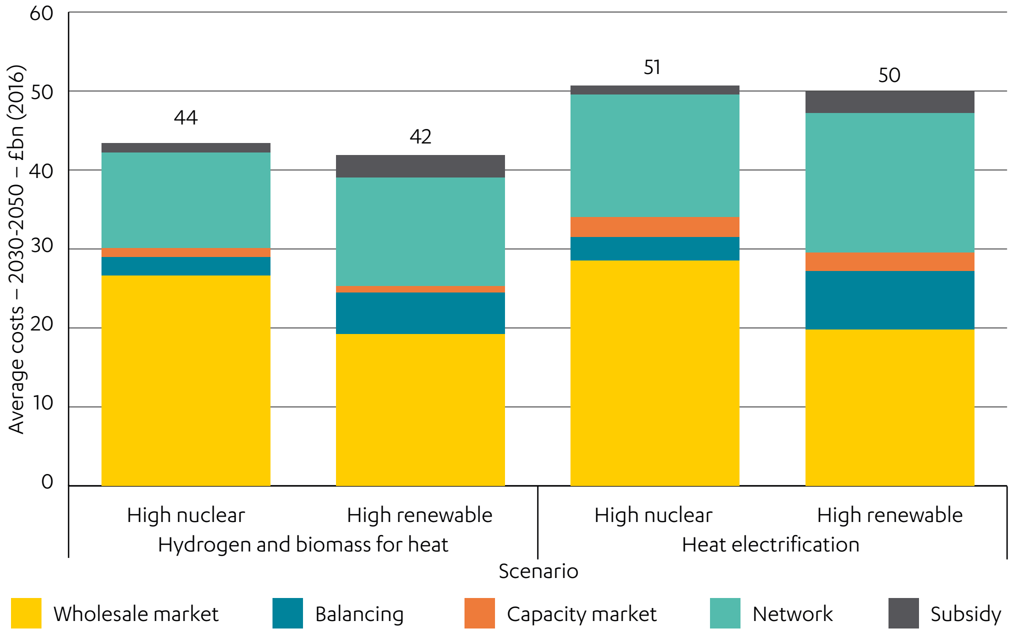


Figure 2.1: Average cost of the electricity system per year for different proportions of renewables/nuclear and heat decarbonisation pathways[6]

Estimates over such a long time period, and with considerable technological change, are inevitably uncertain. Specific figures should not be given undue weight. However, the broad conclusion of the analysis implies that an electricity system with no further nuclear plants after Hinkley Point C is likely to be cost comparable with a system which accommodates a new fleet of nuclear reactors.

These estimates assume continued reductions in the costs of renewable technologies. However, in recent years actual cost reductions have exceeded expected reductions.[7] If the trend were to continue, and reductions were to exceed those assumed here, then the case for renewables would be stronger still. Further reductions could arise, for example, from new, cost effective, technologies for energy storage: the modelling does not assume untried technologies.

Historical evidence suggests it is much less likely that nuclear costs will fall. Figure 2.2 shows the construction costs of nuclear power stations in various countries, by construction start date. This shows no discernible trend in construction costs over time. This is true even for countries, such as France, that have built fleets of similarly designed reactors. The issue of long term disposal for nuclear waste is also still unresolved in the UK.

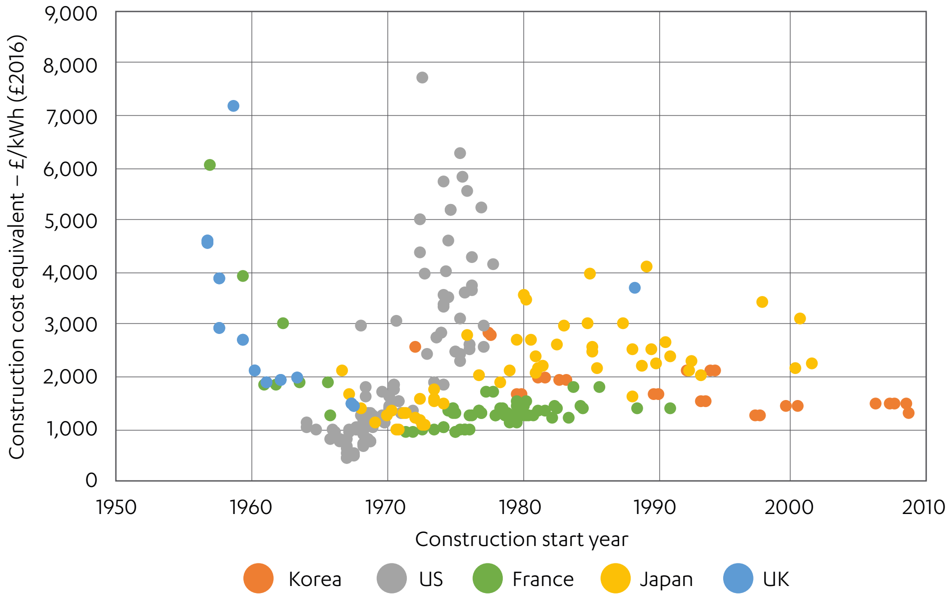


Figure 2.2: Construction costs of nuclear power stations over time[8]

Paying for nuclear and carbon capture and storage

New nuclear power plants and carbon capture and storage infrastructure will not be built by the private sector without some form of government support. This can come in a variety of forms. Expenditure will be treated as either 'on' or 'off' the public balance sheet (the account of government's assets and liabilities) depending on an assessment by the Office for National Statistics of where the risks and rewards sit.

Off public balance sheet deals, such as the package for Hinkley Point C, leave risks predominantly with the private sector. The National Audit Office found that this procurement model for Hinkley Point C did not provide best value for money for consumers.[9] It is also questionable whether a further deal on this basis could be agreed, given the scale of risk that the private sector is required to hold.

A commonly discussed alternative 'regulated asset base' model, as used for the Thames Tideway Tunnel, could also be classified as off the government balance sheet. In this case, however, consumers hold both some risks and some elements of financing. The Thames Tideway model requires consumers to pay for infrastructure in advance. This makes projects appear cheaper as consumers are effectively financing the projects at zero interest. At least some of the risk associated with construction costs also sit with consumers, a further hidden cost, since consumers are not paid to hold these risks in the way investors would be.

Funding nuclear power stations or carbon capture and storage on the public balance sheet represents a transfer of risk from the private to the public sector. Cost overruns would ultimately be paid for by taxpayers, at least in part. These risks are not reflected in the government's cost of borrowing, since it is taxpayers, rather than the holders of debt, who bear the risk. But this does not mean the risk, and its associated costs, have been avoided. The apparently lower financing costs represent a transfer, rather than a reduction, in risk.

On balance sheet options would need to compete with alternative uses of the government's balance sheet. Chapter 7 sets out the Commission's choices within the resources government have set out (the 'fiscal remit'). The Commission have not assumed any on balance sheet nuclear power stations in making these choices.

It is not clear what the best model for either type of project would be, since this would depend on the commercial terms available and where risk can best be managed. Past experience of on balance sheet nuclear construction in the UK has been mixed. There is limited experience of using the regulated asset base model for anything as complex and risky as nuclear. However, any assessment needs to recognise the full costs and risks. It should not be distorted by hidden costs or used to present costs as artificially lower.

Given the balance of cost and risk, a renewables based system looks like a safer bet at present than constructing multiple new nuclear power plants. But a large amount of uncertainty does remain. No country has yet built an electricity system with very high levels of variable renewables. It will be important to develop a better understanding of how such a system performs under adverse weather conditions, particularly given that climate change itself makes such conditions harder to predict. The risk is that the extra services required to accommodate large amounts of renewables may be harder, or more expensive, to source than envisaged. But given that some technologies which provide flexibility are still fairly immature, the costs could also be lower than the analysis suggests.

Given these uncertainties, the Commission is recommending a 'one by one' approach to new nuclear plants, as opposed to the current government policy to develop a large fleet. This is preferable to a 'stop start' approach, in which the nuclear programme is cancelled only to be restarted at a later date. It will allow the UK to maintain, but not expand, a skills base and supply chain. This allows the UK to pursue a high renewables mix, which is most likely to be the preferred option, without closing off the nuclear alternative.

The Government should also seek to ensure continuity with current Euratom arrangements as the UK leaves the EU, to ensure that on 29 March 2019 the UK has the necessary measures in place for the nuclear industry to continue to operate.

A more flexible power system

Matching energy supply and demand means the electricity system needs 'flexibility', both within days and across seasons. This can be provided by a combination of flexible supply (energy that can be generated on demand); energy storage; and flexible demand (demand that can be moved to a time of day when there is more supply).

To date, carbon intensive fossil fuels have met some of this need by providing plenty of flexible supply. But as they come off the system in favour of (mostly variable) renewable energy, flexibility will need to be maintained in other ways. The Commission's analysis takes into account the cost of providing additional flexibility, as well as wider system costs such as the transmission and distribution of electricity. More renewables do lead to more money being spent to match supply and demand: a system with 90 per cent renewables is estimated to cost up to £4.5 billion more per year to balance. But cheaper capital costs are estimated to offset this within the costs for the overall system.[10]

In all scenarios, extra flexibility, which includes technologies such as storage, interconnection and demand side response, is a low regrets investment which reduces estimated total energy system costs by between £1-7 billion per year on average between 2030 and 2050.[11] This finding echoes the conclusions of the Commission's *Smart Power* report.[12] Extended periods of low sun and wind in the winter can be met by a range of flexible technologies or, in the extreme case, by using limited amounts of fossil fuels. These events are rare, so the impact on emissions would remain small.[13]

The Commission's analysis demonstrates that a rapid uptake of electric vehicles in the 2020s (see Chapter 3) can not only be accommodated, but that the batteries in electric vehicles could be a valuable and low cost source of flexibility for the electricity system in future. Provided smart charging is implemented, electric vehicles can provide demand when it is otherwise low and potentially return power, stored in car batteries, to the grid at peak times ('vehicle to grid').[14]

A level playing field for different renewables

The existing mechanism for supporting low carbon generation technologies is called 'Contracts for Difference'. To reduce generators' exposure to volatile wholesale electricity prices, Contracts for Difference require generators to sell energy to the market as usual, but contract government to pay generators any difference between the market price and a pre agreed 'strike price', which is usually valid for 15 years. At times of high market prices these payments reverse and the generator is required to pay government back the difference between the market price and strike price.[15]

The Commission favours the use of existing market mechanisms – Contracts for Difference and the capacity market – where possible, to avoid creating more uncertainty, but incremental improvements could be made. The Contracts for Difference mechanism can provide both certainty for generators and a subsidy (depending on the agreed 'strike price'). Low carbon generation technologies have so far not been cost competitive, bringing both of these into play.

Since the introduction of Contracts for Difference, there have been significant reductions in the costs of renewables to consumers, through the competitive allocation of support. For each Contracts for Difference auction, technologies at similar stages of development are grouped together in different 'pots'. Pot 1 was set up for 'established' technologies, including onshore wind and solar, and pot 2 (for 'less established' technologies) contains, amongst other technologies, offshore wind. Only one pot 1 auction has been run to date.

Revising the distribution of technologies between pots and reinstating a pipeline of pot 1 auctions would enable the lowest cost renewable generation mix to be brought forward in the 2020s. Onshore wind, which enjoys strong public support overall,[16] but has been controversial in some communities, would still be subject to planning restrictions in England. Projects in Wales and Scotland would no longer be held back. Pot 2 auctions could be used to allocate small amounts of support to emerging technologies, especially where they are likely to be able to contribute to the reduction of system costs in future.

Low carbon generation technologies should benefit from the support from Contracts for Difference. However, as set out in the Commission's interim National Infrastructure Assessment, it is also important that generators are responsible for costs and benefits they impose on the system, such as those related to where they situate. Some sites impose costs, for example due to the need for new transmission infrastructure, or benefits, for example if local weather conditions complement those elsewhere.

Over time, the different costs and benefits of new generation should increasingly be reflected in the auction process, allowing the lowest cost system to be developed. However, calculating these impacts is very complex, and in practice a mixture of pricing and other mechanisms will need to be used to ensure total system costs are reflected in the bid price. As the generation mix evolves, it will be essential that both technological and spatial diversity are maintained across the system. This may involve making use of administrative limits for each technology within auctions.

As the prices of low carbon technologies continue to fall, the need to subsidise low carbon generation through Contracts for Difference will reduce and, particularly in later years, the mechanism may require payments from generators. This could result in contracts that provide the certainty required for low cost investment, but which are low cost or cost neutral for consumers over their duration. This may be important, as no one knows what the electricity markets will look like in the long term, or what factors will drive the electricity price. However, contract lengths will also need to reflect the need to retain flexibility in the future development of the electricity market.

Tidal power

The Commission's analysis suggests that tidal lagoon power will remain an expensive technology in the future. The extra benefits which arise from its predictability are not enough to offset its higher capital costs.[17] And it will never be a large-scale solution: an entire fleet of tidal lagoons would only meet up to 10 per cent of current electricity demand in the UK.[18] This also limits the scope for cost reductions through the kinds of learning and scale economies that have been achieved with wind and solar power. Further details are set out in technical annex: *Tidal power*. Given the broad portfolio of readily available lower cost, low carbon technologies, special treatment for tidal lagoons in the form of bilaterally agreed contracts is not justified. However, tidal should be allowed to compete on an equal basis with other technologies for Contracts for Difference.

The near term: 2020 – 2030

Increasing population and electric vehicle uptake means that energy demand could increase by 9-26 per cent from today to 2030.[19] And over this period, up to 40 GW of older power stations will come offline.[20] This creates a large opportunity to continue to reduce emissions from the electricity system throughout the 2020s without stranding assets.

New nuclear power stations are unlikely to be an additional source of electricity in the 2020s, with the possible exception of Hinkley Point C. Large scale projects have long construction timelines and often face delays. Smaller reactors are still at an early stage of development and their benefits remain speculative. It is estimated that the end-to-end deployment process will take 12-14 years for the first small modular reactor.[21]

Since a system with a high proportion of renewable generation looks cost effective in the long term, and adding more nuclear to the system in this timeframe is unlikely, it makes sense to continue to add more renewables to the system in the 2020s.

However, not all new sources of supply in the 2020s need be renewable. Interconnectors, of which there is a large pipeline of projects, are likely to become of increasing importance throughout this period, and the Government should ensure that the current pipeline is not affected by the UK's exit from the EU. It may also be cost-effective to deploy a limited amount of new gas power stations, provided they can be accommodated within the carbon budgets, and recognising that load factors are likely to be on a reducing path.[22]

The Commission recommends that in order to keep the option of a highly renewable system in 2050 open, at least 50 per cent of generation (in TWh) should be renewable by 2030. This would be equivalent to between 12 and 19 GW of offshore wind being deployed, in addition to the current pipeline.[23] The Commission's analysis suggests that the budget of £557 million that the government has set aside for future Contracts for Difference auctions may be sufficient to achieve this, depending on the future wholesale price of electricity.[24] However, if interconnectors do not deliver expected benefits, up to 65 per cent of generation may need to be renewable to meet 2030 carbon targets.

The Commission recommends that government should set out a pipeline of pot 1 Contracts for Difference auctions, to deliver at least 50 per cent renewable generation by 2030, as part of the transition to a highly renewable generation mix. Government should:

- **Move technologies that have recently become cost competitive, such as offshore wind, to pot 1 following the next Contracts for Difference auction in Spring 2019. Pot 1 should be used for the overwhelming majority of the increase in renewable capacity required.**
- **Publish indicative auction dates and budgets for the next decade by 2020.**
- **Over time take whole systems costs into account in Contracts for Difference auctions, as far as possible.**
- **Consider whether there is a case for a small-scale, pot 2 auction in the 2020s, if there are technologies which are serious contenders for future pot 1 auctions.**
- **Not agree support for more than one nuclear power station beyond Hinkley Point C, before 2025.**

Carbon capture and storage

The Commission's analysis included carbon capture and storage (CCS) as a potential option for the electricity system. Carbon capture and storage would allow the continued use of fossil fuels. However, the Commission's analysis showed that it rarely appeared to be a cost effective option for reducing power sector emissions. In scenarios where small amounts were cost effective, this was in the 2040s. This finding held even when carbon dioxide transport and storage costs were assumed to be very low, indicating the outcome if carbon capture and storage had already been built for other purposes. This shows it does not make sense for electricity consumers to subsidise the development of carbon capture and storage, since it will not benefit them in future.

Generation scenario	Heat decarbonisation scenario	CCS cost assumption	Percentage of CCS in the 2050 generation mix
40% renewable	Hydrogen and biomass	Central	1%
		Low	5%
	Electrification	Central	4%
		Low	8%
90% renewable	Hydrogen and biomass	Central	0%
		Low	0%
	Electrification	Central	0%
		Low	0%

Figure 2.3: Percentage of generation from fossil fuelled power stations equipped with carbon capture and storage in 2050 under different scenarios for generation mix, heat decarbonisation pathways and carbon capture and storage costs

There are several other potential uses for carbon capture and storage, including the reduction of emissions from industrial processes and combining it with biomass combustion to create negative emissions. However, the most pressing reason to develop it at scale is likely to be for the manufacture of low carbon hydrogen. This will be required if the UK chooses to remove carbon emissions from heat through diluting or replacing natural gas with hydrogen, especially in the absence of a global hydrogen market. Removing and storing the carbon from natural gas as part of producing hydrogen is a simpler process than capturing it as it is burnt in a power station.[25]

Informing future decisions on heat

Reducing emissions from heating in an affordable way is the next challenge. Currently 69 per cent of heat is produced through burning natural gas, a fossil fuel.[26] This must be radically reduced. Uncertainties around cost, technology, and consumer behaviour means that it is difficult to decide the cheapest way to replace natural gas to meet future Climate Change Act targets now. However, this uncertainty is not an excuse for inaction in the near term. Low carbon heat at lowest cost will benefit the environment and improve many people's lives.

There are two potential large scale solutions for low carbon heat, and a range of smaller solutions which may complement one of them. The first option is electrification, using heat pumps to increase the efficiency of using electricity for heating. Alternatively, hydrogen from a zero carbon source (which creates only water vapour when burnt) could be used as a direct replacement for natural gas, fuelling boilers and appliances.

Whilst there are incremental steps that can be taken to address some aspects of the challenge, an incremental approach on its own will not be enough. In the 2020s, decisions will be required on whether the gas network should be maintained and converted, or phased out.

The Commission's analysis shows that currently all routes to low carbon heat are more expensive than maintaing the status quo, although the cost of heating as a proportion of GDP in 2050 is estimated to reduce.[27] The impacts of this cost will also be offset by switching to cheaper forms of energy in other areas, particularly transport.[28] Central estimates indicate an average annual cost between now and 2050 of £13 – 16 billion above the current system cost of £24 billion.[29] These figures are highly uncertain. Finding ways to reduce both the uncertainty and magnitude of them must be a priority.

For government to make choices about the decarbonisation of heat in the 2020s, there needs to be a coherent programme to ensure that the evidence to do so is in place. This should include collaborating internationally on research and development, to give government the confidence to invest in the best solution when the time is right. The Commission plans to provide further advice to government on this issue in the next National Infrastructure Assessment, taking into account parallel strategies in Scotland and Wales.

The Commission recommends that government needs to make progress towards zero carbon heat:

- **Establishing the safety case for using hydrogen as a replacement for natural gas, followed by trialling hydrogen at community scale by 2021.**
- **Subject to the success of community trials, launching a trial to supply hydrogen to at least 10,000 homes by 2023, including hydrogen production with carbon capture and storage.**
- **By 2021, government should establish an up to date evidence base on the performance of heat pumps within the UK building stock and the scope for future reductions in the cost of installation.**

Buildings which require less energy to heat

Improving the insulation of buildings makes sense both now and in a low carbon future. The Commission's analysis suggests that there are over 21 million individual improvements to buildings in England that together could save billions of pounds. This includes insulating 10 million lofts, 6 million floors and almost

5 million walls. This is equivalent to 21,000 improvements being installed every week between now and 2035.[30] The current rate of progress is around 9,000 improvements installed per week.[31]

Delivering these improvements alone represents a major challenge. Driving widespread improvements in energy efficiency is notoriously difficult. Different interventions to stimulate uptake will be required across different segments of the building stock.

However, an even more ambitious approach may ultimately be required. The optimum level of energy efficiency is partly linked to the choice of heat technology: in particular, heat pumps work best in buildings with reasonably high insulation standards because they provide constant, but low temperature levels of heat.

A range of different initiatives will need to be trialled and fully evaluated, learning from international experience, and progress regularly reviewed. The government will need to prepare for the fact that it is likely that some future energy efficiency initiatives may fail. But this should not lead to a loss of momentum or enthusiasm for energy efficiency. Alongside this, innovation in energy efficiency products and processes should also continue to be supported, particularly for solid walls. An immediate priority is the social rented sector. Under any approach, government will inevitably bear most of the cost of improving energy efficiency either through direct grants, support to social landlords or rental payments via Housing Benefit. The Commission estimates that cost effective improvements to existing socially rented properties would cost £3.8 billion. A ten year programme would meet government's own stated ambition of ensuring social rented properties reach at least Energy Performance Certificate level C by 2030.[32]

The Commission recommends that government should set a target for the rate of installations of energy efficiency measures in the building stock of 21,000 measures a week by 2020, maintained at this level until a decision on future heat infrastructure is taken. Policies to deliver this should include:

- **Allocating £3.8 billion between now and 2030 to deliver energy efficiency improvements in social housing.**
- **Government continuing to trial innovative approaches for driving energy efficiency within the owner occupier market.**
- **Government setting out, by the end of 2018, how regulations in the private rented sector will be tightened and enforced over time.**

Incinerating less, recycling more

Low cost, low carbon waste is also necessary and achievable in the near term. The Commission's remit on waste covers England only, where waste generation is expected to rise as the population grows. Energy from waste plants (incinerators) facilitated the move away from landfill, and make sense when the alternative is energy from fossil fuels. They incinerate 'black bag' waste and other wastes that cannot be recycled, producing electricity and providing heat where there is a source of demand nearby.

However, lower cost, lower carbon options exist for some types of waste, in particular food waste and plastics. In these areas, England should not settle for the minimum standards set out in EU legislation but should seek to be amongst the best performers, learning from the example set by Wales.

Separating food waste

As an alternative to incineration, food waste can be treated in 'anaerobic digesters'. Anaerobic digesters break down biodegradable waste in the absence of oxygen, producing biogas and a low grade fertiliser ('digestate') at a fraction of the capital cost of incinerators.[33] In future, technologies such as pyrolysis or gasification, may also become available commercially.[34]

Biogas can be used as a low carbon substitute for natural gas. It can also be converted to a range of biofuels, which may prove especially valuable in sectors where fossil fuels are hardest to replace, such as aviation. Besides treatment, there are benefits to collecting food waste separately, such as preventing the contamination of other recyclable materials.

Using anaerobic digestors requires the separate collection of food waste, which is typically collected weekly in household 'caddies' designed for the purpose. In 2014-15, only 26 per cent of English households had separate food collection.[35] The Commission's analysis shows universal food waste collection would avoid the need to build between 1 and 3 energy from waste plants between now and 2050. It would save up to £400m in capital costs and £1.1bn in operational costs for local authorities in total between 2020 and 2050.[36] [37] This includes the cost of weekly collections.

In the Commission's social research, 79 per cent of participants without caddies said they would be willing to use one.[38] A higher recycling rate more generally reduces the demand for residual waste infrastructure. By 2035, a 65 per cent recycling rate, with separate food waste collection, would mean that 7 million tonnes less residual capacity is needed, equivalent to 20 energy from waste facilities.[39]

The Commission recommends that government should establish separate food waste collection for households and businesses (to enable production of biogas) by 2025.

Wales: a world leader in recycling

In 2008, Wales had a similar recycling rate to England (approximately 40 per cent). Today, Wales has the third highest municipal recycling rate in the world (64 per cent).[40]

Wales achieved this through its 'towards zero waste' strategy. The strategy established ambitious recycling targets for local authorities, mandated the separate collection of food waste and provided a blueprint for standardised collection of other materials.[41]

To ensure local authorities had the capacity to deliver effective recycling collection systems, the Welsh Government provided £68 million in capital support for recycling infrastructure.[42] Additionally, the ability to fine local authorities that missed their recycling targets was introduced.[43] In practice, only one local authority has been fined; all that missed the targets were referred to a support program. Communication campaigns were conducted to raise awareness of what could be recycled.

By becoming a leader in recycling, Wales saw the total cost of collection for local authorities fall. In the process, it avoided 105,000 tonnes of carbon dioxide emissions.

Reducing plastic waste

A more circular economy, with a higher recycling rate that keeps materials in use for longer, could save local authorities a total of £6.2bn between 2020 and 2050.[44] Targeting plastics is particularly important. Increasing the plastic recycling rate will also reduce emissions generated from burning plastics (effectively a fossil fuel) and reduce leachates that can contaminate local water systems when plastic is landfilled.

Despite this, the UK's plastic recycling rate is just 30 per cent.[45] This is due to both household behaviour, and product design. In England, 53 per cent of households throw away items that could be recycled.[46] This appears, at least in part, to be due to a lack of clarity on recycling; the Commission's social research suggests many people would like to recycle more but find it complex and confusing.[47,48]

The first priority should be to reduce unnecessary packaging and other single use plastics. The government have launched a range of consultations in this area. It is important that these lead to action. Thereafter, it is important to target hard-to-recycle materials. The way packaging is designed can alter the cost and viability of recycling. To date, incentives in the waste system have been focused on weight. The government is currently reviewing this approach, as reductions in weight may have reached their limit. Setting incentives to improve product design could help reduce the cost of recycling.

Some materials are particularly problematic. PVC can compromise recycling of PET, which is otherwise widely recycled.[49] Polystyrene is almost never economical to recycle and particularly dangerous to marine life.[50] In the long run, these materials need to be replaced if packaging is to be sustainable. A clear timetable by which these products would be phased out would allow industry to develop sustainable alternatives.

A package of measures to improve supply of recyclable material, standardise collection regimes and clarify labelling is needed to push recycling rates upwards. Government initiatives and incentives to target specific products such as the Deposit Return Scheme or recent proposals on packaging reform are important steps forward, but they need to work alongside ambitious headline targets.[51]

The Commission recommends that government should set a target for recycling 65 per cent of municipal waste and 75 per cent of plastic packaging by 2030. Government should set individual targets for all local authorities and provide financial support for transitional costs.

The government should establish:

- **Clear two symbol labelling (recyclable or not recyclable) across the UK by 2022.**
- **A consistent national standard of recycling for households and businesses by 2025.**
- **Restrictions on the use of hard-to-recycle plastic packaging (PVC and polystyrene) by 2025.**
- **Incentives to reduce packaging and for product design that is more easily recyclable by 2022.**
- **A common data reporting framework for businesses handling commercial and industrial waste by the end of 2019, ideally through voluntary reporting but if necessary by legislation.**

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3. REVOLUTIONISING ROAD TRANSPORT

GETTING READY FOR THE ROADS REVOLUTION

Vehicles of the future will be cheaper, cleaner, quieter and safer.

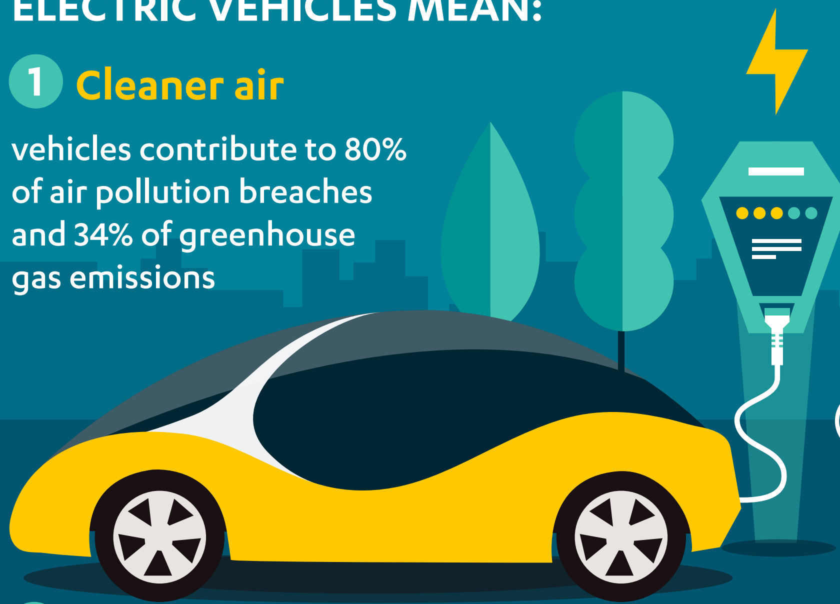
As prices fall and range increases, take up of electric vehicles could accelerate rapidly

ELECTRIC VEHICLES MEAN:

Charge point infrastructure is required to enable close to 100% electric new car and van sales in 2030

1 Cleaner air

vehicles contribute to 80% of air pollution breaches and 34% of greenhouse gas emissions



2 Lower costs

electric motors are 3 times as efficient as petrol

3 Flexibility for the energy system

smart charging is a form of flexible demand

CONNECTED, AUTONOMOUS VEHICLES WILL MEAN:

Safer roads

over 1,700 people are killed on the roads per year

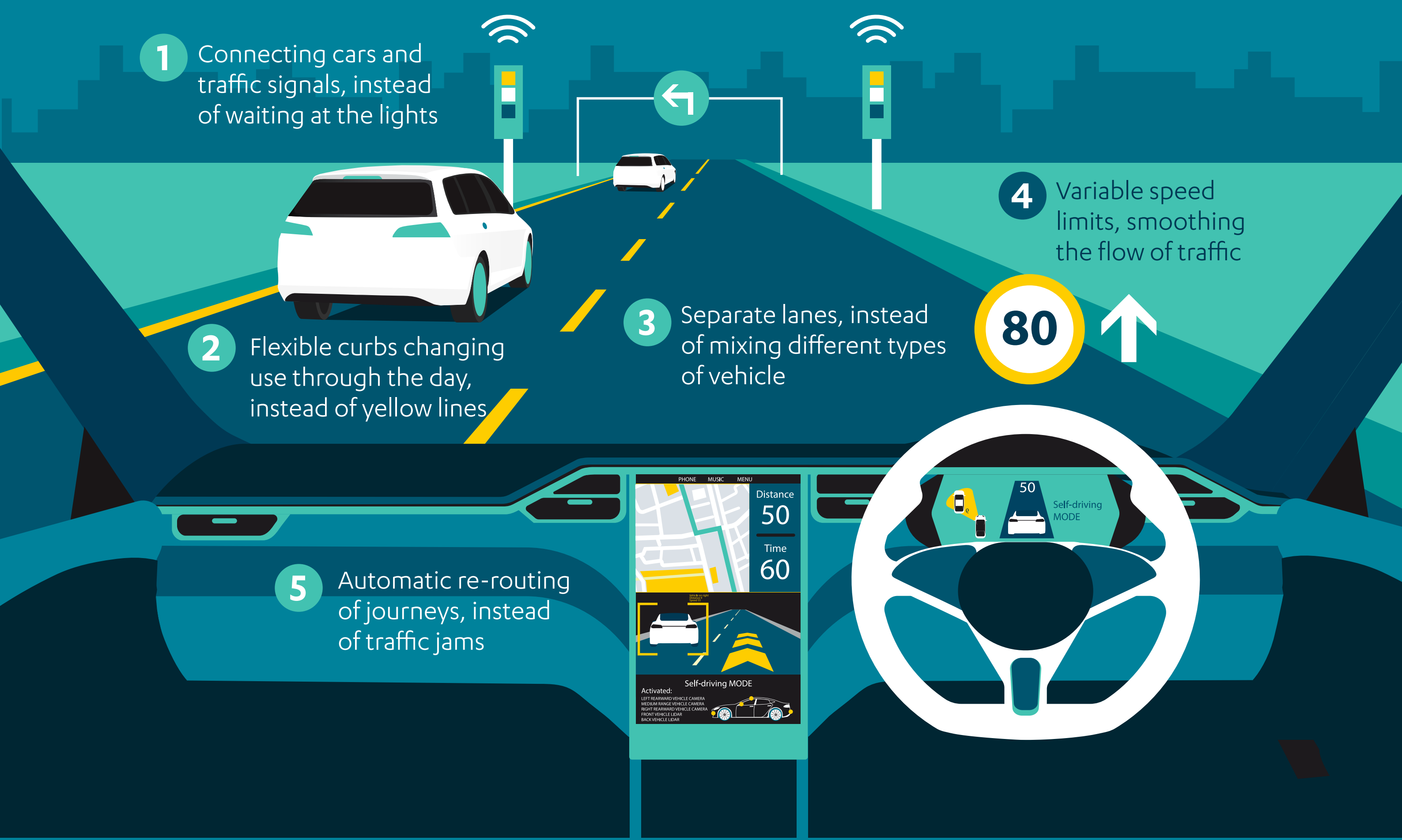
Accessibility

more people can travel by car

Time freed up

driving takes an average of 140 hours per year

BUT ROADS WILL NEED TO CHANGE. SOME IDEAS ARE:



THE COMMISSION RECOMMENDS:

- Making it easier to convert parking spaces and provide charge points on the street
- Investing in the electricity network to achieve the benefits of electric vehicles
- Future road and rail investment plans need to reflect the impact of connected and autonomous vehicles
- Government support for rural charge points

Sources: Defra, BEIS, Newbury and Strbac, Aurora Energy Research, DfT, NIC Roads for the Future Competition entries

Most journeys in the UK are made by road. After 100 years of incremental change, road transport is about to undergo a revolution. More electric cars and vans are being built and sold, and autonomous vehicles could soon be on the roads too. These vehicles will change the nature of the transport debate in the UK. Conventional vehicles bring pollution, noise and accidents; electric vehicles are cleaner and quieter, and connected and autonomous vehicles could make roads safer.

The UK is one of the top European countries in terms of electric vehicle sales,[1] and government already supports the move to electric vehicles.[2] But the UK should speed up its preparations; electric vehicles are fast becoming cheaper and better, and take up could accelerate. With the right conditions, including a national network of electric vehicle charge points, the UK could become a world leader in electric vehicles.

There is also potential for the UK to become a world leader in connected and autonomous vehicles. KPMG has ranked the UK fifth in the world in terms of readiness for connected and autonomous vehicles,[3] and the UK is home to many companies developing this technology. The Commission has launched an innovation competition for ideas on how to deliver world-class roads ready for this revolution: 'Roads for the Future.'

Government must set a clear policy direction to encourage private sector investment in charging infrastructure for electric vehicles, and to prioritise research and innovation for connected and autonomous vehicles in the longer term. This will require:

- enabling electric vehicles to provide additional flexibility to the energy network
- enabling commercial charge point provision, with support in rural areas
- putting connected and autonomous vehicles at the heart of government planning
- preparing roads for connected and autonomous vehicles.

Electric vehicle uptake predictions

Electric cars and vans could become widespread ahead of most predictions, as prices continue to fall. Price falls are being driven by reductions in the cost of batteries, the most expensive component of an electric vehicle. Battery prices fell by 80 per cent between 2010 and 2016.[4] This initially meant that the range of electric vehicles could be extended: some cars can now travel up to 300 miles on a single charge.[5] Once ranges are sufficient, further falls in battery prices can translate directly into falls in the prices of the vehicles.[6] Upfront cost parity between electric and conventional vehicles is now expected by the mid-2020s.[7] And as purchase prices become comparable, fully electric vehicles will look increasingly attractive, as they are cheaper to run.[8] As these facts emerge, projections are evolving to reflect them: figure 3.1 shows how National Grid's electric vehicle uptake estimates have increased over the past three years.

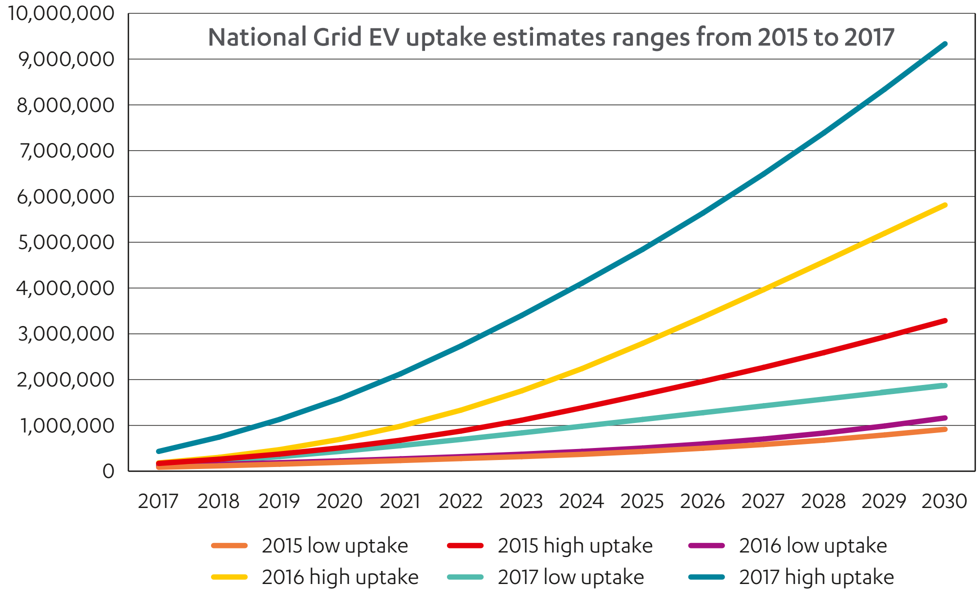


Figure 3.1: Range of battery electric and plug-in hybrid vehicle uptake estimates from National Grid's Future Energy Scenarios[9]

Given current industry momentum and falling costs, it looks like electric vehicles, rather than alternatives such as hydrogen, will capture the market for low emission cars and vans in the short to medium term. It is too early to know if electric vehicles are the future for larger vehicles. The Commission's study on the future of the freight system, due to report in Spring 2019, will consider how to reduce emissions and congestion from road freight.

New technologies typically follow an s-shaped diffusion curve, which starts to accelerate as uptake moves into the 'take-off' period. This can start when they have reached 5 per cent of their potential market.[10] Figure 3.2 demonstrates how sales of videos declined as consumers switched to purchasing DVDs.

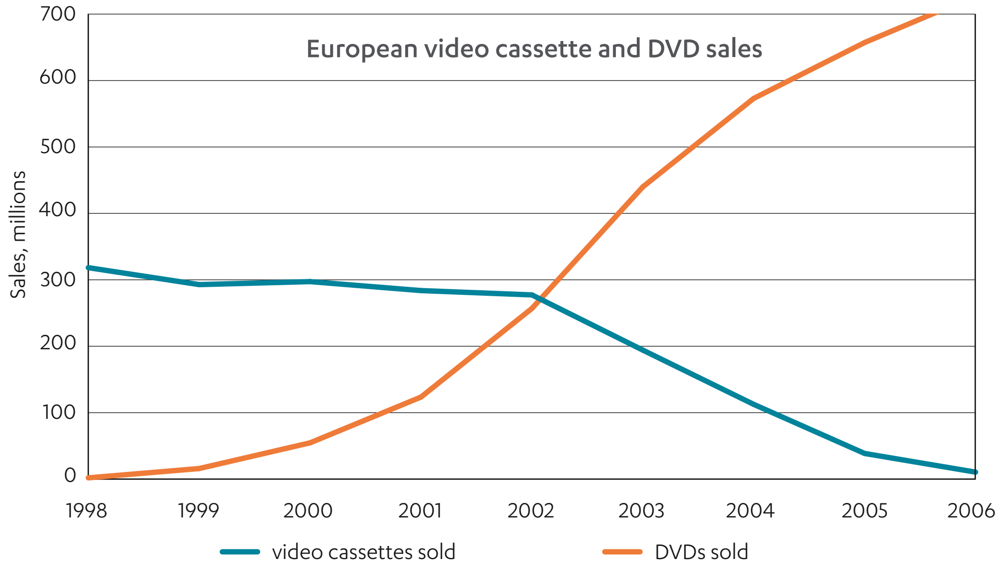


Figure 3.2: Sales of video cassettes and DVDs in Europe over time showing a typical s-shaped technology diffusion curve.[11]

In 2017, electric and hybrid vehicles represented 1.8 per cent of all new registrations, up 27 per cent on the previous year.[12] Electric vehicles could therefore soon enter the 'take-off' stage in the UK. Some projections suggest that the UK could even see 100 per cent sales of electric vehicles by 2027, and 100 per cent stock by 2042.[13]

A 2016 Department for Transport survey showed concern about recharging was the most significant factor preventing consumers buying an electric vehicle (45 per cent), followed by the distance travelled by one charge (39 per cent).[14] But aside from the need for a charging network, electric vehicles are likely to become increasingly attractive to consumers.

The uptake of electric vehicles will also depend on supply. Car manufacturers are beginning to ramp up electric vehicle production. Ford, the best selling car maker in the UK today, plans to have 40 fully electric or hybrid models in its global line-up by 2022, while Volkswagen, the second best selling car maker, is targeting 80 fully electric or hybrid models by 2025.[15] At Nissan's factory in Sunderland, electric vehicles roll off the same production line as petrol and diesel vehicles.

A rapid increase in uptake of electric vehicles is not certain. But it is certain that electric vehicles reduce the cost of driving, lower air pollution, and reduce emissions, in addition to supporting a highly renewable energy system. Therefore, government should encourage and facilitate the swiftest possible uptake of electric vehicles.

The Commission recommends that government, Ofgem and local authorities should enable the roll out of charging infrastructure sufficient to allow consumer demand to reach close to 100 per cent electric new car and van sales by 2030.

Electric vehicles and the energy system

The transition to electric vehicles will provide additional, low cost flexibility for the energy system.[16] When electric vehicles are able to follow price signals and charge when demand is low ('smart' charging), they help to smooth out daily electricity demand. As shown in figure 3.3, the daily demand profile with electric vehicles leads to a lower proportion of capacity being spare throughout the day than without electric vehicles. This means that electricity networks are used more efficiently and reduces the need for other types of flexibility, such as small gas engines and batteries. Overall system costs are reduced.[17] Furthermore, batteries considered at the end of their useful life in an electric vehicle may still retain up to 80 per cent of their original capacity.[18] These batteries can provide a source of storage for the grid, reducing the need for further investment (and supporting the price of second-hand electric vehicles).

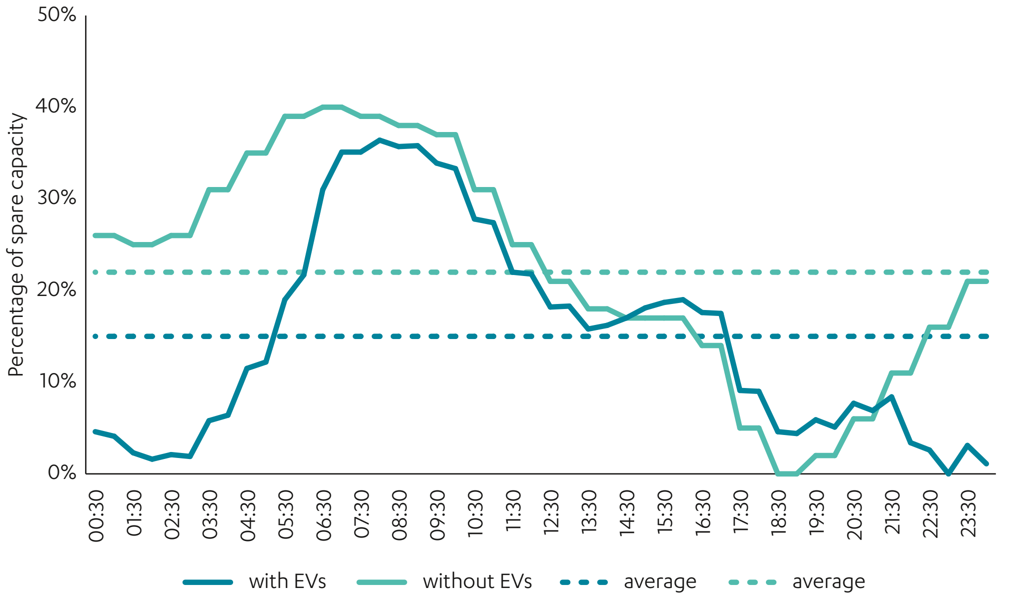


Figure 3.3: Percentage of spare generation capacity throughout the day with electric vehicles and without[19]

The Commission's analysis suggests that a 100 per cent uptake of electric cars and vans could increase total annual electricity demand by 26 per cent by 2050.[20] However, as electric engines are more efficient than petrol or diesel, each car would use less energy overall,[21] and as electricity becomes increasingly low carbon, emissions would reduce. Chapter 2 sets out how the UK can achieve a low cost, low carbon energy system, whilst accommodating an increase in electric vehicles.

Smart charging

Smart charging is essential for reducing the overall cost of the energy system as the number of electric vehicles increases. Not putting in place the necessary policy incentives could increase power system costs by £2 billion per year on average (2030-50), adding up to £30 per year on average to consumer bills (2030-50).[22] This would primarily be driven by increased power prices and electricity network reinforcement costs.[23] Smart charging will be much cheaper for the consumer than on-demand, rapid charging, as prices are likely to be lower when there is less demand on the electricity network.

Smart charging should therefore be the default option for home charging. There is likely to be an overall consumer preference for smart and slow charging.[24] But this is not certain. It is slightly less convenient, and carries some risk if a car is needed for a long journey earlier than expected.

Regulation

The Office for Low Emission Vehicles works to support the early market, and the Automated and Electric Vehicles Bill, which is currently before Parliament, will give government powers to make regulations on the specification of charge points (including requiring all charge points to be smart and interoperable).[25]

Given the importance of managing the interaction between charging and the energy system, it makes sense for Ofgem to take on the role of ensuring that there are arrangements to optimise use of chargers within the energy system. Ofgem should also consider whether there is a need to protect consumers from spikes in energy prices which could make rapid charging prohibitively expensive. Consumers should be able to refuel their car in an emergency without having to pay over the odds.

Government, industry and Ofgem should work together with the Office for Product Safety and Standards, the Institute of Engineering and Technology and the International Standards Organisation to ensure interoperability and the development of minimum standards for charge points.

The Commission recommends that Ofgem should take on the role of regulating the interaction between electric vehicle charge points and the electricity network immediately, ensuring that electric vehicle charging and vehicle to grid services contribute to the optimisation of the energy system. Government, industry and Ofgem should work together to set minimum standards for a network of interoperable, smart charge points.

A national network of charge points

Developing a nationwide, electric vehicle charging network offers the chance for the UK to get ahead. Too often in the past, short-term interests, a lack of coordination, and a tendency to endlessly debate difficult issues and delay difficult decisions have meant the UK has been slower to adopt new infrastructures than other countries. This time can be different.

Government funding is already available in the form of grants for home, workplace and on-street residential charge points. The Autumn Budget 2017 announced a new £400 million Charging Infrastructure Investment Fund, including £200 million of investment from the private sector.[26] However, so far, no private sector partner has been procured.[27]

Supporting charge point installation

Building electric vehicle charge points represents a big opportunity for the private sector. Demand for charge points is likely to grow.

Charge points are already being built across the country, growing from a total of 2,880 points in 2012 to 14,160 points in 2017.[28] Chargemaster plc plans to expand its POLAR charging network to 25,000 chargers by 2020.[29] A UK-based energy company, Pivot Power, is working with National Grid to build 45 new charging sites, each with up to 100 charge points, across the country, investing £1.6 billion.[30] And some petrol companies, such as Shell, have already begun installing electric vehicle charge points at their petrol forecourts.[31]

However, some potential charge point providers may be put off by the uncertain cost of connecting new charging infrastructure to the electricity network. New connections can trigger the need for network reinforcement, which the customer pays a proportion of as a connection charge.[32] Ofgem aims to avoid imposing general charges for reinforcement costs, preferring to link them to a customer's own network usage. However, this needs to take into account the indirect system benefits from both rapid and smart chargers.

Rapid charge points are more likely to trigger reinforcements than slow, smart chargers. They do not directly benefit the energy system in the way that smart chargers do. However, at present rapid chargers also provide an indirect benefit to the electricity network by reducing range anxiety, incentivising uptake and therefore incentivising the spread of smart charging.

Passing reinforcement costs on to public charge point providers risks reducing the amount of charge points installed and ultimately ignores the benefits that network users gain from an electric vehicle fleet. Ofgem's recent process to look into whether extra investment was required concluded that given the current pace of change it was unlikely to be needed before 2023. However, this was only done in consultation with network owners and not with the aim of facilitating a rapid uptake of electric vehicles.[33]

The Commission believes that this represents a missed opportunity. Ofgem should take a more proactive approach to preparing for future reinforcement needs for charging points; electricity networks should work with charge point providers to identify likely future reinforcements and invest ahead of time.

The Commission recommends that Ofgem should commission electricity network operators to work with charge point providers to identify potential anticipatory investments required to accommodate public charging infrastructure. Opportunities for investment within the current price control period should be identified by Summer 2019.

Furthermore, engagement with local authorities should not hold up the process of delivering charge points. Local authorities should work with commercial investors, make it easy for charge points to be built on their land, require charge points to be built as part of new developments, and free up parking spaces to be used for electric vehicle charging.

If travel patterns and car ownership models are fundamentally disrupted, vehicles may park and charge in different locations to today. But in the short term ensuring that charge points are installed and accessible for electric vehicles, and that this rollout is balanced against the needs of drivers of internal combustion engine vehicles, must be a priority.

On-street charge points for electric vehicles will be particularly important in dense urban areas where access to home off-street parking is limited, but these are the same areas where parking spaces in general will be at a premium. Local authorities will need to work with private sector providers and electricity network owners to identify where demand for charge points is likely to be highest, and ensure that there are sufficient parking spaces available for charge point installation as demand materialises.

The Commission recommends that government should place a requirement on local authorities to work with charge point providers to allocate 5 per cent of their parking spaces (including on-street) by 2020 and 20 per cent by 2025 which may be converted to electric vehicle charge points.

A visible core network

Although the majority of charge points are likely to be slow and smart, having a core network of visible, rapid chargers in place could significantly increase the pace of uptake. This network should provide both sufficient coverage, so that it is possible to find a charge point within a reasonable distance throughout most of the country, and enough power to fully recharge an electric vehicle within a reasonable timescale (for example within 1 hour). To enable close to 100 per cent of new car and van sales to be electric by 2030, the core network would need to be in place in the early 2020s to avoid inhibiting electric vehicle uptake.

The charge point network is often compared to the petrol station network but differs in two respects. Firstly, drivers of petrol and diesel vehicles do not suffer from range anxiety. Consumer confidence already exists in the petrol station network. Visible charge points in more places will combat this issue for potential electric vehicle drivers, and allay their concerns about being able to travel anywhere in the UK.

Secondly, the shape of the charging network is likely to be different to the petrol station network. Electric vehicle owners are more likely to recharge in towns and places where they can undertake other activities, than stop en-route. And petrol stations need to be accessible for fuel deliveries, which is not a consideration for charge points.

The pattern of private sector provision of charge points in the early stages of the electric vehicle market is likely to be similar to mobile and fixed broadband, where provision is strong in densely populated areas, but rural areas are initially underserved. Charge points in rural locations, which benefit users and society by contributing to a complete network providing coverage across the country, will not be as profitable as those in urban centres and main arterial routes, and many of the benefits from providing this network will go to electric vehicle purchasers and manufacturers rather than charge point providers. Therefore, commercial investors are less likely to build charge points in rural areas before electric vehicles become the mainstream choice.

This means there is a case for government support to build charge points in rural areas, to deliver a core national network in the short term, before relying entirely on the private sector to take forward the delivery of the network at scale as the pace of uptake increases. There are 332 'built-up' areas[34] in the UK with populations above 20,000. 187 of these are not served by a rapid charger. There are 145 built-up areas with populations above 50,000, 52 of which are not served by a rapid charger (shown in figure 3.4).

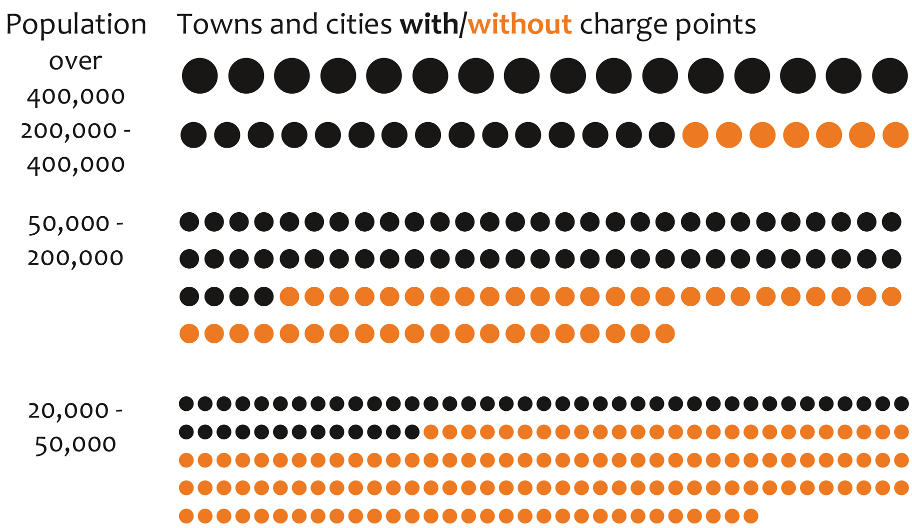


Figure 3.4: Proportion of built-up areas with at least one rapid charge point in June 2018 (by population)[35]

At least one rapid charger in each of those places would represent a reasonable core network. The cost of installing a rapid charger is around £50,000, so the costs of installing chargers at 200 currently unserved locations would be around £10 million. Government does not need to directly own or operate these charge points.

The Commission recommends that government should subsidise, by 2022, the provision of rapid charge points in rural and remote areas, where the market will not deliver in the short term.

Preparing for connected and autonomous vehicles

Whilst electric vehicles represent a revolution in how vehicles are powered, the changes delivered by connected and autonomous vehicles could be more profound still. Connected and autonomous vehicles could have implications for the roads themselves, as well as the way people travel.

Connected vehicles can communicate with other vehicles or infrastructure on the road network, to assist with safer and better informed driving. Autonomous vehicles use a range of technologies to reduce the need for human involvement for navigating the road. These vehicles will have impacts on infrastructure design, capacity, demand, travel patterns, land use, and interactions between transport modes. All this is not yet understood. Government should start planning for these changes now.

Connected and autonomous vehicles will create new travel opportunities, free up time focused on driving, and could improve safety. They could also increase road capacity, enable higher speed limits and shorter journey times, encourage vehicle sharing, and release street space currently used for parking. Traffic lights and stop signs may become unnecessary. And the use of road space could be automatically and constantly changing according to need.

It is uncertain when fully autonomous vehicles will be a reality on the roads. Existing technology can already control the vehicle in a wide range of circumstances and is increasingly being deployed within cars on the market today.[36] Some estimates suggest that self-driving cars could be on the road by the 2020s,[37] although others predict this will take much longer. But despite uncertainty about the timetable and extent of change, it is no longer reasonable to assume existing patterns of road use will remain unchanged in future.

Government must first act decisively on the Commission's recommendation in *Connected Future* to roll out digital connectivity across the road network, starting with the strategic roads network by 2025.[38] Research indicates that improved connectivity, either 5G or in other forms, could enhance the road capacity benefits of automation by improving vehicle-to-vehicle and vehicle-to infrastructure communication.[39]

The potential impacts and benefits of connected and autonomous vehicles vary in different places and on the level of automation. For example, in urban areas, although careful management will be needed to avoid adding to congestion, automated on-demand public transport options could provide more convenience than buses or trams. Road transport is unlikely to supplant rail in its core markets: commuting into city centre (where physical space is a key limitation) and long distance city centre to city centre travel (where rail has a speed advantage). However, overall, connected and autonomous vehicles could have a significant positive impact on interurban connectivity.

Building the evidence base

Government has made a good start in positioning the UK as a centre of excellence for connected and autonomous vehicles. It has created a conducive environment for trialling, stimulated private sector innovation through various funding initiatives, and launched an extensive review of the regulatory environment. It has also begun to think strategically about the longer-term implications for transport through programmes such as the Industrial Strategy's Grand Challenge on the Future of Mobility.

These key steps are welcomed by the Commission. But the research programme now needs to evolve to ensure that connected and autonomous vehicles are central to transport policy and investment decision-making in future. In October 2017, government was funding at least 53 separate research projects, but the evidence on the impact of connected and autonomous vehicles has so far not been sufficient to influence the latest plans for road and rail (the second Road Investment Strategy and Network Rail's Control Period 6).

Planning for the 2025-2030 investment period, when highly autonomous vehicles are predicted by some to be on sale, will begin in the early 2020s. Government should aim for evidence on the impact of connected and autonomous vehicles to be sufficiently robust to start to factor in policy making for both planning processes.

The Commission recommends that government should address the implications of technological innovation in long term transport planning processes, including the next rail control period and road investment strategy.

A research framework

A research framework is required, focussing on four key areas: technology; legislation and regulation; people; and infrastructure. Extensive work is already being undertaken on the first two areas. Therefore, the priority for new research within the framework should be to focus on people and infrastructure, where research is less advanced. These two areas are fundamentally linked; how roads are changed to accommodate connected and autonomous vehicles will reflect and impact how, where, when and why people choose to use them and other forms of transport.

To assess people's behaviour patterns, trials will need to ensure that the information gathered is useful and reflects a wide cross-section of the public. While reliable forecasts of the take up and use of connected and autonomous vehicles are not likely to be developed until highly autonomous cars are on sale, government should focus on improving existing analytical tools to prepare as far as possible.

In terms of infrastructure, the government will ultimately need to determine changes in the way roads are planned, designed and operated to maximise the potential benefits of connected and autonomous vehicles. A key question will be how acceptable it is for individual drivers to give up a degree of control, at least on parts of the road network, to improve the outcome for road users. Despite the uncertainty, the process of thinking about how roads should adapt must start now, and take a flexible approach.

Roads for the future

The Commission launched 'Roads for the Future' in January 2018: an innovation competition on how roads should be designed, managed and used to maximise the benefits of connected and autonomous vehicles. An overall winner will be announced in September. The shortlisted entries are:

Smart signals, AECOM, York: Examining how smart signals could alert drivers and vehicles to the speed they should drive at so they arrive at the next set of traffic lights just as they turn green, cutting congestion and ending polluting 'stop-go' driving.

Active traffic management, Leeds City Council, Leeds: Examining how the data generated from digitally connected cars could be used to improve traffic light systems, allowing highway authorities to better manage traffic on their roads.

FlexKerbs, Arup, London: Looking at how kerbsides with fixed features such as double yellow lines, parking bays and bus stops could become more flexible, changing their use according to the time of day and levels of demand.

AI short term traffic prediction, Immense Simulations, Oxford: Using AI to help sat-nav systems to 'learn' better routes to improve the directions given, so that both driven and driverless cars could change course to avoid congestion.

Segregated connected and autonomous vehicle zones, City Science, Exeter: Examining how sections of existing roads could be dedicated to driverless cars, making it easier for highways authorities to manage risks, integrate connected and autonomous vehicles into the existing transport network, and encourage take-up.

To ensure that the framework is delivered and connected and autonomous vehicles are fully embedded in long-term transport planning processes the right structures need to be in place within government. At present, there is no single long-term home within government for research and analysis into future disruptive transport technologies.

The Commission therefore believes that a new body should be created, subsuming the Centre for Connected and Autonomous Vehicles' current functions but with a wider policy remit and a more influential role in the Department for Transport's long-term transport planning processes. Amongst its responsibilities should be the Commission's proposed connected and autonomous vehicles framework. However, its core focus should be on ensuring that technological innovation is fully embedded in the planning processes for the third Road Investment Strategy and the next rail investment cycle, Control Period 7.

The Commission recommends that government should establish a centre for advanced transport technology in the Department for Transport to bring together work on technological innovation and ensure its implications are central to future investment proposals. This should include developing and overseeing the Commission's proposed connected and autonomous vehicles framework.

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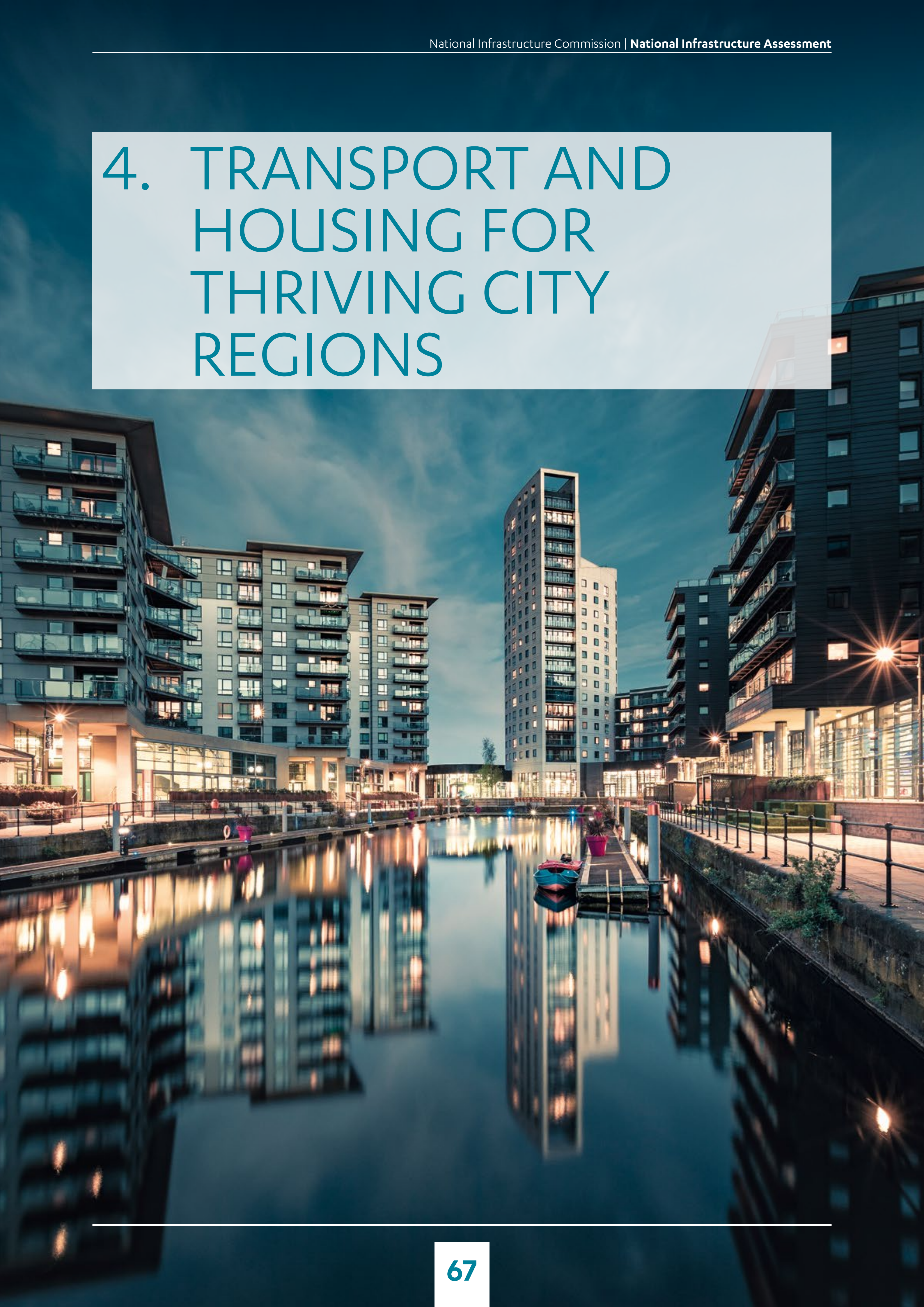
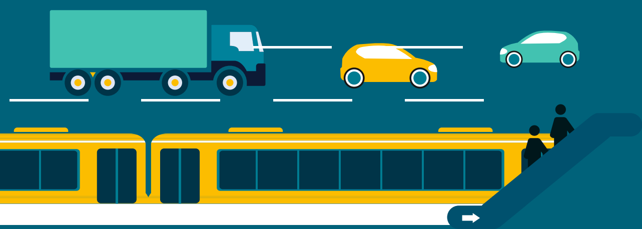
4. TRANSPORT AND HOUSING FOR THRIVING CITY REGIONS



CITIES ARE THE PRIORITY FOR FUTURE TRANSPORT INVESTMENT

Investing in urban transport can support productivity and quality of life

Intercity transport is getting the investment it needs



Highways England
4 billion
per year (2020-25)

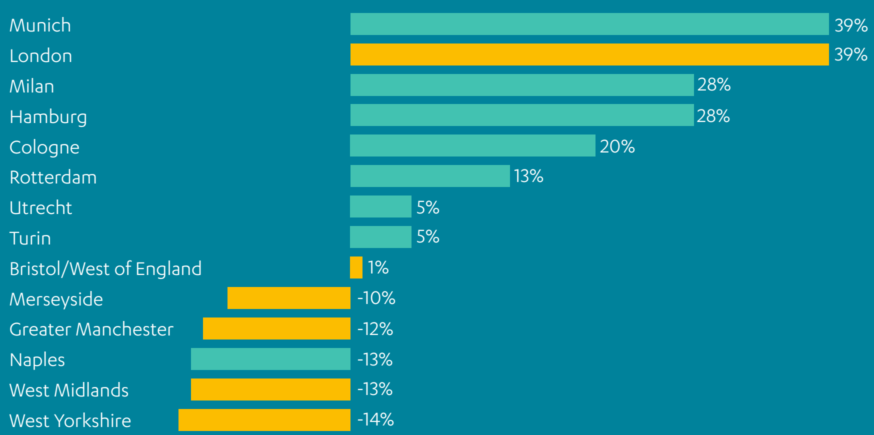
Network Rail
6 billion
per year (2019-24)

High Speed 2
4 billion
per year (2020-30)

BUT:

productivity is low in too many UK cities, unlike in Europe

GVA per capita relative to national average for relevant country

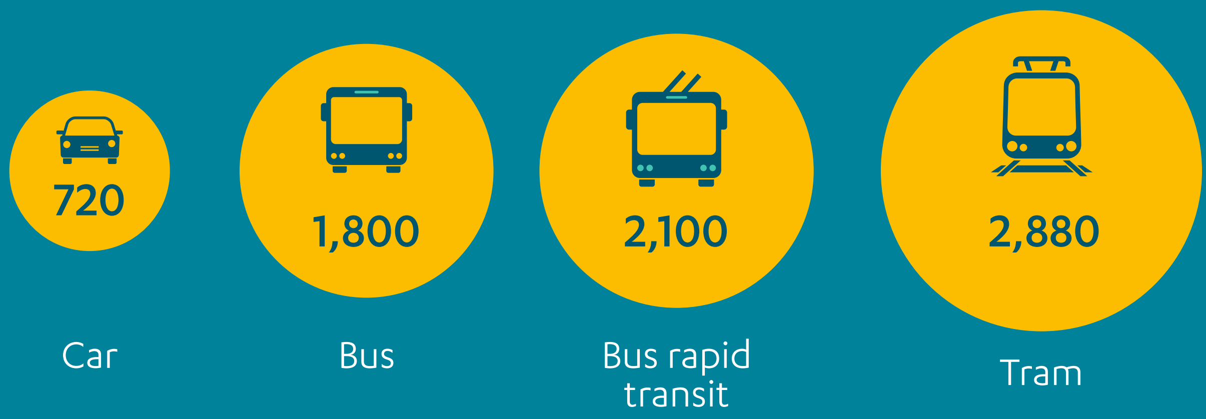


Transport networks are close to capacity in many UK cities

In cities, better cars can't solve the problem as there isn't enough space

Mass rapid transport is needed to increase accessibility

Typical maximum capacity per lane (inbound passengers per hour)



But transport alone isn't enough – cities need skills, green space, cultural and leisure activities

THE COMMISSION RECOMMENDS:

- City-led plans for transport to connect housing and jobs
- Devolved, long-term funding to give certainty to all cities
- Major projects in the fastest growing, most congested cities

Sources: HM Treasury, Network Rail, Department for Transport, Eurostat, ONS, Steer Davies Gleave

Cities can and should be great places to live and work. But their increasing popularity means they are becoming full and congested, and this risks inhibiting growth and undermining quality of life. Space in cities should be used effectively, with room allocated for fast, frequent public transport systems, well connected and affordable housing, and pleasant public spaces. This will require a new approach to governance, strategy and funding for urban transport.

In recent years, government has prioritised major upgrades to transport between cities. The next wave of major upgrades should increase the focus on transport within cities. Infrastructure cannot drive growth alone; other factors, especially skills, are essential. But lack of infrastructure can inhibit growth.

The UK is unusual in that most large cities outside of the capital are less productive than the national average; cities such as Birmingham and Leeds should have the potential to be as successful as major cities elsewhere in Europe which boost their countries' productivity.[1] But this will require vision and planning. London, and to some extent Manchester, have benefitted from having a mandate to transform their cities' transport infrastructure. Other cities, large and small, need to be able to take the same approach.

Unlocking growth in cities requires:

- developing integrated strategies for housing, employment and transport, to allow cities to grow and people to live and work where they want
- devolving planning and funding for urban infrastructure to all cities
- prioritising major upgrades for cities with the most growth potential and capacity constraints
- £43 billion of additional investment in urban transport by 2040

Cities as social and economic hubs

Cities[2] are increasingly critical to the UK's economy and international competitiveness. The benefits of firms in knowledge based services clustering together in close proximity has made city centres attractive places for firms to locate, leading to a revival in many cities' fortunes.[3] They are hubs for high value industries and employment; 60 per cent of all jobs and 71 per cent of knowledge intensive business service jobs are in cities.[4] Supporting growth in city-regions is essential to providing balanced growth across the UK, as cities provide employment and a range of specialist services across a whole region.

Cities have also become more attractive places to live as they have attracted highly skilled workers and cultural and leisure amenities have grown.[5] More than half of the UK's population live in cities, and as the UK economy has become more city focused, the popularity of cities has grown. [6] London's population fell from 8.6 million in 1939 to 6.7 million in 1988, but this huge shift has since reversed, with London growing 30 per cent to 8.8 million in 2016.[7] In other major cities, recovery started later, but in almost all cases population growth was stronger in the 2000s than in the 1990s and has accelerated in the current decade.[8]

Unlocking growth

Enabling people to work and live in or around cities is a key way in which infrastructure investment can support growth in every region. There are fast growing, infrastructure constrained cities spread across the regions of the UK,[9] and addressing these constraints is the greatest opportunity for infrastructure to help each region to do better.

Most major UK cities lag behind national productivity levels. This contrasts with large cities in many other European countries, which add to their countries' productivity.[10] Infrastructure cannot drive growth alone; other factors, especially skills, are essential. But lack of infrastructure can inhibit growth. To sustain future growth, transport policy must reflect the economic and structural changes that are shaping the UK's transport needs.

The priorities for transport investment should be growing and congested urban areas and their catchments, the key interurban corridors, and the key international gateways.[11] There has been welcome progress on the latter two areas in recent years. After years of delays, decisions on aviation capacity are being made following the report of the independent Airports Commission.[12] Investment in interurban corridors has increased sharply and is planned to increase further in the 2020s. Chapter 7 sets out the Commission's proposals for future investment in the strategic road and rail networks, with substantial continued investment. Chapter 3 sets out the need for future plans to respond to the opportunities from connected and autonomous vehicles.

However, investment in urban transport outside of London continues to lag behind.[13] Urban transport networks underpin commuter journeys that create deep labour markets, and enable people to access cultural and leisure activities. Most urban journeys are short, relying predominantly on urban transport networks. The average trip length for people who live in cities and towns is under 10 miles, with fewer than 5 per cent of journeys over 25 miles.[14] Rail journeys tend to be longer, but most start or end in cities.[15] Infrastructure to support public transport in growing and congested cities offers some of the highest returns for transport investment.[16]

Investment in local and strategic transport

Intercity networks

Investment in national road and rail has been increasing, with further investment forthcoming to improve interurban transport. Highways England is proposing to spend more than £4 billion per year from 2020 to 2025; the government has committed around £6 billion per year for Network Rail between 2019 and 2024; in addition, HS2 is expected to cost around £4 billion per year on average throughout the 2020s.[17] Northern Powerhouse Rail will deliver long overdue improvements in travel times between the major cities of the North of England.

Continued focus is needed to deliver these major commitments. Sub-national transport bodies will need to work with government on the development and delivery of these programmes and will play an important role in ensuring that they are integrated with regional and local networks.

Local road maintenance

In recent years, insufficient funding has led to poor conditions on local roads, affecting road users throughout the country. Six per cent of urban local A roads are considered to be in poor or very poor condition, and 3 per cent of rural A roads.[18] This creates hazards for road users, and also increases the long term cost of maintenance. The economic case for maintenance is very strong , since inadequate upkeep creates a risk that roads may need to be closed for emergency repairs.[19]

The major funding decisions for transport in the first half of the 2020s – Road Investment Strategy 2 for Highways England, Control Period 6 for Network Rail and major projects such as HS2 – have already been made or are shortly to be decided. They therefore fall outside the scope of the Assessment, since the Commission's remit states that the Commission "will not reopen decision making processes where programmes and work have been decided (or are due to be decided immediately after a [Commission] report is published)".[20]

It is for the Department for Transport to prioritise in the early 2020s between providing the funding needed to maintain the existing road network or to deliver the full programme of enhancements. In the later 2020s, the Commission believes that £500 million a year of funding should be made available for local highways authorities to address the local road maintenance backlog probably through to the early/mid 2030s.

The Commission recommends that government should make £500 million a year of funding available from 2025/26 to 2034/35 for local highways authorities to address the local road maintenance backlog.

Urban transport

In growing urban areas, transport networks are coming under increasing pressure. Cars and buses in central Manchester or Bristol experience delays of more than 100 seconds per mile travelled.[21] This compares to an average of 78 seconds on all urban A roads, 22 seconds on rural A roads and 9 seconds on the intercity road network. [22] Crowding on the railway is also focused on cities, particularly London, Manchester, Birmingham and Leeds.[23]

Figure 4.1 shows that the capacity of road networks to deal with peak traffic falls with increases in the size of towns and cities, particularly in areas with populations above 100,000. The chart uses the Commission's newly developed measure of how quickly people can travel from where they live in a town or city (using the Office for National Statistics' 'built up areas' definitions) to that town or city's centre of employment. The dataset and technical details are available on the Commission's website. The chart uses the ratio of peak to off-peak connectivity for towns and cities to assess capacity constraints. A value of 1 implies that the connectivity is the same at peak and off-peak times. Lower values imply constraints at peak times. As settlement size increases, road networks become increasingly less effective at managing peak demands.[24]

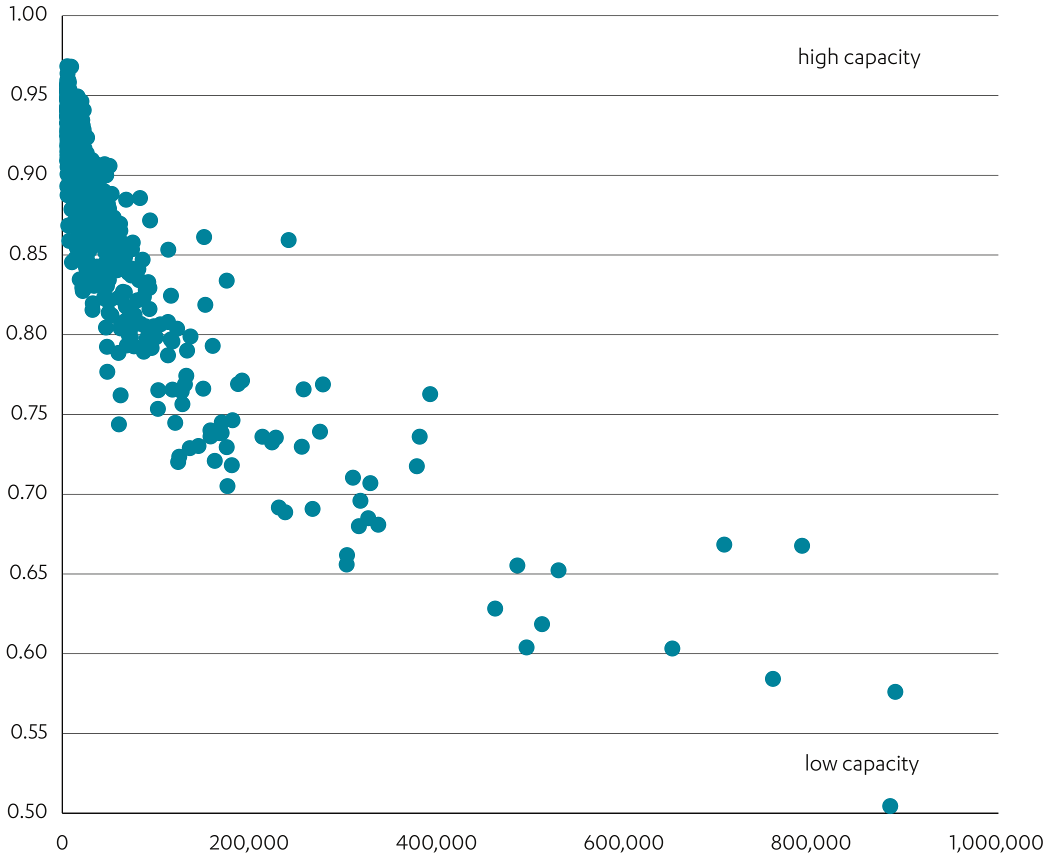


Figure 4.1: Built up area population and ratio of peak to off-peak connectivity for built up areas with population under 1 million[25]

Making best use of limited space

More investment in public transport, alongside the promotion of safe cycling and walking, is the only way that cities can increase their infrastructure capacity to support growth. Connected and autonomous vehicles could have a positive impact on intercity transport, but they will never be an effective replacement for high capacity public transport in dense city centres and may simply increase pressures on road space.[26]

New forms of public transport – from dockless cycle or even electric scooter hire to autonomous buses – are emerging. City leaders need to consider how to manage the impacts of changing travel patterns in their transport planning. But the basic challenge of urban transport is still the same: there is simply not enough space in cities for everyone to travel by car.

Typically new roads lead to new journeys, filling up the additional space.[27] But, as shown in figure 4.2, it is possible to increase capacity by investing in high capacity public transport.

Transport mode	Typical maximum capacity per lane (inbound passengers per hour)
Car (1.2 people – current commuter average)	720
Bus	1,800
Bus rapid transit	2,100
Tram	2,880

Figure 4.2: Maximum system capacity for different modes of transport[28]

A less car focused approach to urban transport can also bring other benefits, including:

- the opportunity to build well designed city centres focused on people's needs
- reallocating space from roads and parking to pedestrianised areas, leisure amenities and green space
- better, safer provision for cycling and walking
- improved transport networks that are more accessible for older and disabled people
- infrastructure aligned with schemes to bring brownfield land back into use, which can help regenerate inner cities.[29]

Poor air quality is also a significant cost of cities dominated by petrol and diesel cars, and has a damaging impact on health. However, in the long term widespread adoption of electric vehicles will reduce the harm caused by this, so it is important that cities help to facilitate the rapid uptake of electric vehicles, as set out in Chapter 3.

Improving transport in every city

Government should make sure all cities are able to deliver the appropriate transport infrastructure in their area. This requires changes in strategy development, funding and governance for urban infrastructure in cities outside London.

Strategy development

Transport policy should not be about schemes. Investment needs to enable the journeys that allow people to live and work where they want to, and to connect people to wider services. Decision makers need to understand all the characteristics of the local economy, environment and geography. Transport policy needs to be integrated with a clear strategy for where housing growth can be accommodated in and around cities, and where employment growth is likely to occur. Linking transport enhancements to housing growth is essential to get the most value from investment.

City leaders should implement long term plans for their city-region reflecting their own economic and social priorities, based on their own local knowledge and accountability. These need to integrate transport, housing and employment. Other urban infrastructure, such as digital (see Chapter 1), electric vehicle charging (see Chapter 3) and flood resilience (see Chapter 5) also needs to be considered.

Recent government policy on devolution has meant cities increasingly have the right powers and governance to tackle these issues, particularly in cities with mayors. However, integration of strategies for transport and housing requires integration of decision making. Currently, leaders in large cities need unanimous approval from individual districts to all aspects of any integrated development plan, limiting the level of ambition. This needs to be addressed to maximise the value from new urban transport infrastructure.

Beyond this, a lack of long term funding means that, outside of London and Manchester, few cities have developed integrated strategies, since there has been no realistic prospect of being able to implement them. In some cities, this has also led to a lack of strategic capacity.

Funding

Local leaders making long term plans for their cities need long term certainty on funding. There is a lack of long term, stable and certain funding structures to support investment in urban transport outside London. City and local leaders have to bid to many different government competitions, which provide an unpredictable and short term funding stream and place a significant strain on the limited revenue funding available for transport planning.[30] The government's recently created Transforming Cities Fund improves on previous funding arrangements by giving mayors more flexibility over their funding allocations, and simplifying requirements before funding decisions can be made. But more progress is needed.

Local transport authorities outside London should have stable, devolved infrastructure budgets, as Highways England and Network Rail have. The devolved budget should comprise of five year settlements, with fixed annual budgets set at least two years before the start of the five year period. This budget should be sufficient to cover all maintenance, small to medium enhancement projects and programmes to deploy or pilot new smart infrastructure technologies.

Devolved infrastructure budgets will be a replacement for Department for Transport and Local Growth Fund grants for local infrastructure, and they will be complementary to the funding that authorities can raise locally through fare income and other local revenue sources.

Maintenance allocations should be determined according to the cost of keeping the relevant infrastructure assets held by the authority in working order. Funding for small to medium enhancement projects in cities should be allocated according to the size of the city, the city's density, and evidence that the city's projected growth will outstrip its existing infrastructure capacity.

Increased funding for cities should be available to all cities with a population over about 100,000 to reflect the higher infrastructure needs of denser urban areas. This broadly matches the definition of 'primary urban areas' (54 cities in England outside London).[31] Whilst there is no perfect boundary, a population of around 100,000, as shown in figure 4.1, is the point at which capacity constraints become most serious.

The level of funding for devolved infrastructure budgets in cities should ensure their spending power increases by around 10 per cent during the 2020s compared to current urban transport investment, an increase of approximately £300 million per year, and increases by around 30 per cent or over £1 billion per year by the mid 2030s. This totals around £12 billion from 2020 to 2040. Chapter 7 sets out the choices that the Commission has made within the resources set out by the government. With large existing commitments, such as HS2, in the 2020s, new funding for cities has to build up gradually. Funding for authorities outside cities should remain broadly at current levels.

To ensure the long term stability of funding for cities and local authorities, government should legislate for an obligation to publish infrastructure allocations in advance. In the future, government should also consider whether local tax raising may be more appropriate than central government grants.

As well as increased funding for investment, it is important that local infrastructure authorities have the resources they need to increase their transport capacity. Government should therefore ensure sufficient revenue funding is available for local project development, network management and bus operations, especially in cities.

Governance

The appropriate authority to make decisions on how to invest devolved urban infrastructure funding will usually be one that already exists: a mayoral combined authority, combined authority or unitary authority. But some cities have no urban infrastructure authority of their own and are served by a county council. In these cases government should ensure that arrangements are put in place for an appropriate urban infrastructure authority.

Once funding is devolved to local authorities, central government should not have powers over how it is spent. Cities will need to coordinate with Highways England and Network Rail and may, in some cases, choose to use some of their resources for enhancements to the strategic networks in partnership with them. Local authorities should be expected to make evidence based decisions, evaluate performance of their investments and publish information enabling them to be held to account by local people on how they have invested in infrastructure. Chapter 6 sets out the Commission's proposals on how to use better data to improve the appraisal and selection of projects. In cases of serious failure, government could withdraw funding devolution.

The Commission recommends that cities should have the powers and funding they need to pursue ambitious, integrated strategies for transport, employment and housing.

- **By 2021, metro mayors and city leaders should develop and implement long term integrated strategies for transport, employment and housing that will support growth in their cities.**
- **By 2021, government should ensure city leaders have the right powers to deliver these integrated strategies, including the power for metro mayors to make decisions on major housing development sites.**
- **Government should set out devolved infrastructure budgets for individual cities for locally determined urban transport priorities in line with the funding profile set out by the Commission. Budgets for 2021-2026 should be confirmed by mid 2019. Government should pass legislation, by 2020, requiring cities to be given regular five year infrastructure budgets.**

Infrastructure to support housing

Infrastructure needs to promote new housing and new communities in areas where they are needed. Infrastructure alone will not solve the UK's housing challenges, but better coordination of infrastructure with new developments is vital if infrastructure is to be deployed effectively.

Siloed planning and delivery of utilities infrastructure and housing means that providing utilities to new housing developments can often be a cause of delay to construction. Consultation responses to *Congestion, Capacity, Carbon: priorities for national infrastructure* identified three causes.

Firstly, there is a tension between the requirements on regulators to protect consumers from price rises and to invest in future infrastructure provision, which can generate perverse outcomes for the delivery of timely infrastructure. In particular there is a lack of incentive for utility companies to develop increased capacity in advance of development, putting these costs on housebuilders. This can create coordination failures where upgrades are large and exceed the needs of any individual development.

Secondly, the diversity of organisations (the Distribution Network Operators, the industry regulators, local planning authorities) involved in the planning, design and delivery of utilities infrastructure in England leads to division and poor communication. And thirdly, there is a lack of mechanisms to improve coordination between housing and infrastructure for smaller scale housing developments.

The Commission will conduct more detailed analysis on the role of utilities in the delivery of housing, working with stakeholders and liaising with ongoing studies.

The next wave of infrastructure upgrades

Substantial funding must be set aside for major upgrade programmes in the city-regions that need them the most, in addition to the devolved funding for small to medium enhancements. London has had the advantage of receiving exceptional funding for upgrades to capacity such as Crossrail. Other cities should have this benefit too. This could provide cities in the UK with major capacity upgrades such as metros or bus rapid transit.

Major upgrade programmes require higher levels of funding to be concentrated in a few areas temporarily, and even fast growing cities do not require transformative upgrades on a continuous basis, meaning that a process of prioritisation is required. Funding should be agreed for major new capacity programmes in cities where infrastructure is the most significant constraint on growth. Identifying programmes will take time; most cities have not developed plans at this scale because they have lacked funding streams that could realistically deliver them. In some cities, it will be important to build capability in strategy, procurement and delivery before launching major investment programmes.

Before funding is agreed, cities should commit to additional housing development alongside new transport, linking employment growth to new homes. They should also be able to demonstrate that they can provide a local contribution to project costs, as for Crossrail 2, although the proportion may need to vary to reflect regional circumstances.[32] This contribution should include local fundraising, potentially through fares or local taxes.

Central government should work closely with cities before making final commitments to funding. Not everywhere will need major investment. The initial phase should identify priority cities. Figure 4.3 illustrates how capacity constraints and expected employment growth vary considerably between cities. This uses the Commission's new measure of transport connectivity (see figure 4.1)[33] and employment growth estimates[34] derived from Office for National Statistics' population projections (which roll forward data from the recent past, adjusting for demographics, and are not forecasts).

Having identified priority cities for the first wave, government should work with them as they develop specific project proposals to support growth. When final proposals are submitted to government, they should also be reviewed by the Commission. The government should then make final decisions on major upgrade programmes and allocate funding, making long term commitments into future spending review periods where necessary.

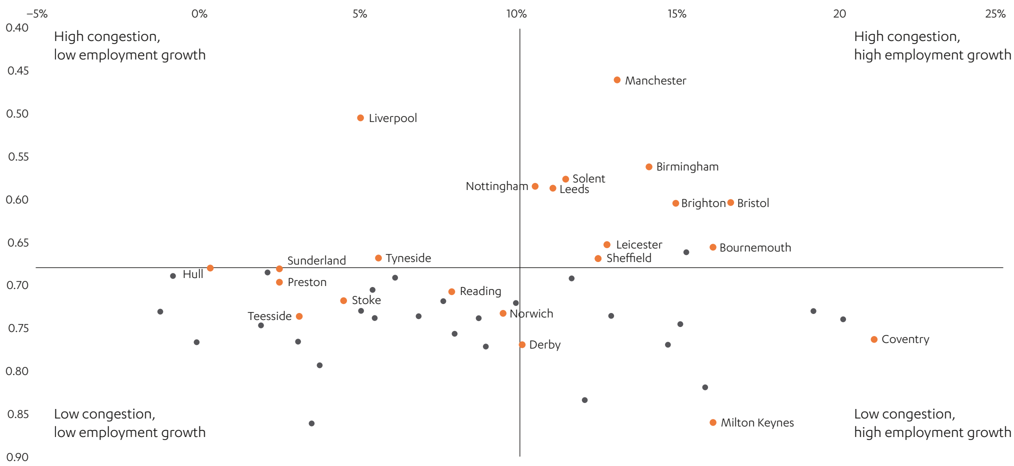


Figure 4.3: Capacity contraints on the roads and employment growth projections for 2018-50 within city centres outside London, based on Commission analysis.

Note: The 25 largest cities by employment are shown in orange, with smaller cities in grey. Cities further to the right are projected to grow faster in their city centre, while cities nearer to the top have greater capacity constraints into the city centre.[35]

Not all cities will need large scale investments. In some, existing capacity and incremental enhancements will be sufficient. Others that are not included in the first wave should be considered for inclusion in future rounds of funding, especially where lower cost interventions, such as bus schemes, have identified demand in key transport corridors. Given the long term funding being proposed (major capacity programmes could easily need to be funded for 5-10 years) future rounds should take place no more than once or twice per parliament. It is essential that the process makes choices about the most important investments rather than giving many small funding grants. Around £31 billion is required by 2040 for major urban transport capacity programmes, delivering on growth needs over that period and preparing for future growth.

The Commission recommends that government should allocate significant long term funding for major capacity upgrades in selected growth priority cities, in line with the funding profile set out by the Commission. Cities benefiting from major projects should make commitments on housing delivery and provide at least 25 per cent of funding. Priority cities should be identified by mid 2019, with long term investment commitments agreed by 2020. Future rounds should take place no more than twice a parliament.

London

Development of regional cities should be in addition to and not instead of continuing to invest in London. The UK's highest value jobs continue to be in London and it is projected to grow faster than anywhere else, with employment growing 18 per cent to 6.7 million by 2041.[36] Taxes paid in London and its surrounding regions fund infrastructure and other services in other regions of the UK, contributing £3,070 per person to the rest of the UK in 2016.[37,38] And it is an internationally competitive city; infrastructure constraints on London's growth are as likely to cause displacement overseas as they are to elsewhere in the UK.

London's transport networks are already more congested and overcrowded than anywhere else in the country. Future growth will not be possible without substantial increases in capacity. The Commission has already recommended that Crossrail 2 should go ahead to increase capacity into central London. The Mayor's Transport Strategy sets out a wider range of interventions that will be needed, including improvements to bus networks, cycling infrastructure, the Underground and suburban rail lines.[39]

Most of the proposals contained in the Mayor's Transport Strategy would be delivered by Transport for London. Transport for London plans to cover all its operational expenditure through its own operational income in future, but it will still need support for investment, which should be sustained at current levels. The government should continue to work with the Mayor to fund Crossrail 2 as recommended by the Commission.

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5. REDUCING THE RISKS OF DROUGHT AND FLOODING

BEING RESILIENT TO EXTREME WEATHER

Climate change increases the risk of both flooding and drought in England

This is already having an impact, and will do in the future:

High flood risk:

1 million

homes have more than 1% chance of flooding in any given year

But also a strong risk of drought:

1 in 4

chance of a severe drought between now and 2050

RESILIENCE SAVES PEOPLE FROM THE TRAUMA OF FLOODING AND THE COSTS OF DAMAGE AND INSURANCE

The Commission have proposed a national standard so that by 2050 communities will be resilient to flooding

99.5%

of the time wherever feasible

This means that someone living in a house at risk of flooding for 20 years would face only a 1 in 10 chance of flooding over that time

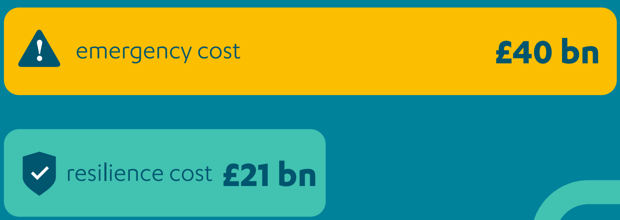
Sources: Commission calculation using inputs from Atkins, Environment Agency, ITRC and Regulatory Economics

BUT WE ALSO NEED TO BE MORE RESILIENT TO DROUGHT

Relying on emergency measures would cost an estimated

£40 billion

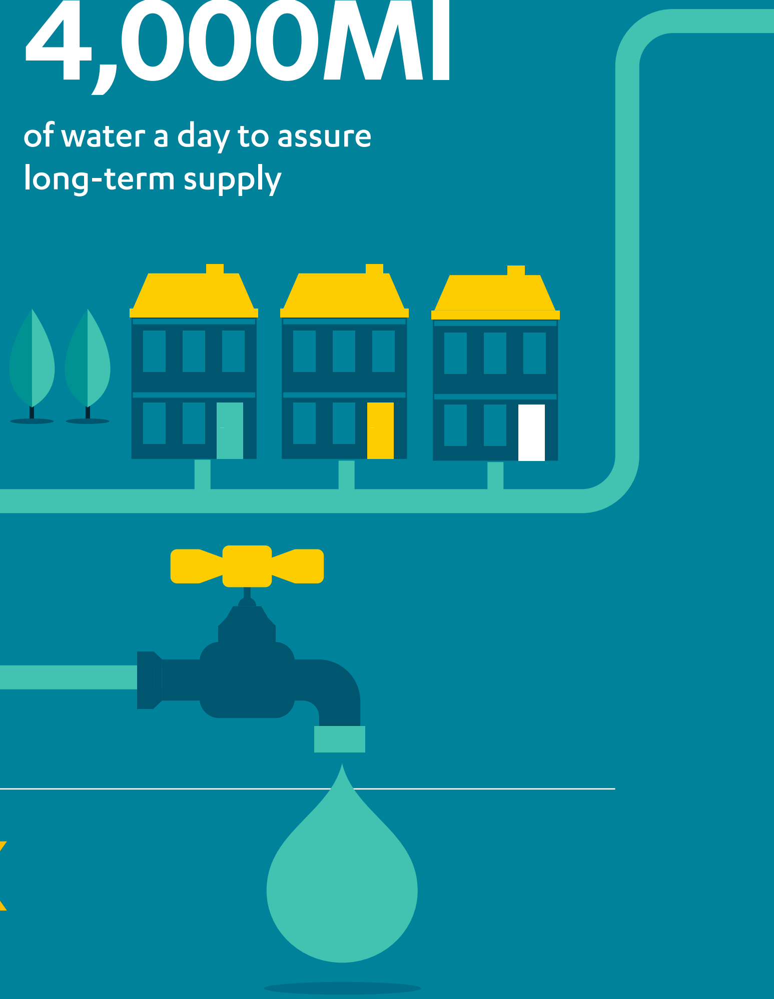
Over the next 30 years – being resilient would cost only £21 billion



The UK needs an extra

4,000Ml

of water a day to assure long-term supply



THE COMMISSION RECOMMENDS:

- A national standard of flood resilience with a higher standard in major urban areas
- A national water transfer network and new water supply, such as reservoirs
- Nationwide, catchment-based plans combining green and grey infrastructure
- Halving leakage by 2050 and reducing demand through efficiency and smart metering

Sources: Commission calculation using inputs from Atkins, Environment Agency, ITRC and Regulatory Economics

Climate change will increase the risk of both flooding and drought. Despite several significant incidents over recent years, the risks continue to rise, and planning has been disjointed. Action is needed now to make communities resilient for the future, rather than waiting until the situation gets worse.

About 5 million properties in England are currently identified to be at risk of flooding. Of these, about 600,000 homes have more than a 1 per cent chance each year of being flooded by rivers and the sea.[1] A similar number have more than a 1 percent chance each year of flooding from surface water.[2] Floods affect people's lives and health as well as causing economic damage.

While it will never be possible to prevent all flooding, the current approach is too piecemeal and too reactive. Government should ensure that all communities are resilient, so they are able to cope with, and recover from, flooding. There should be a long term national programme: resilience cannot be increased everywhere overnight and the extra funding needed will only become available gradually. But a long term strategy, with long term funding, can deliver a national standard by 2050.

At the same time, households and businesses in large and densely populated parts of England face significant risk of having their water supplies rationed because of drought. While water companies' plans show some progress in addressing this risk, they fall short of what is needed. The Commission's 2018 report *Preparing for a drier future: England's water infrastructure needs*[3] set out the action needed for drought resilience.

To minimise the impact of severe weather and climate change, England requires:

- a long term strategy to ensure that all communities are resilient to severe flood events by 2050, with higher standards for the most densely populated areas
- increased resilience to drought through a national water network, halving the water lost through leaks, and reducing demand through smart metering

A lack of reliable data has meant that it has not been possible to consider surface or waste water in detail for this Assessment. Surface water flooding is significant[4] and there has been little progress in the decade since the Pitt review.[5] Further work is needed urgently.

The risk of flooding

Climate change is expected to both increase rainfall in winter and decrease it in summer, as shown in figure 5.1. Together with population growth, this will lead to greater risks of both flooding and drought.

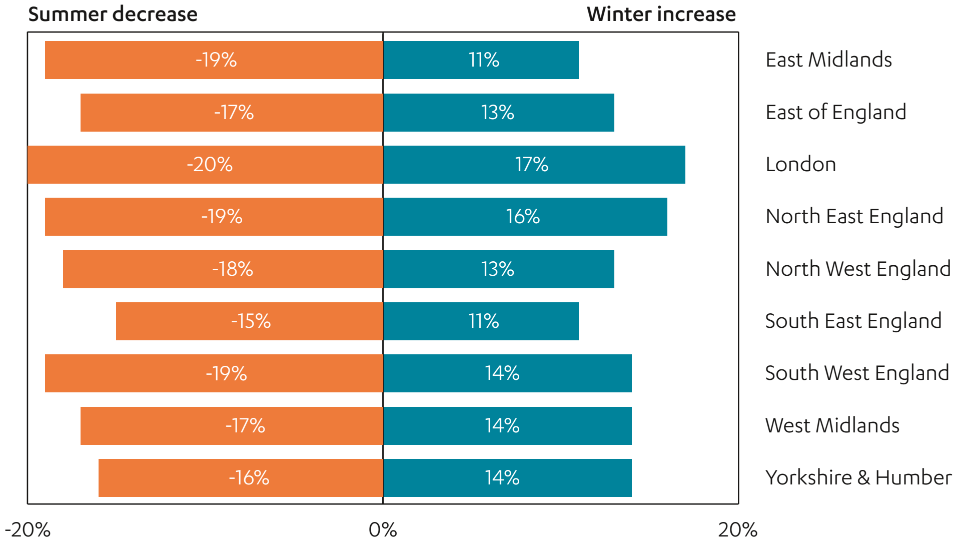


Figure 5.1 Projected changes in summer and winter precipitation by 2050[6]

Note: changes for 50% probability in the 2050s assuming medium emission scenario.

The likelihood of drought and flooding is expressed as an annual probability. For example, a 1 per cent annual probability of flooding corresponds to a 1 in 100 chance of a particular area being affected each year. As there are many areas at risk of flooding across England, there is a high chance that at least one will be flooded by a 1 per cent event in any year. Probabilities can only be an estimate: in particular, the uncertain impacts of climate change limit the ability to forecast future risk precisely. Care should be taken in interpreting specific figures, but scenarios allow a broad assessment of plausible future flood risk. Further details and references to the assumptions and analysis are in the technical annexes: *Flood modelling and Analysis of drought resilience*.

Increasing numbers of households across England are at risk of flooding in severe events (shown in figure 5.2), but long term objectives for flood risk management are unclear. Levels of risk and investments vary widely across otherwise similar places and there is no certainty of whether or when preventative action will be taken.

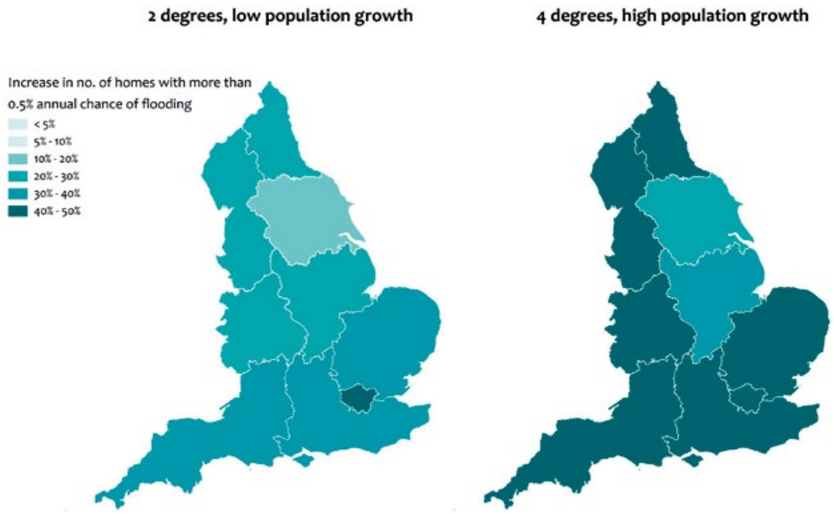


Figure 5.2 Percentage increase in homes at 0.5 per cent or greater annual chance of flooding in future population and climate change scenarios[7]

Flooding has significant impacts on the local community including disruption, loss of employment, and mental ill health as well as direct impacts on buildings and property.[8] Insurance can help, and is currently subsidised for homes at most risk, but only covers some of the impacts.

A national standard of flood resilience

Management of flood risk over recent years has too often been short term and reactive. In the past, government budgets for flood risk management have been reduced, only to be increased again after floods: budgets were reduced in 2006/7 and 2007/8 but then increased following floods in 2007, and cut again in 2011/12 with a large increase following floods in the winter of 2013/14.[9] It would clearly be better to build flood resilience before it is needed. The six year capital programme agreed for 2015/16 – 2020/21 provides greater certainty and should result in more efficient planning. However, there is no clear long term objective for the level of flood resilience that the government is seeking to achieve.

Decisions about capital investment in flood risk management have generally been made on the basis of cost benefit analysis. Essentially, this involves an assessment of whether it is 'worth' protecting particular homes and commercial properties. This is not a sustainable basis for decision making. Properties at risk of flooding are seldom abandoned or adapted to cope with the risk, so people are left to live with the risk. Subsidised insurance can incentivise homeowners in flood risk areas not to take any action. Without a clear objective, it is harder for the Environment Agency to take a strategic view across a whole catchment, although some catchment based plans have been made.

A better approach would be to set a nationwide objective for a minimum level of resilience wherever feasible. This has public support: the Commission's social research showed that 59 per cent of people thought everyone should receive the same level of protection, even though in some areas it would cost more, with only 16 per cent against.[10] However, a national standard should not be statutory or imply a right to compensation if not achieved.

Setting a standard

There is no absolute way of setting the right standard. What is affordable and achievable will vary over time. The Commission has considered what standards would be reasonable by 2050. Over longer time periods, higher standards might be achievable.

The Commission has analysed the investment that would be required to provide a range of resilience standards across different settlement types for river and sea flooding. Average annual capital costs between 2020 and 2050 are shown in figure 5.3, based on a climate change scenario equivalent to a 2°C increase in global mean temperatures.

The costs were estimated using recent Environment Agency data on flood risk management activities. The modelled cost per property varies depending on the property's current and future risk, whether it benefits from existing flood defences, property density and source of flooding.[11] The baseline assumes that current resilience is maintained, broadly following the Environment Agency's Long Term Investment Scenarios.[12] Further details are in the technical annex: *Flood modelling*.

The modelling produces estimates of the costs of a national standard of resilience to flooding with 1 per cent, 0.5 per cent or 0.1 per cent annual probability, and additional costs for providing higher standards in the most densely populated areas.

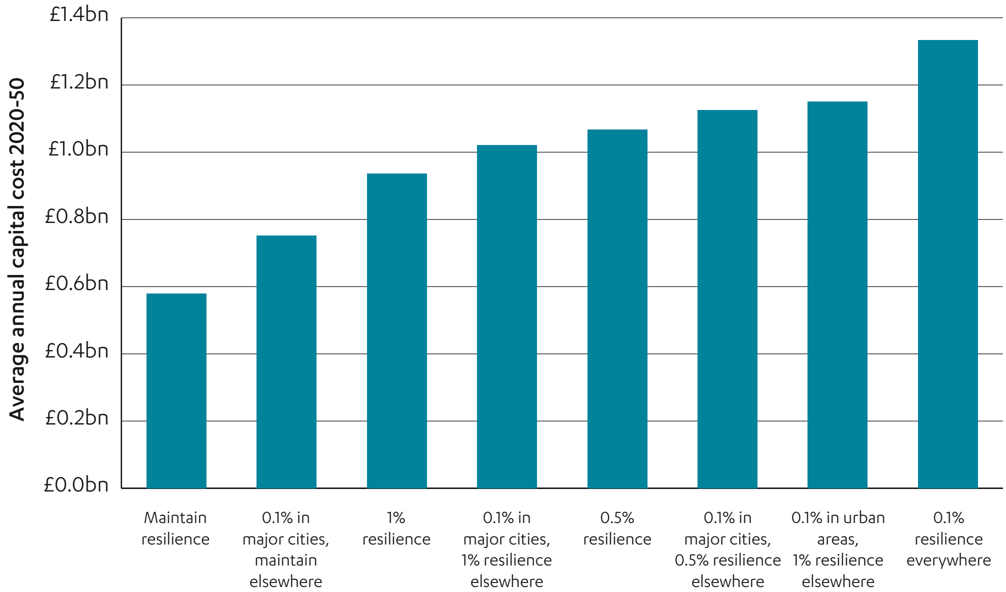


Figure 5.3 Estimated average annual public capital costs for different standards of resilience to flooding from rivers and the sea, 2°C increase in global mean temperatures climate scenario, 2017 prices, in England

The annual ongoing cost of a particular standard can be compared to the estimated avoided damage, including property damages, emergency response costs, risk to life and physical injury, mental health effects and impacts on infrastructure, transport, schools and leisure. Setting a national standard will ensure that society as a whole is better off, but without requiring that each home or commercial property justifies its level of flood resilience.

Whilst the estimated costs of nationwide flood resilience are up to three times current investment, the benefits (reduced damages) exceed costs for the range of standards. Estimates are inevitably uncertain; climate change means weather patterns, and therefore the scale of impacts, may fall outside the range of available data.

The Commission's judgement is that all properties, wherever feasible, should be resilient to severe flooding, with a 0.5 per cent annual probability, by 2050. This is consistent with the advice provided to government by the Natural Capital Committee for the 25 year Environment Plan.[13] Under this standard, someone living in a house at risk of flooding for 20 years would face less than a 1 in 10 residual chance of being flooded.

Densely populated areas

A higher standard should be provided for the largest cities, with populations over half a million. This reflects the lower cost per property for protecting densely populated areas[14] and the potential for natural disasters in cities to result in cascading failures, putting severe pressures on disaster response. The largest cities provide a range of economic and social services to their region as a whole, not just to those who live within them, so the potential impact of flooding is greater.

Precise estimates of probability for extreme events are hard to obtain. Economically important locations should be stress tested against a range of plausible extreme events. The Thames Barrier was designed for sea levels with an annual probability of 0.1 per cent. The Commission's analysis has assumed the same standard for the largest cities.

Climate change scenarios

The Commission undertook similar analysis for a climate change scenario equivalent to a 4°C increase in global mean temperatures. The costs of achieving each resilience standard in a 4°C world are much higher than for the same standard in a 2°C world, but so are the benefits.

This might suggest a precautionary approach of building resilience against higher climate change. However, flood resilience can be designed to be enhanced incrementally. Measures that provide resilence in a 2°C world can be upgraded if it becomes apparent that a 4°C world is more likely. This 'adaptive management' is consistent with catchment based approaches using a range of interventions, rather than just conventional flood defences. This is the most appropriate approach until there is more certainty on climate change impacts, allowing resilience standards to be increased over time.

The Commission recommends that government should set out a strategy to deliver a nationwide standard of resilience to flooding with an annual likelihood of 0.5 per cent by 2050 where this is feasible. A higher standard of 0.1 per cent should be provided for densely populated areas where the costs per household are lower.

A long term strategy for flood resilience

A clear objective will allow for a long term, national strategy for flood resilience. The Environment Agency are due to update their National Flood and Coastal Erosion Risk Management Strategy in 2019. This should expand on the 25 Year Environment Plan to set out how these standards of flood resilience can be achieved by 2050.

Delivering the strategy will require action on long term funding, updated catchment and shoreline management plans, surface water management and development control. Environment Agency monitoring of the strategy should include data on the number, locations and resilience of properties flooded from different sources and events each year.[15]

The strategy should set out a clear plan to deliver the proposed resilience by 2050, as well as ensuring that different aspects of flood management are joined up. It should make clear what is expected of different stakeholders and maximise the opportunities for partnership working. This should be backed up by a long term funding commitment, building on the existing six year capital programme, enabling efficient planning and delivery of projects to address the risk from all sources of flooding.

Catchment and shoreline plans

Existing Catchment Flood Management Plans and Shoreline Management Plans should be updated to take account of the new standard and set out long term plans for flood risk management across catchments and coastal cells. These plans should use the latest evidence to evaluate the full range of options to achieve the proposed resilience standard including traditional flood defences, 'green infrastructure' (whether natural flood management or sustainable drainage systems), individual property measures, spatial planning and coastal realignment or 'managed retreat.' They will need to take account of the replacement of the Common Agricultural Policy following the UK's exit from the EU which should support natural flood management. As risk can never be eliminated, flood warning, response and recovery will also continue to be important.

The plans will need to show how risk can be managed for all plausible climate futures. They should ensure interventions are adaptable to different futures and that climate change is factored into the design and construction of all infrastructure. This should be undertaken in such a way that the plans can be updated to reflect new information on climate change with the minimum of effort.

Surface water management

The data needed to robustly assess the costs and benefits of different resilience standards for surface water flooding is currently unavailable. All relevant organisations should ensure data is available in good time for the next Assessment. Water companies are developing Drainage and Wastewater Management Plans. Water companies and local authorities should work together to build on their existing plans and take action on local flood risk where this is possible. This should include identifying communities at greatest risk from severe surface water flooding and developing joint plans, including investment requirements, to ensure resilience. These plans should inform the next Price Review and Assessment.

Development control

Preventing inappropriate housing development is essential for effective long term flood risk management. In 2016/17, 11 per cent of new homes were built in the floodplain[16] and while many will have been designed to minimise the risk, long term sustainability and compliance is difficult to demonstrate. Consideration should also be given to development outside the floodplain which could increase risk, for example through increased surface water runoff.

The Commission recommends that, to deliver the strategy:

- **By the end of 2019, government should put in place a rolling 6 year funding programme in line with the funding profile set out by the Commission. This should enable efficient planning and delivery of projects and address the risks from all sources of flooding.**
- **The Environment Agency should update plans for all catchments and coastal cells in England before the end of 2023. These should identify how risk can be managed most effectively using a combination of measures including green and grey infrastructure, spatial planning and property level measures.**
- **Water companies and local authorities should work together to publish joint plans to manage surface water flood risk by 2022.**
- **The Ministry of Housing, Communities and Local Government and planning authorities should ensure that from 2019 all new development is resilient to flooding with an annual likelihood of 0.5 per cent for its lifetime and does not increase risk elsewhere.**

Drought resilience

A reliable water supply is usually taken for granted in the UK. But the country faces a real and growing risk of water shortages, especially in the south east of England. Climate change, an increasing population, and the need to protect the environment are bringing further challenges for an already strained system. And the pressure will only rise over the coming decades as shown in figure 5.4.

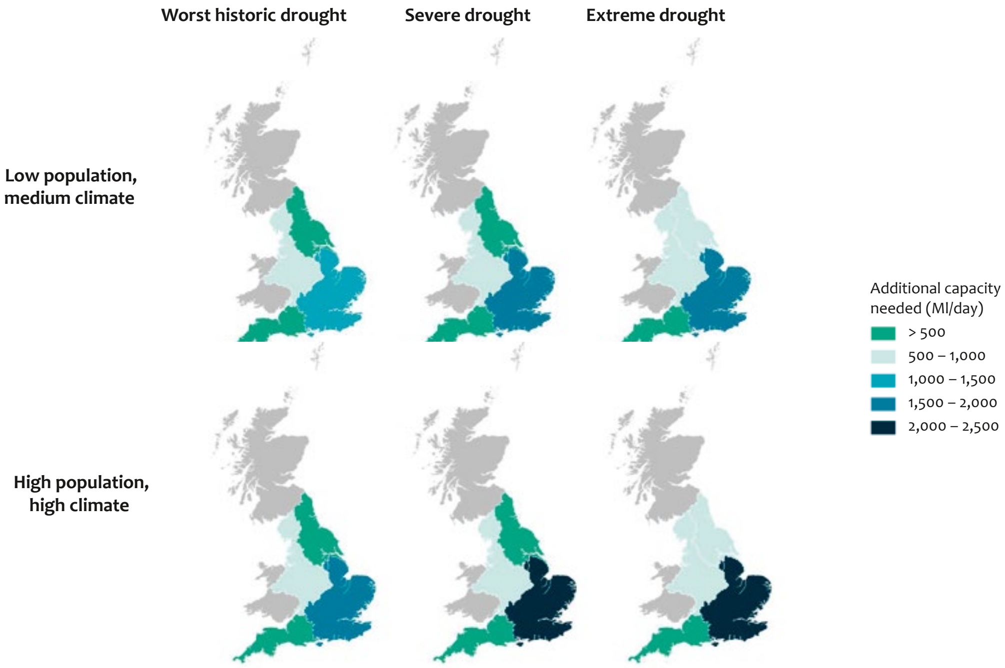


Figure 5.4 Additional water capacity for droughts with different population and climate scenarios[17]

Note: medium climate refers to an average medium emission scenario, high climate refers to a drier, medium emissions scenario with less water in the south east.

The full analysis is shown in the Commission's report *Preparing for a drier future* and the technical annex: *Analysis of drought resilience*. Conflicting incentives, limited cooperation between water companies and a short term focus have constrained action. As a result a serious drought would lead to an unacceptably high risk of severe supply limitations; homes and businesses could even be completely cut off.

Maintaining current levels of resilience until 2050 in the face of rising population, environmental and climate pressures, would require additional capacity of about 2,700-3,000 million litres per day (Ml/day) in England.[18] Additional capacity required to protect the UK from extreme drought (0.2 per cent annual chance) is between 3,500 and 4,000Ml/day as shown in figure 5.5.[19] The Commission's analysis shows that the costs of providing proactive long term resilience are less than those for relying on emergency response.

The Commission therefore believes that additional supply and demand reduction totalling 4,000Ml/day should be delivered by 2050.

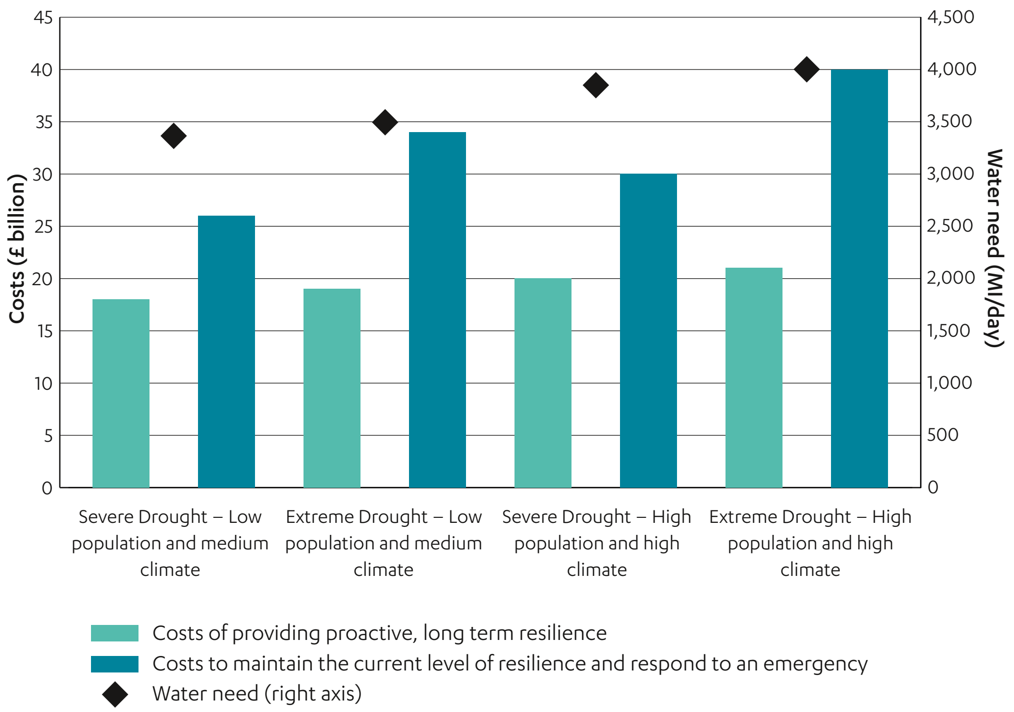


Figure 5.5 Costs of providing proactive, long term resilience and relying on emergency response for droughts beyond current resilience levels[20]

Note: Costs are expected present values to 2050 (in 2018 prices) and include maintaining 1 per cent resilience, which is considered to be 'business as usual'.

A 'twin-track' approach of reducing demand and increasing supply is the lowest cost and most sustainable way to increase resilience. And more ambitious long term plans are needed, as shown in figure 5.6. These should address leakage, enable water companies to undertake more comprehensive water metering and demand management, and ensure the delivery of a national water network, and other options for additional supply infrastructure.

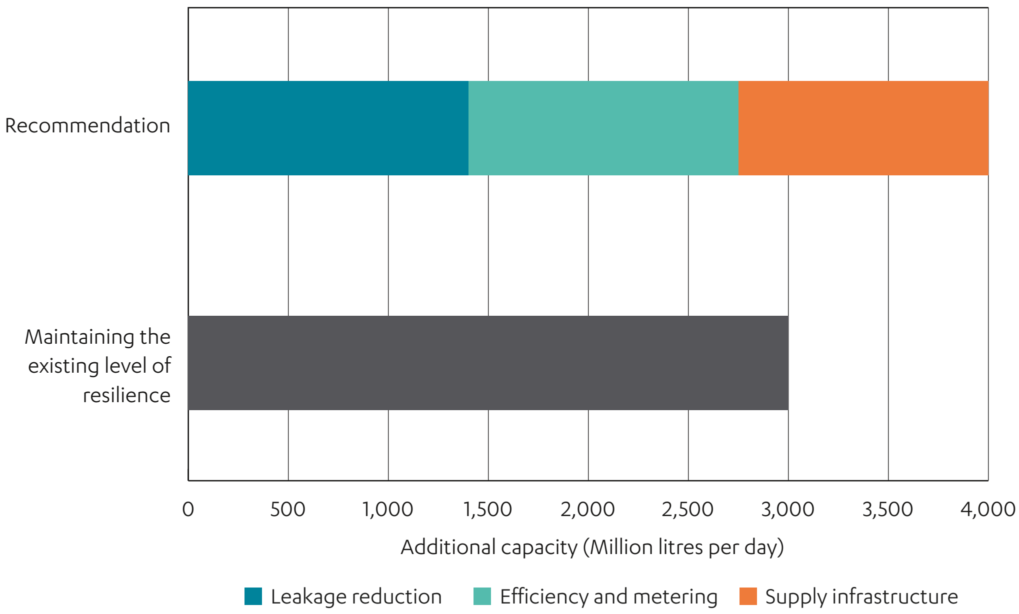


Figure 5.6 Twin-track approach addressing demand and supply[21]

Supply

Even with ambitious action to reduce demand, more supply infrastructure will be needed. Aiming for additional capacity of 4,000Ml/day will require a minimum of 1,300Ml/day additional supply infrastructure.[22] Different options are available, including transfers, reservoirs, reuse and desalination. A range of studies have all found a positive cost benefit case for greater transfers and water trading.[23] A network of strategic water transfers, which can move water from areas with a surplus to those where it is needed, could provide about 700Ml/day more capacity at comparable cost to other options and with increased adaptability of the overall system.[24] The remaining capacity should be provided by the most cost effective combination of supply infrastructure.

The scale of this infrastructure goes well beyond that seen in the draft plans proposed by water companies. It is likely to need strengthened regional approaches and an independent national framework. Ofwat has developed a 'direct procurement' mechanism for large infrastructure projects which could form the basis of open and transparent competition ensuring all options for significant additional supply capacity can be considered.

Demand

Demand reduction, including addressing leakage, can deliver the remaining 2,700Ml/day needed. Today, around 2,900Ml/day (20 per cent) of water put into the public supply is lost through leakage.[25] An ambitious long term strategy to reduce leakage would encourage action by customers and incentivise technological innovation, which should drive down the costs of managing leaks. Halving leakage should save over 1,400Ml/day by 2050.

Conventional metering can reduce demand by around 15 per cent and smart meters are expected to reduce this further (to about 17 per cent) and help identify leaks.[26] Water companies can introduce compulsory water metering in water stressed areas. About 50 per cent of homes in England are currently metered and this is expected to reach around 80 per cent by 2050, saving around 400Ml/day. Bringing forward metering more quickly would result in a further 400Ml/day reduction in demand by 2050. In addition, efficiency improvements (as washing machines and toilets use less water, for example) are expected to reduce demand by around 600Ml/day. There might be potential to go further in increasing efficiency, for example through local reuse schemes or labelling appliances, and companies should be more ambitious and show what can be achieved.

The Commission recommends that government should ensure that plans are in place to deliver additional supply and demand reduction of at least 4,000Ml/day. Action to deliver this twin-track approach should start immediately:

- **Ofwat should launch a competitive process by the end of 2019, complementing the Price Review, so that at least 1,300Ml/day is provided through (i) a national water network and (ii) additional supply infrastructure by the 2030s.**
- **The Department for Environment, Food and Rural Affairs should set an objective for the water industry to halve leakage by 2050, with Ofwat agreeing 5 year commitments for each company (as part of the regulatory cycle) and reporting on progress.**
- **The Department for Environment, Food and Rural Affairs should enable companies to implement compulsory metering by the 2030s beyond water stressed areas, by amending regulations before the end of 2019 and requiring all companies to consider systematic roll out of smart meters as a first step in a concerted campaign to improve water efficiency.**

Joining up flood and water management

A healthy aquatic environment is important for water supply and flood management as well as for biodiversity. Interventions to improve flood and drought resilience should consider the range of interactions that water has with people and the environment. There are opportunities for green infrastructure approaches that deliver multiple benefits including groundwater recharge, water quality and flood risk management.

The Environment Agency, local authorities and water companies should all work together to better coordinate their plans. The Environment Agency has a key role through its strategic overview for all flood and coastal erosion risk management as well as regulatory responsibility for water quality and abstraction. Appraisal and funding should encourage interventions that improve both drought and flood resilience. Decisions on flood and water infrastructure should take into account the full range of potential benefits as well as wider impacts to ensure that all objectives can be delivered effectively.

Endnotes

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[17] Commission calculations, based on data from Water UK, water companies and the Environment Agency and using the NISMOD model developed by the Infrastructure Transitions Research Consortium

[18] To put this in context, the typical volume of water available to supply households and businesses averages 15,000 Ml each day

[19] This represents the need beyond intra-company transfers and small interventions needed to maintain existing capacity

[20] Commission calculations and analysis, using input from Atkins, Infrastructure Transitions Research Consortium and Regulatory Economics. See technical annex: *Analysis of drought resilience* for more details and references

[21] Commission analysis, using input from Infrastructure Transitions Research Consortium and Regulatory Economics, see technical annex for more details and references

[22] This represents the need beyond intra-company transfers and small interventions needed to maintain existing capacity

[23] Deloitte (2015), Water trading – scope, benefits and options; Cave (2009), Independent Review of Competition and Innovation in Water Markets; Ofwat (2010), A study on the potential benefits of upstream markets in the water sector in England and Wales; Ernst and Young (2011), Changing course through water trading

[24] However, there are also risks; for example, transfers can enable invasive species and pathogens to spread, so options need to be considered on a case by case basis

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6. CHOOSING AND DESIGNING INFRASTRUCTURE

The UK needs to have confidence in its decision making and its ability to deliver innovative, world-leading, well designed infrastructure projects. It must make effective and timely decisions, and prioritise getting the best value out of its infrastructure projects over their lifetime.

The Commission was established to address many serious weaknesses in infrastructure decision-making. Policy uncertainty, reversals and prevarication have driven up costs and hampered delivery, with short term considerations often leading to decisions on controversial projects being postponed or, alternatively, taken in a rush without considering the evidence.

Better decisions can be taken. Part of this is to improve the processes by which individual projects are assessed and designed. This requires:

- **improving project appraisal by collecting better data on outturn costs and benefits of major infrastructure projects**
- **ensuring quality design in future nationally significant infrastructure projects**
- **developing a clear framework for measuring infrastructure performance.**

Delivery of high quality infrastructure also depends on the availability of the right skills, the approach to construction and project management, the depth of the supply base, and the capability of government and other infrastructure owners and operators to procure and act as an intelligent client for infrastructure. The UK's exit from the EU will impact the UK's skills base and supply chain; there should be a strategic approach to manage this. These areas are the remit of the Infrastructure and Projects Authority, rather than the Commission. Therefore, they are not covered in this chapter, but they remain critical.

Choosing projects

Government needs a robust approach to assessing the costs and benefits of infrastructure projects. Cost benefit analysis (also known as economic appraisal) is widely used to assist in deciding between infrastructure projects in the public sector, especially for transport projects. The UK is generally thought to be a leader in cost benefit analysis.[1] The Commission has engaged with a range of experts and interested stakeholders over the past year to better understand the limitations of existing methods and assess where improvements could be made.[2] Issues include:

- capturing system wide effects, rather than simply the marginal impact of individual projects

- the treatment of uncertainty – too often a single number is presented which does not reflect the range of possible outcomes
- ensuring the process does not become overly precise and focused on a preferred option at too early a stage.

Improving data

These are not straightforward issues to address. The Commission intends to continue working with experts and interested parties to find solutions. One key area where immediate progress could be made is in addressing the lack of consistent and publicly available outturn data on the costs and performance of infrastructure projects. In many cases, considerable time and energy is devoted to estimating expected costs and benefits but very little on establishing actual costs and benefits when projects are built.

Better data would allow:

- decision makers to understand the range of uncertainty in project appraisals by showing how outcomes have varied for similar projects, mitigating the natural tendency to optimism in assessing costs and benefits[3]
- consideration of a wider range of approaches at an early stage, by highlighting historic examples of successful alternatives to decision makers
- simplification of the early stages of appraisal, basing initial estimates on results from comparable projects
- greater scrutiny of proposals, at a stage when decisions are still open
- a more balanced understanding of past success and failure, in place of an excessive focus on the best or worst cases
- a better understanding of how different procurement and financing models affect outcomes (see Chapter 7).

The Commission's technology study, *Data for the public good,* identified the potential economic benefits from collecting and sharing infrastructure data. It recommended that the Infrastructure Client Group should cultivate a shift towards minimum levels of commercial confidentiality in the infrastructure industry.

Highways England routinely publish outturn project evaluations of major investments. This system has led to more accurate estimates of the likely costs of future projects, reducing the average error in forecast costs by 20 per cent between 2000 and 2009.[4] Other public bodies could adopt a similar approach.

Historic outturn costs and performance data from major projects, which are appraised individually to a high level of detail, will be of greatest value. The inclusion of historic data is vital to ensure that these datasets can inform decision making. Data should be reported on at least projects with a whole life cost above:

- £10 million for flood management
- £100 million for roads
- £500 million for rail

Cost data should be routinely comparable between initial estimates and actual outturns. Similarly, direct measures of benefit, such as whether passenger numbers meet expectations, should be straightforward to compare. More complex impacts, such as those on GDP or natural capital, can be hard to separate out from other background changes. But this should not be an excuse for failing to publish simpler measures.

Commercial considerations are sometimes stated as a reason for non disclosure but these can be overblown: projects which go wrong are scrutinised in public, so it is only success stories which are not available.

Full evaluation should more often be undertaken to estimate impacts. In many areas, very few robust evaluations exist. For example, the What Works Centre for Local Economic Growth has only identified two high quality evaluations worldwide of the economic impacts of high speed rail and none for trams or cycling schemes.[5]

The Commission recommends that government should publish good quality data on infrastructure costs and performance. All public bodies taking decisions on strategic economic infrastructure should publish the forecast costs and benefits of their major infrastructure projects at each appraisal stage and at a suitable point after completion, by the end of 2019. The Infrastructure and Projects Authority should work with departments to ensure that costs are comparable between sectors.

The value of good design

Once a decision is taken, infrastructure needs to be designed and built well. This Assessment demonstrates the need for investment in the nation's infrastructure, and the Commission is committed to ensuring this is of the highest quality. Now is the time to embed design into the culture of infrastructure planning, saving money, reducing risk, adding value, supporting environmental net gain and creating a legacy that looks good and works well.

Design Task Force

In February 2018, the Commission announced a Design Task Force chaired by Commissioner Professor Sadie Morgan, to advise on how best to ensure quality design in future major infrastructure.[6]

The Task Force has concluded that achieving the Commission's design ambitions requires two things: advocacy for design at the highest level within projects and access to design expertise. Major projects, including HS2 and Crossrail already do this, embedding design in the procurement and delivery process. This approach should be adopted for all Nationally Significant Infrastructure Projects (as defined within the Planning Act 2008) and those which require Parliamentary approval. Similar arrangements should be encouraged for all other infrastructure projects. The approach could also be amplified in the Government's National Policy Statements for infrastructure.

A new independent National Infrastructure Design Group, to be established by the Commission, will develop infrastructure design principles to guide design panels, which will be published in 2019. This group will also act as a champion of design quality in the nation's infrastructure, by:

- promoting new national infrastructure design principles
- commissioning and publishing research to promote continuous improvement in infrastructure design quality
- providing inspiration and intelligence on good infrastructure design
- promoting and supporting public debate on infrastructure design.

The Commission recommends that government should be embedded into the culture of infrastructure planning, to save money, reduce risk, add value, support environmental net gain and create a legacy that looks good and works well, by:

- **Government ensuring that all Nationally Significant Infrastructure Projects, including those authorised through hybrid parliamentary bills, have a board level design champion and use a design panel to maximise the value provided by the infrastructure.**
- **Design panels for nationally significant infrastructure projects having regard to design principles to be published by the National Infrastructure Commission based on advice received from the national infrastructure design group.**

Smart, resilient design

Smart capability and resilience should form an important part of the infrastructure design process.

New data capture and processing technologies such as sensors, artificial intelligence and digital twins can generate better quality data about infrastructure, and be used to improve the way that infrastructure is planned and maintained. They can help to optimise networks, prevent failures, and better target maintenance and renewals. The Commission set out recommendations in

Data for the public good to support infrastructure becoming increasingly smart. All new projects should consider data collection and use at the design stages.

Resilience is also a key dimension in the design and management of infrastructure, including adaption to climate change. Resilience needs to be considered both at the level of individual projects and at the level of wider systems. Individually small scale failures can multiply up in complex systems to far more serious impacts.[7]

The Commission recognised in its initial consultation on process and methodology that, given the breadth and complexity of resilience, it would not be possible to consider the issue fully in this first Assessment.[8] The Commission intends to carry out a more in-depth analysis of resilience as a theme, working with key stakeholders, to inform a future approach ahead of the next Assessment.

Measuring infrastructure performance

Measuring the quality of the UK's current infrastructure systems can reliably inform the assessment of the UK's future infrastructure needs, and in turn enable the delivery of high quality infrastructure. Currently, the assessment of how well infrastructure is doing too often focuses on the amount of money being spent.[9] But infrastructure has a long lifetime, and so its performance should consider the quality of service delivered by the whole infrastructure system, including its impact on natural capital. Understanding how the performance of each system changes over time could form a crucial part of the Commission's decision making in future.

The Commission intends to measure the quality of the UK's current infrastructure systems based on the framework presented in table 6.1 below. The measures in the framework work across most sectors, allowing the Commission to compare different infrastructure systems. They have also been designed to measure the performance of infrastructure against the Commission's objectives. These measures were developed following consultation on an earlier set published in the Commission's interim report, *Congestion, Capacity, Carbon: Priorities for national infrastructure*.

Table 6.1 – Perfomance measures

Domain	Sub-domain	Transport	Energy	Waste	Water and wastewater	Flood risk	Digital communications
Volume	Volume of consumption	Passenger/tonne km travelled (e)	Energy consumed (e)	Total waste generated (e)	Water consumed (e)	N/A	Gigabytes of data consumed (fixed and mobile) (e)
				Residual waste generated (e)	Wastewater produced (n)		Voice minutes (fixed and mobile) (e)
		Number of trips (e)					4G subscriptions (e)
							Full fibre subscriptions (e)
Resilience	Resilience to large shocks	Stress test (n)	Stress test (n)	Stress test (n)	Security of supply index (e)	Risk of flooding and coastal erosion (e)	Stress test (n)
			Capacity margin (e)		Probability of drought (n)	Standard of protection (n)	
			Expected loss of load (e)				
	Everyday resilience	Travel time reliability (n)	Time that properties lose access to energy (e)	N/A	Time that properties lose access to water (e)	Number of properties flooded (n)	Number of serious incidents reported to Ofcom (e)
					Number of sewer flood events (e)		
Quality	Service quality	Connectivity (n)	N/A	Gross value added from waste material recovery (e)	Number of water quality incidents (e)	N/A	Coverage by technology (e)
				Recycling rates (e)			Actual speed at peak time (n)
	Quality of user experience	Satisfaction derived from survey (e)	Satisfaction derived from survey (c)	Design quality (n)	Satisfaction derived from survey (e)	Design quality (n)	Satisfaction derived from survey (e)
		Design quality (n)	Design quality (n)		Design quality (n)		Design quality (n)
							Percentage of all 90-second calls completed without interruption (e)
							Percentage of mobile data connections which deliver a speed of at least 2 Megabits per second (e)

Note: (e) denotes existing measures; (n) denotes new measures; and (c) denotes measures constructed by the Commission using existing measures

Domain	Sub-domain	Transport	Energy	Waste	Water and wastewater	Flood risk	Digital communications
Cost	Cost	Cost per passenger/ tonne km (c)	Cost per kilowatt hour of energy (c) Average annual energy bill (e)	Cost per tonne of waste collected and disposed/treated (c)	Cost of water per litre (c) Cost of wastewater treated per population equivalent (c) Average annual water and sewerage bill (e)	Cost per property protected (c) Cost incurred on flood risk insurance claims (e)	Cost per gigabyte of data (fixed and mobile) (e) Average monthly bill (fixed and mobile) (e)
Environment	Emissions	CO_2e emissions per passenger/tonne km (e)(c) Total CO_2e emissions from transport (e)	CO_2e emissions per kilowatt hour used (c) Total CO_2e emissions from energy (e)	CO_2e emissions per tonne of waste produced (c) Total CO_2e emissions from waste (e)	CO_2e emissions per litre of water consumed (e) Total CO_2e emission from water and wastewater (e)	N/A	CO_2e emissions per gigabyte of traffic used (n) Total CO_2e emissions from digital comms (n)
	Environmental externalities	Air quality (e) Noise (e)	Air quality (e)	Waste generated per capita (e) Ground pollution from waste (n)	Number of serious pollution incidents caused by water companies (e) Percentage of water bodies with unsustainable levels of abstraction (e) Average concentration of reactive phosphorus in rivers (e)	Measure of habitat improved or created (e)	N/A
	Natural capital	To be developed	Value of energy services provided by natural environment (e) Cost that energy services impose on the natural environment (e)	To be developed	Value of water services provided by natural environment (e)	To be developed	To be developed
Efficiency	System efficiency	Congestion (e)	Energy efficiency of buildings (e) Transmission/ distribution losses (e) Ratio of average to peak demand (c)	Reject rates from sorting facilities (e) Capture rate of recyclable materials (e)	Leakage (e)	N/A	N/A

Note: (e) denotes existing measures; (n) denotes new measures; and (c) denotes measures constructed by the Commission using existing measures

Details on responses to the consultation and how these informed the framework and the measures will be provided in a separate technical annex, to be published after this Assessment. The annex will also set out how the Commission intends to further develop performance measures that do not yet exist, including measures linked to natural capital (working with the Natural Capital Committee), design quality and stress tests. The measures in the framework are a work in progress and the Commission expects to update them as new measures are developed or better data becomes available.

The Commission has gathered data on many of these measures, which will also be published on the Commission's website in September 2018. This data gathering process has highlighted two significant gaps so far:

- commercial and industrial waste, where government has launched a competition to develop a new digital solution to track waste.[10]
- the number of properties that are flooded where data recorded by local authorities is not aggregated and published centrally.[11]

Recommendations on filling these gaps have been set out in earlier chapters of the report.

Endnotes

[1] Institute for Government (2017), How to value infrastructure
[2] See National Infrastructure Commission (2017), **Congestion, Capacity, Carbon: priorities for national infrastructure**, pp.38-39
[3] National Audit Office (2013), Over-optimism in government projects
[4] Highways England (2015), Post Opening Project Evaluation (POPE) of Major Schemes
[5] What Works Centre for Local Economic Growth (2015), Evidence Review 7, Transport
[6] The Design Task Force was announced in the interim National Infrastructure Assessment *Congestion, Capacity, Carbon* in October 2017 and launched by Professor Sadie Morgan at the Institution for Civil Engineers in February 2018. Its members are Lucy Musgrave, Hanif Kara and Isabel Dedring. It is chaired by Commissioner Professor Sadie Morgan and advised by Tony Burton.
[7] Perrow (1984), Normal Accidents
[8] National Infrastructure Commission (2016), The National Infrastructure Assessment, process and methodology consultation response.
[9] Institute for Government (2017), What's wrong with infrastructure decision making?
[10] See SBRI: smart waste tracking data collection, storage and reporting services: **https://apply-for-innovation-funding.service.gov.uk/competition/175/overview**
[11] According to internal communication between the Commission and the Environment Agency.

7. FUNDING AND FINANCING

The recommendations set out in this Assessment are not simply a wish list. The recommendations are affordable within the resources set out by the government and provide a fully costed plan for infrastructure spending without significant additional costs to billpayers.

The recommendations in the Assessment have all been carefully considered by the Commission bearing in mind its objectives. The implications of the recommendations for public expenditure and for bills have been weighed up. The Commission has made judgements on priorities for expenditure within the government's infrastructure funding guidelines. In reaching its conclusions, the Commission has drawn on a wide range of evidence and considered the outcomes of its recommendations under a range of scenarios.

The cost of infrastructure services affects business competitiveness and households' quality of life. The Assessment therefore sets out recommendations to ensure that infrastructure projects are paid for at the lowest whole life cost. Efficient delivery and management of assets and good design have a part to play in this. But it also requires improvements in funding and financing arrangements:

- A UK infrastructure finance institution if the UK loses access to the European Investment Bank
- Improving the analysis of costs and benefits of private financing and traditional procurement
- Engaging stakeholders and the public on paying for road use, recognising that the existing approach is unsustainable
- Expanding and strengthening the range of mechanisms for capturing a share of increases in land value associated with infrastructure.

Paying for infrastructure

The costs of the Commission's recommendations and who will pay are included in the tables below. These set out planned infrastructure spending in the period from 2020 to 2050.

Households ultimately fund all new infrastructure. This occurs through a variety of channels. Government funded infrastructure is paid for via tax. Infrastructure paid for in this way is covered in the 'fiscal remit' table. Infrastructure funded by the private sector is paid for through bills and charges paid by households, businesses, and the public sector (for example water and gas bills). Higher costs to businesses ultimately feed through to households via the costs of goods and services. Infrastructure paid for in this way is covered in the bills table.

Fiscal remit

The government has given the Commission a long term funding guideline for public capital expenditure, the 'fiscal remit'. The Commission "must be able to demonstrate that its recommendations for economic infrastructure are consistent with, and set out how they can be accommodated within, gross public investment in economic infrastructure of between 1.0% and 1.2% of GDP in each year between 2020 and 2050."[1]

The fiscal remit covers capital expenditure by the public sector, including both local and national expenditure. It does not include spending by the devolved administrations, nor does it include day to day spending ('resource' spending).[2]

The fiscal remit does not only cover new projects. Existing commitments and ongoing investment in maintenance and renewals must also be accommodated alongside the Commission's recommendations. The Commission's remit specifically excludes consideration of decisions that have already been made, and spending that has already been committed, such as HS2. Committed spending, such as HS2; Crossrail 2 and Northern Powerhouse Rail; and maintaining current assets together add to 1.1 per cent of GDP from 2020-2025 and 0.9 per cent from 2025-2030.

Table 7.1 sets out the Commission's proposals for the fiscal remit.

The Commission recommends that government should deliver long term certainty over infrastructure funding by adopting the funding profile set out in the 'fiscal remit' table in Spending Review 2019 and other future spending plans.

Bills

Households typically pay for infrastructure via bills where consumers can choose how much, or what level, of a service to purchase. For example, linking households' energy bills to their usage helps to keep total consumption at an efficient and sustainable level.

The Commission is required to provide "a transparent assessment of the overall impact on costs to businesses, consumers, public bodies and other end users of infrastructure."[3] Table 7.2 sets out these impacts. Detailed analysis of this is included in N*ational Infrastructure Assessment impact and costings notes*.

Where recommendations have net costs, the Commission believes that these are manageable and good value relative to the benefits the infrastructure provides.

Table 7.1: The fiscal remit

Average annual expenditure (£ million, 2018/19 prices)	2020-2025	2025-2030	2030-2035	2035-2040	2040- 2045	2045-2050
Transport						
HS2	4,500	3,900	900			
Crossrail 2	200	2,200	2,900			
Northern Powerhouse Rail	200	1,100	1,700	1,800		
Network Rail	6,100	6,100				
Highways England	4,300	3,200				
Strategic Transport*			10,500	11,400	11,200	11,600
Devolved Cities	3,300	3,600	4,600	5,400	6,100	6,800
Transport for London	2,600	2,900	2,200	2,000	2,200	2,400
Urban Major Projects	500	400	2,400	3,100	3,500	3,900
Non-urban local transport	2,700	2,900	3,400	3,800	4,200	4,700
Local Roads Backlog		500	500			
Housing Infrastructure Fund	500	200	200	200	200	200
Energy						
Energy efficiency	100	300	300	100		
EV Charging	2**					
Digital						
Rural fibre	400	300	100			
Waste	600	500	500	500	500	500
Flood Resilience	600	700	900	1,300	1,300	1,300
Studies Contingency	300	400	400	400	400	400
Total expenditure on infrastructure	**26,900**	**29,200**	**31,500**	**30,000**	**29,600**	**31,800**
As a % of GDP	**1.2%**	**1.2%**	**1.2%**	**1.0%**	**0.9%**	**0.8%**

*combined allocation for road and rail.
**£10m funding in 2020/21.

Table 7.2: The impact on bills

Average annual aggregate impact (£ million, 2018/19 prices)	2020-2025	2025-2030	2030-2035	2035-2040	2040- 2045	2045-2050
Heat trials and energy efficiency	+110	+270	+190	+180	+180	+180
Waste	+140	+110	+50	-10	-30	-60
Flood risk – lower insurance costs	-60	-240	-420	-610	-790	-980
Water – resilience to drought	+310	+640	+280	+280	+280	+280
Total impact on households, businesses and public sector	+510	+780	+100	-150	-370	-580
Total impact on households	+440	+650	+120	-60	-240	-420
Average impact per household (£/year)	*+£20*	*+£20*	*£0*	*£0*	*-£10*	*-£10*
Total impact on businesses	+50	+90	-20	-70	-100	-130
Total impact on public sector resource spending	+20	+40	0	-20	-30	-30

Impacts are shown relative to a baseline without the recommendation. This is different to the energy bills impacts described in the *Low Cost, Low Carbon* chapter which compare 2050 to today. Negative figures denote savings. Columns may not sum to totals due to rounding

The Commission's choices

The recommendations in this Assessment, and the implications for public expenditure and for bills, reflect the judgement of the Commissioners. In reaching its conclusions, the Commission has drawn on a wide range of evidence, including scenario based modelling, stakeholder expertise and opinions, social research, and specially commissioned studies (which are available on the Commission's website). Further details on the Commission's approach are set out in *The National Infrastructure Assessment: process and methodology* and the interim report *Congestion, capacity, carbon: priorities for national infrastructure*.

Meeting the Commission's objectives

These recommendations reflect the Commission's objectives: to support sustainable economic growth in every region; improve competitiveness; and improve quality of life.

Sustainable economic growth in every region: Full fibre digital infrastructure and urban transport networks lower the costs of connecting firms, workers and consumers; capture the benefits of higher productivity in dense clusters of firms; and enable innovation.

International competitiveness: Low cost energy supports international competitiveness as an input to all economic activity. Promoting electric, connected and autonomous vehicle infrastructure supports the UK motor industry to stay at the forefront of innovation.

Quality of life: Better air quality from electric vehicles, warmer homes from energy efficiency and a better designed public realm can improve people's quality of life. Resilience to floods and droughts protects people against natural disasters.

Prioritising within the fiscal remit

Resources are inevitably limited. This has required the Commission to prioritise between available options in some areas.

Prioritise support for new infrastructure networks in the short term: Broadband and electric vehicle charging have been prioritised in the short term, when resources are most constrained. These new technologies represent major opportunities for growth and are particularly time critical if the UK is to remain internationally competitive.

Prioritise urban transport over intercity networks in the 2030s: Most spending on major upgrades to urban infrastructure, recommended in Chapter 4, will come in the late 2020s and especially in the 2030s. This profile reflects the overall availability of resources, as well as the need for local capability and for proposals to be developed by cities. In later years, urban spending will be balanced by reduced spending on major enhancements on the intercity networks, which will have seen at least a decade of sustained high investment.

Focusing on low regret options on the motorway and major road network while the impact of new technology is uncertain: Figure 7.1 sets out the enhancement budget for Road Investment Strategies 1 to 3, together with historic estimates of equivalent spending in the past. For future Road Investment Strategies, maintenance, renewals and incremental enhancements should be prioritised over 'mega projects' given the increased uncertainty that new technology creates for projects with very long payback periods. Large road and rail projects should compete for the same funding, as indicated in the fiscal remit table, to ensure the most beneficial projects are taken forward regardless of mode. An additional £500m a year should be spent on basic maintenance for local roads between 2025-2035.

Balance increased rail expenditure in the late 2020s with other priorities: There is a major increase in rail expenditure in the 2020s from HS2, Northern Powerhouse Rail and Crossrail 2, as shown in figure 7.2. Continuous change is not sustainable for the rail network and there are other priorities; sums for further enhancements in Network Rail in the late 2020s ('Control Period 7') should be correspondingly lower, although funding for maintenance and renewals should be protected.

Provide an indicative budget for Northern Powerhouse Rail of £24 billion from 2023-24 to 2039-40: The business case for Northern Powerhouse Rail remains under development. It is important that Transport for the North sets its priorities for the region and a clear budget will allow that to happen. However, city leaders in the region should have the freedom to shift additional funding from urban budgets to Northern Powerhouse Rail if they choose.

Provide an indicative budget for Crossrail 2 of £27.7 billion from 2023-24 to 2035-36: In line with *Transport for a world city,*[4] this reflects the need for Transport for London to reduce and phase the costs of the scheme. London should contribute at least half of the scheme costs.

Provide a gradual increase in the budget for flood protection: This reflects the long term strategy proposed in Chapter 5. Spending is weighted towards later years due to other priorities in the 2020s and the time needed for the development of robust plans to achieve the required level of protection.

Apply efficiency savings to renewals spending: These are in line with the government's *Transforming Infrastructure Performance*[5] productivity programme.

Maintain the Housing Infrastructure Fund outside cities: Within cities, this funding should be merged into wider devolved funding for strategic transport and housing strategies.

Leave headroom in the later period: Some recommendations, such as flood protection, involve spending to 2050. But overall there is considerable space in later years. This will be needed for future priorities such as zero carbon heat, surface water flooding or even completely new infrastructure that may be needed in decades to come.

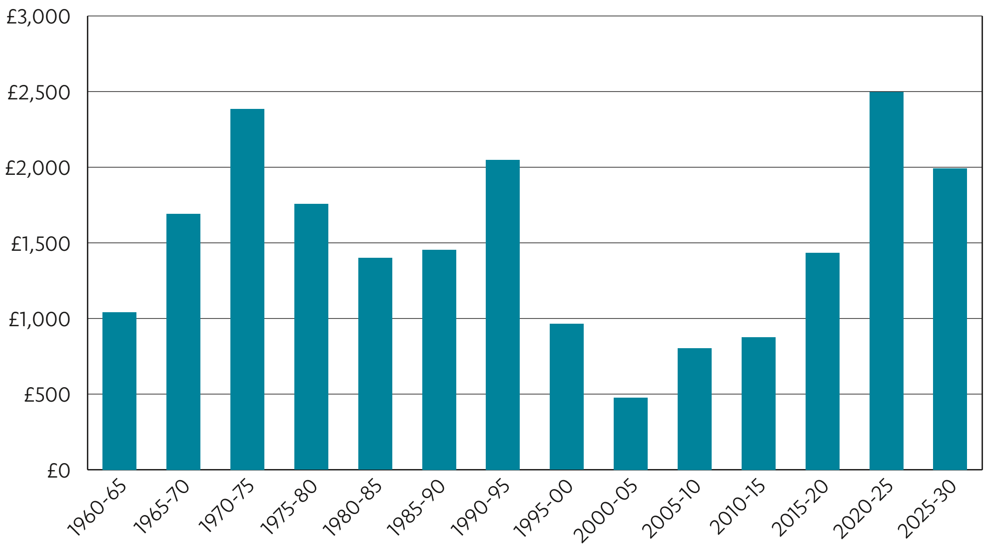

Figure 7.1: Historic and planned enhancement spending on strategic roads[6]

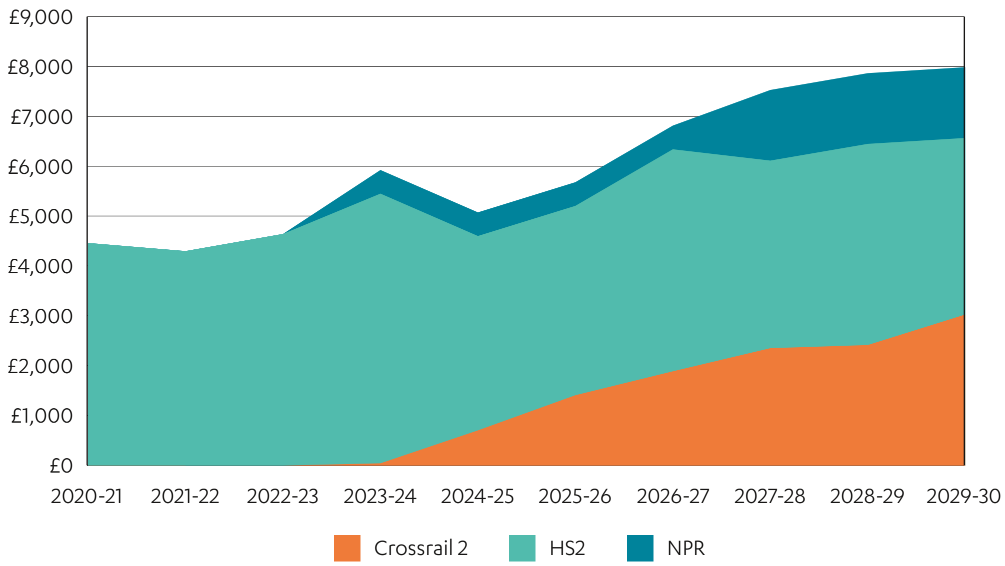

Figure 7.2: Capital Investment in rail 'mega projects' (£m, 2018/19 prices)

Managing uncertainty

The Commission has also considered how the impact of its recommendations may be affected by uncertainty, focusing particularly on technology, population, economic growth and climate change.[7] The Commission has sought to understand how robust its decisions would be to uncertainty, seeking solutions that will stand the test of time, but recognising that some uncertainty is unavoidable given the timescales for infrastructure investment.

Balancing the risks of major investments: For full fibre and water, the potential costs of inaction are much higher than those of action. For flood protection, a more 'adaptive' approach can be taken because defences can be added to incrementally if risks turn out higher. For energy, the Commission's judgement is that the supply chain for nuclear power should be maintained by agreeing a further plant beyond Hinkley Point C, even though renewables look like an increasingly viable alternative, as the costs of re-establishing the nuclear supply chain would be very high.

Making complementary recommendations: Investing in both urban transport and rural fibre mitigates uncertainty about the future location of economic activity. Electric vehicle charging helps reduce the cost of more renewables intensive electricity generation by providing more flexible demand and potentially lowering the cost of storage.

Planning for future decisions: Investing in renewables in the 2020s will improve understanding of system balancing costs for the 2030s and 2040s. Separation of food waste is good value for money today, but also maximises the availability of biogas. Biogas has a range of potentially high value uses replacing hard to substitute fossil fuels in future. Assessing the potential impact of connected, autonomous vehicles on road and rail investment could reduce the risk of costly long term investments being overtaken by technology.

Strategic use of public and private financing

Infrastructure typically requires large up front investment ('financing') followed by a long period in which these costs, plus on going maintenance and operational costs, are repaid by users or taxpayers ('funding'). The Commission's recommendations will require a combination of public and private financing mechanisms and these arrangements should be as efficient and as cost effective as possible.

Finance itself is not in short supply.[8] However, in some cases public sector support can ease constraints on the financing of projects in the private sector. In other cases, private finance could increase the efficiency of projects in the public sector and share risks.

UK infrastructure finance institution

The UK has a high proportion of privately owned, operated and financed infrastructure.[9] Almost half of the planned pipeline of infrastructure projects to 2020/21 will be delivered and funded privately.[10] It has well developed capital markets which generally help to facilitate this private finance. And there is an appetite on the part of institutional investors to increase both the scope and scale of their investment in infrastructure projects.[11]

Both government and arms length independent state institutions can help to support this investment, by absorbing risk that the market finds hard to manage and supporting due diligence functions for innovative projects. The government already has some established mechanisms to support private investment such as the UK Guarantee Scheme.

There is an ongoing market failure around innovation in the infrastructure sector; the risks associated with innovative technologies, techniques and financial products can be too high for the private sector without government support.[12] For example there is strong evidence that the Green Investment Bank helped to catalyse private investment in offshore wind.[13] And there is a role for government in easing liquidity constraints in the infrastructure market during times of crisis.[14]

Independent financing institutions can mitigate some of the risks involved in public sector support for private investment. Independent institutions can provide policy stability in areas which exist outside of the short term political cycle. They can also develop expertise and credibility, which can be used to build the understanding and capabilities of both private investors and local government.[15] A portfolio of investments allows an institution to take risk without imposing an overall cost on the public purse.

In the past, the European Investment Bank and the recently privatised Green Investment Bank have provided this kind of function in the UK.[16] The government has indicated that it may be mutually beneficial to maintain a relationship between the UK and the European Investment Bank[17], and the Commission has heard from a wide range of stakeholders that this would be their preferred outcome. However, it may not be possible: a contingency plan is needed.

Any new domestic institution would not score within the Commission's fiscal remit, since its activities would score as 'financial transactions' rather than as capital expenditure. However, unlike the European Investment Bank, lending by any domestic institution would score within the government's main debt measure, Public Sector Net Debt.[18] A new institution would therefore need a clear remit, and robust processes, to ensure additionality and 'sound banking' (measuring project returns in terms of risk adjusted interest rates and lending at market rates).[19]

The Commission recommends that government should maintain access to the European Investment Bank if possible. If access is lost, a new, operationally independent, UK infrastructure finance institution should be established by 2021. To enable this, government should consult on a proposed design of the new institution by Spring 2019. The consultation should cover:

- **Functions, including provision of finance to economic infrastructure projects in cases of market and coordination failures; catalysing innovation; and acting as a centre of excellence on infrastructure project development, procurement and delivery**
- **A clear mandate, including sound banking, additionality and having a wider economic and social impact**
- **Governance to safeguard the operational independence of the institution.**

Evaluating the performance of private financing and traditional procurement

As well as the public sector supporting private financing, private finance can support public sector projects. The introduction of private financing into public infrastructure delivery came following a poor record of public sector delivery.[20] It has led to quicker delivery of projects, enabling society to access infrastructure services earlier, and contributed to better public sector commercial capability.[21,22]

Private financing, in comparison to traditional procurement, encourages a whole life approach to project design. The transfer of risk to the private partner incentivises efficiency in delivery over the project lifecycle but can sometimes create challenges where requirements change during the project lifetime. There is a residual level of risk that can never be transferred, since in extreme circumstances projects can return to the public sector where private providers go bankrupt.

There has been a slowdown in the use of private financing in recent years due to uncertainties about its cost effectiveness and the rationale for its use.[23] The overall performance of private finance has not been robustly evaluated.[24]

The Commission proposes an analytical framework for whole life analysis of the costs and benefits of private financing and traditional procurement, set out in the technical annex *Proposed analytical framework for evaluating the performance of private financing and traditional procurement*. It builds on past studies considering performance and costs during construction by covering the whole lifespan of projects and a wider range of potential benefits.

Consultation has found a wide consensus on the dimensions in the framework. The immediate next steps are for the framework to be piloted to develop insights on its practical application and identify where it needs to be revised.

Following the pilot, the Commission aims to develop a consistent evidence base of costs and benefits of financing models through more detailed analysis. This independent source of evidence should lead to the more strategic use of private financing and traditional procurement, and improve the design of existing models to build more collaborative long term approaches.

Additional funding mechanisms

Paying for road use

Road use is a notable exception to the general principle that infrastructure is paid for through bills where consumers can choose their level of usage.

Over the Assessment's timeframe changes to the way drivers pay as they use roads are inevitable. Fuel duty revenues will decline with the impending shift to electric vehicles.[25] Technological change has the potential to radically change driving patterns and vehicle ownership. The current system of road taxation is not sustainable.

One option might be to introduce a 'road pricing' scheme to charge drivers according to where and when they drive, which could deliver valuable benefits. Road pricing can:

- Pay for new and better road infrastructure; creating a revenue stream from roads can attract private investment, as with some toll roads
- Reduce congestion; congestion is estimated to cost the economy over £35 billion a year, and pricing congestion has been shown to reduce traffic volumes[26,27]
- Protect tax revenue; fuel duty will decline and road pricing is a sustainable alternative

The changing use of roads presents an opportunity to design a road pricing scheme that improves on current road taxation by being fairer, more sustainable and more effective at reducing the negative impacts of driving. Developments in technology provide new ways to implement road pricing that have previously been too expensive or impractical. Some possible changes, such as 'mobility as a service', where people pay for journeys rather than car ownership, would naturally fit with alternative forms of road pricing.

There has often been a disconnect between theoretically perfect road pricing systems suggested by policymakers and the perceived fairness and practicality of those systems by the public.[28] Rather than propose a further technocratic recommendation the Commission will explore new ways to engage stakeholders and the public on this topic, looking at a full range of potential options in light of the major changes in road use and taxation that are inevitable. Reforming how road use is paid for has been discussed for decades,[29] but the issue is becoming more and more pressing and cannot be avoided forever.

Land value capture

Local funding for infrastructure can strengthen local accountability, sharpen the incentives for scheme designers to maximise local benefits, and improve the fairness of the funding regime as local beneficiaries contribute to the scheme costs. One approach to raising funding locally is to capture part of any increase in land values from infrastructure development or planning permission for new developments. But the Commission's analysis suggests this is not the silver bullet for funding local infrastructure.[30]

Whilst the current system, comprising Section 106 contributions from developers and the Community Infrastructure Levy, is complex, it is more successful at raising funding than previous approaches.[31] Other parts of the tax system, such as Capital Gains Tax and Stamp Duty, also capture a proportion of land value increases, although there are no reliable measures of how much. Some have argued for radical reform of local funding.[32] However, without a full picture of existing receipts it is unclear this would increase total revenues, and the history of previous reforms argues for caution.[33] Reform would undoubtedly lead to costs and delays in the short term as land owners and developers sought to understand new liabilities before making major decisions.

The sums potentially available would vary significantly across the country. Analysis undertaken for the Commission indicates that roads investment which reduces travel times by 10 per cent in the Cambridge – Milton Keynes – Oxford Growth Arc is associated with higher average property values of over £3,000 per property; a similar scheme in the East Midlands is associated with higher values on average of £2,000 per property and in Yorkshire of £1000 per property.[34]

The Commission's remit covers the interaction between infrastructure and housing, but not housing itself. The Commission has therefore looked at local funding mechanisms from the perspective of infrastructure funding and has concluded that the existing system should be improved rather than replaced, identifying three policies to help raise local revenues.

Business rates and council tax

London used a business rate supplement to help fund Crossrail 1.[35] This supplement, charged at 2p for every £1 paid by businesses above a certain threshold, will eventually provide nearly one third of Crossrail 1's costs. Applying a small charge to a large base of rate payers is a simple way to gather a contribution to scheme costs. The same approach could be applied to council tax, where a precept could be applied to reflect part of the increase in property values that result from new transport infrastructure.[36] To protect existing residents, the precept could be applied only to new residents that move into the area. To ensure the precept is genuinely related to project costs, it could be time-limited.

Changes in the 2011 Localism Act now require a majority of business rate payers to agree to the supplement, both in number of rate payers and by the value of the rates paid.[37] This is difficult to coordinate; introducing a threshold of one third of scheme costs before ballots are used would make the funding tool simpler to use while retaining safeguards. In this way, future infrastructure projects could benefit from Crossrail 1's innovative funding structure.

Community Infrastructure Levy

The government are currently consulting on changes to improve the Community Infrastructure Levy. Pooling section 106 agreements across several projects was an important means for local authorities to develop bespoke funding solutions such as the Milton Keynes Tariff. However local authorities are currently not allowed to do this.[38] The government's proposals would remove pooling restrictions in some but not all cases, which would create further complexity and limit flexibility. A simpler approach would be to remove all pooling restrictions which would allow local authorities to use section 106 more effectively.

Compulsory purchase regime

The compulsory purchase regime, whereby local authorities can buy land as a last resort, could be strengthened. The current regime is costly, time consuming and uncertain.[39] Conducting an independent assessment of site value at the start of the process could save money and provide more certainty for the parties involved in a compulsory purchase order.

The Commission recommends that local authorities should be given further powers to capture a fair proportion of increases in the value of land from planning and infrastructure provision. To enable this, government should:

- **Remove pooling restrictions on Section 106 in all circumstances, through forthcoming secondary legislation by 2020**
- **Remove the ballot requirement for upper tier authorities' powers to levy a business rate supplement of 2p or less in the pound for infrastructure, except where the supplement exceeds one third of scheme costs by 2021**

- Give local authorities powers to levy zonal precepts on council tax, where public investments in infrastructure drive up surrounding property values by 2021
- Provide greater certainty in compulsory purchase compensation negotiations by including independent valuations early in the process to be paid for by the acquiring authority by 2021.

Endnotes

1 HM Treasury (2016), National Infrastructure Commission Remit letter
2 Further details are set out in the Charter for the National Infrastructure Commission, the Government's Remit letter for National Infrastructure Commission of 23 November 2016 and in the Commission's interim report Congestion, Capacity, Carbon: Priorities for national infrastructure
3 HM Treasury (2016), National Infrastructure Commission Remit letter
4 National Infrastructure Commission (2016), Transport for a world city, converted to 2018/19 prices
5 Infrastructure and Projects Authority (2017), Transforming infrastructure performance
6 Historic data from Department for Transport (2014), Road Investment Strategy: Strategic Vision, 2013/14 prices
7 The Commission has published discussion papers on each of these topics, which are available on the Commission's website
8 Cambridge Economic Policy Associates (October 2017), Financing for infrastructure summary report
9 Eunomia Consulting (2018), Comparative Study of National Financing Institutions – commissioned by the National Infrastructure Commission
10 Infrastructure and Projects Authority (2017), Analysis of the National Infrastructure and Construction Pipeline
11 Pensions Infrastructure Platform (2018), Response to Congestion, Capacity, Carbon
12 HM Government (2011), Update on the design of the Green Investment Bank
13 Vivid Economics (2018), The role and impact of the EIB and GIB on UK infrastructure investment
14 Ibid
15 LSE Growth Commission (2013), Chapter IV: Investment in Infrastructure, LSE Growth Commission Report (2013), Investing for Prosperity – Skills, Infrastructure and Innovation; Vivid Economics (2018), The role and impact of the EIB and GIB on UK infrastructure investment
16 Vivid Economics (2018), The role and impact of the EIB and GIB on UK infrastructure investment
17 Mansion House 2017: Speech by the Chancellor of the Exchequer, 20 June 2017
18 ONS (2017), Wider measures of public sector liabilities. As a public corporation, a domestic institution would not score within the more widely used international measure of General Government Gross Debt. The government has also introduced a new measure, Public Sector Net Financial Liabilities, which would more accurately reflect the impact of any new institution on overall fiscal risk, by including both assets and liabilities.
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25 National Infrastructure Commission (2017), Congestion, Capacity, Carbon: Priorities for national infrastructure
26 Cookson, INRIX Research (2018), INRIX Global Traffic Scorecard
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29 Ibid
30 Institute for Fiscal Studies (Forthcoming), Property Value Uplift Tool
31 Crook, T., Henneberry, J., Whitehead, C. (2012), Planning Gain – Providing Infrastructure and Affordable Housing, Wiley Blackwell
32 Centre for Progressive Policy (2016), Bridging the infrastructure gap
33 Ibid
34 Institute for Fiscal Studies (Forthcoming), Property Value Uplift Tool
35 Greater London Authority (2018), Crossrail Business Rate Supplement 2018/9 ratepayer leaflet
36 Transport for London (2017), Land Value Capture
37 The Localism Act (2011)
38 National Infrastructure Commission (2017), Partnering for Prosperity, and Regulation 123 of the Community Infrastructure Levy Regulations 2010
39 Compulsory Purchase Association (2017), Annual Law Reform Lecture 2017 pre-event reading material, available at: http://www.compulsorypurchaseassociation.org/cpa-law-reform-lecture-2017.html

8. NEXT STEPS

This is the Commission's first Assessment of the UK's economic infrastructure. Since its establishment, the Commission has been working to identify the key priorities for the nation's infrastructure, culminating in the recommendations set out in this Assessment. But the work does not stop here. These recommendations need to be implemented. Government, regulators, industry and others will all need to contribute to making this a reality. The Commission will report on progress in its Annual Monitoring Report. And the second Assessment, expected in around 5 years' time, will develop on these themes and identify future priorities for the UK's infrastructure.

Over the coming months and years, the Commission will:

- seek consensus on its recommendations
- work with government to establish its recommendations as government policy
- monitor the implementation of the recommendations set out in the Assessment alongside those in its earlier studies
- carry out further work on some of the areas outlined in this Assessment, including housing, design and economic regulation
- begin work on the second National Infrastructure Assessment, expected around 2023.

Consensus building

Too often in the past, a lack of political consensus has led to delays and extra costs in infrastructure. The Commission was established to provide independent advice and analysis and to move away from a position where the main promoters of infrastructure are either politicians or scheme developers, whose arguments, however well made, are often treated with scepticism. Ultimately, it is for government to decide on the Commission's recommendations. However, over the coming months, the Commission will endeavour to build consensus around its recommendations and engage across parties and with the public, policy makers, infrastructure experts and relevant bodies, as set out in its framework document.

As set out in the Executive summary, the Commission's remit extends to economic infrastructure within the UK government's competence, and will evolve in line with devolution settlements. This means the Commission's recommendations will apply to non devolved UK government infrastructure responsibilities in Scotland, Wales and Northern Ireland (and all sectors in England). The Commission will continue to engage closely with devolved administrations and bodies under their jurisdictions as appropriate, particularly on matters where the respective infrastructure policy responsibilities of the UK government and devolved administrations interact.

Government response

The Commission's framework document states that:

"The government will lay the [Commission's] reports before Parliament, and will respond to the [Commission's] national infrastructure assessment and specific studies. The government will respond as soon as practicable; it will endeavour to respond within 6 months, and not longer than a year. The response will set out clearly any further work required to take forward the recommendations. Recommendations the government agrees should be taken forward will become known as 'endorsed recommendations'. Where the government does not agree with a Commission recommendation, it may put forward an alternative proposal.

"Where the government is responsible for delivering endorsed recommendations, the government's endorsement will be a statement of government policy. Where recommendations have wider implications for the planning regimes, the government will highlight any further steps needed to confirm the endorsed recommendation as planning policy. The government will use the levers at its disposal to deliver endorsed recommendations – whether through spending, regulation, deregulation, market stimulation, or by setting strategic priorities for regulators as appropriate. In some cases, endorsed recommendations will not be directly taken forward by the government, but may be relevant for decisions made by other bodies such as economic regulators."

The Commission will provide support to government as it makes its decisions on the Assessment's recommendations, including as it prepares for the forthcoming Budget and Spending Review, to ensure that the analysis and conclusions in the Assessment are fully understood and any questions are answered accurately.

Monitoring

The Commission has been established as a permanent, independent body, and so has a role in holding the government to account for implementing its recommendations, where they have been agreed. The Commission's framework document states that "the [Commission] will hold the government to account for delivering [Commission] recommendations that the government has endorsed and agreed to take forward."

The Commission will monitor the government's progress in delivering endorsed recommendations, and will comment on this in its Annual Monitoring Report.

Where the recommendations have implications for other bodies, such as economic regulators, the Commission will also comment on the progress made by the relevant bodies.

Further work

The Commission has set out an ambitious set of recommendations in this Assessment. However, in some areas there is still further work to do. Alongside its study programme, which is currently focusing on the future of the UK's freight network, the Commission has identified the following priorities for further work:

- developing the Commission's work on the link between infrastructure and housing
- developing further the work of the design task force to champion design quality in the nation's infrastructure
- addressing the evolution of the regulatory framework and its adaptability to different models of utility service provision
- continuing development of the ideas generated by the Commission's 'Roads for the Future' innovation competition, which concludes in September
- continuing to develop the Commission's performance measures, both by filling gaps – including establishing measures linked to natural capital, design quality and resilience – and by progressively updating the measures set out in Chapter 6 as new approaches are developed or better data becomes available
- continuing work on cost benefit analysis, including developing alternative approaches where current methods perform less well
- developing the analytical framework for the performance evaluation of public private partnership projects.

The Commission also intends to work with a small number of urban authorities to explore how the national strategies set out in this Assessment could inform long term infrastructure planning for cities and city regions.

The second National Infrastructure Assessment

The Commission publishes an Assessment once every five years. Work on the next Assessment will begin as soon as the first is published.

Given that this kind of cross-sector assessment has not been undertaken at a national level before in the UK, as a first step the Commission will carry out a 'lessons learnt' review shortly after the publication of the Assessment, informed by stakeholder views.

Drawing upon the outputs from this review, the Commission will prepare the process and methodology for the next iteration of the Assessment, on which it expects to engage with stakeholders before carrying out a public consultation. Alongside this, it will develop its evidence base and identify the key areas for further research and analysis.

An important priority will be to undertake more in-depth analysis of infrastructure resilience, as previously indicated in the Commission's Process and Methodology consultation.[1] In addition, a number of other areas have been identified, which the Commission will return to in its next Assessment, in the light of developing evidence and technology. They include: the future of heat, as set out in Chapter 2; a national transport strategy that considers the potential changes to travel patterns by road and rail as connected and autonomous vehicles become more widespread, discussed in Chapter 3; the use of data in improving the performance and planning of infrastructure as data is becoming part of infrastructure; surface water, building on the joint plans to manage surface water flood risk to be developed by local authorities and water companies, covered in Chapter 5; and paying for road use, where the Commission will explore new approaches to public engagement to identify options which are fair, sustainable and reduce the negative impacts of driving, covered in Chapter 7.

The second Assessment is expected to be published around 2023.

Endnotes

1 National Infrastructure Commission (2016), National Infrastructure Assessment: Process and methodology consultation

Annex A: Glossary

Term	Meaning
1. Building a digital society	
4G	Fourth generation of mobile systems. 4G provides faster data speeds than previous generations.
5G	The fifth generation of wireless networks beyond 4G mobile networks. 5G is expected to deliver even faster data rates and better user experience, although international standards have not yet been set.
Anti-competitive behaviour	Strategies designed to limit and prevent fair competition, for example predatory pricing and collusion.
Augmented reality	Augmented reality is a technology that overlays computer generated enhancements on the real world.
Broadband	A type of high speed internet connection.
Capital costs or expenditure	Fixed one-time expenses that are incurred upfront, usually when paying for assets such as buildings, construction or equipment (ongoing costs are usually referred to as operational costs).
Clawback mechanism	A special contractual clause which allows money that has already been spent to be paid back under certain conditions.
Connected and autonomous vehicles (CAV)	Connected vehicles can communicate with their surrounding environment. Autonomous vehicles can operate with little or no human input (be driverless) for some, or all, of the journey. Connected and autonomous vehicles can do both.
Deregulation	Deregulation is the removal of regulation, usually with the aim of increasing competition and innovation.
Digital economy	The digital economy refers to the economic activity that is based around digital technologies.
Ducts	A tube or passageway to hold cables, usually underground.
Economic regulation	Economic regulation applies the principles of competitive markets to network industries to achieve greater efficiency and to move away from monopolistic outcomes.
Fair bet	This is a regulatory principle which recognises that an investing firm needs to benefit from sufficient upside potential from any investment to offset the downside risk of failure. The regulator should only impose regulation once a 'fair' return has been made.

Term	Meaning
Gigabit speeds	Download speeds above 1000 megabits per second. 1 gigabit is 1,000 megabits.
Megabits per second (Mbps)	A measure of the rate at which data can be transmitted. One megabit per second is 1 million bits per second (bps). One bit is a single binary digit: 1 or 0
Mobile coverage	The geographic area covered by mobile services.
Openreach	Openreach is the UK's telecoms incumbent network operator. It owns, operates and maintains the UK's main broadband and landline network.
Operating costs or expenditure	Day-to-day spending on running services and maintenance.
Reasonable cost threshold	A reasonable cost threshold is the cost limit at which government will subsidise up to. The costs above this threshold are not deemed reasonable or fair to impose upon taxpayers or billpayers.
Superfast broadband	Broadband services that deliver download speeds of at least 30 megabits per second (mbps).
Ubiquitous connectivity	Digital connectivity everywhere.
Virtual reality	Virtual reality (VR) is an artificial, computer-generated and immersive simulation usually through a headset.
WiFi	A wireless connection which allows devices to connect to the internet.
2. Low cost, low carbon	
Balancing	The processes and systems required to balance supply with demand in the electricity system. A range of technologies can provide balancing services.
Biogas	A gas produced by breaking down organic matter in the absence of oxygen. This gas can be used in a similar manner to natural gas to produce heat or electricity but unlike natural gas, biogas from sustainable sources is a renewable fuel.
Biomass	A renewable fuel of organic material, such as wood, plants or other waste. Biomass can be burned directly or processed into biofuels such as ethanol and methane.
Black bag waste	Black bag waste is household items which cannot be recycled.
Capacity market	In the capacity market the government determines what level of system security is required for four years ahead and then commissions National Grid to calculate the amount of generating capacity that would deliver this. National Grid then runs an auction to procure this capacity at the lowest price.
Carbon capture and storage (CCS)	A process to capture, transport and store carbon dioxide emissions from fossil fuel use. It prevents the carbon dioxide from entering the atmosphere, usually by storing it underground.

Term	Meaning
Climate Change Act	The Climate Change Act, established in 2008, sets legally binding targets to reduce carbon dioxide emissions in the UK by at least 80% by 2050, from 1990 levels.
Decarbonisation	Decarbonisation refers to the removal or reduction of carbon dioxide (a greenhouse gas) from energy sources with the purpose of reducing the impact of climate change.
Deposit Return Scheme	Consumers pay a deposit for an item, such as a single use drink container, which is redeemed on return of the item.
Digestate	Digestate is the solid residue left over from anaerobic digestion which can be used as fertilizer.
Distribution of electricity	The lower voltage (as compared with the transmission of electricity), local, electricity network which is used to deliver electricity to most customers.
Electric vehicle	For the purposes of this report, 'electric vehicles' refers to fully electrified plug-in vehicles that run entirely from an electric battery that must be recharged. This is distinct from hybrid and plug in hybrid vehicles which have both a conventional and an electric motor.
Energy Performance Certificate level C	An Energy Performance Certificate is required for properties when constructed, sold or let. It provides details on the energy performance of the property and what can be done to improve it. The levels range from A-G, A is the most energy efficient whilst G is the least energy efficient.
Energy system	The energy system is the combination and interaction of supply and demand for energy. Energy is used for a range of different activities, such as: transport, heating and powering homes and in industrial processes. Energy is created from a variety of sources including renewables, fossil fuels and nuclear.
Fossil fuel	Fossil fuels are hydrocarbons formed in the earth from biological origin such as coal, oil and natural gas. They are non-renewable and produce greenhouse gases when burnt for energy which cause global warming.
Gasification	Gasification is a process of converting biomass and waste into fuel. It uses little or no oxygen to convert carbon-based materials into synthetic gas which can be used to generate electricity or in place of natural gas.
Greenhouse gas emissions	Greenhouse gases trap heat in the atmosphere which leads to global warming and climate change. Carbon dioxide is the most prevalent of the greenhouse gases and is emitted from activities such as burning fossil fuels.
MW, GW, TW	A watt is a unit of power, which quantifies the rate of energy transfer. A megawatt (MW) is 1,000,000 watts, a gigawatt (GW) is 1,000 megawatts and a terawatt (TW) is 1,000 gigawatts.

Term	Meaning
MWh, GWh, TWh	A watt hour is a measure of energy. It is equal to the total energy delivered by a rate of energy transfer of one watt, provided for one hour. A megawatt hour (MWh) is 1,000,000 watt hours. A gigawatt hour is 1,000 MWh and a terawatt hour is 1,000 gigawatt hours (GWh).
Incinerators	Facilities in which waste is burned in a controlled fashion, either to reduce its volume or its toxicity. Energy from waste plants use incineration of waste to generate electricity, and in some cases heat for domestic or industrial heating.
Interconnector	Electricity interconnectors are physical links which allow the transfer of electricity across country borders. Britain's electricity market currently has links with France, the Netherlands, Northern Ireland and the Republic of Ireland.
Landfill	Area of land where waste is disposed of, either on top or buried.
Load factors	The load factor is the ratio of total energy used in a period to the maximum possible energy use in that period.
Natural gas	Natural gas is a fossil fuel used as a source of energy for heating, cooking, and electricity generation. It is mainly composed of methane, which burns to give carbon dioxide and water vapour.
Nuclear power plant	Power plants make electricity. A nuclear power plant does this through nuclear reactions relying upon uranium (a non-renewable energy source). Nuclear power plants do not emit greenhouse gases but they do produce radioactive waste.
PET	PET (polyethylene terephthalate) is a very common plastic widely used for packaging food and drinks.
Power generation	Power generation refers to the creation of electricity.
Power station	A power station is where electricity is generated.
PVC	PVC (polyvinyl chloride) is a very common plastic used in packaging.
Pyrolysis	The burning of waste in a controlled (oxygen-depleted) environment to generate a combustible gas (syngas).
Recycling	The process of converting waste into reusable material.
Renewable energy	Renewable energy is generated from natural resources, such as sunshine and wind.
Small modular reactor	Small modular reactors generate electricity by a nuclear reaction. These reactors are smaller than conventional nuclear reactors, with power outputs of around 300 MW compared to around 1000 MW or more. No small modular reactors are currently in commercial operation.
Tidal lagoon	A tidal lagoon is a power station which generates tidal power. It is an enclosed area of coastline with a high tidal range which drives turbines and generates electricity.

Term	Meaning
Tidal power	Tidal power is the production of electricity using the ocean's tide. It is a renewable and predictable source of energy.
Transmission of electricity	The high voltage electricity network, used to move electricity long distances across the country.
Wholesale market	Great Britain has a liberalised electricity wholesale market where prices are not set by a regulator. The wholesale market is where retail suppliers, traders and large consumers purchase energy in bulk from those that the generate energy.
3. Revolutionising road transport	
Centre for Connected and Autonomous Vehicles (CCAV)	The organisation which works across government to support the market for connected and autonomous vehicles.
Charge point	A charge point is the infrastructure which supplies the electricity to recharge electric vehicles.
Control Period 6/7	Network Rail, which owns and operates the railway infrastructure in England, Wales and Scotland, has 5-year 'control periods' to decide investment priorities. Control Period 6 and 7 refer to the periods 2019/20-2023/24 and 2024/25-2028/29 respectively.
Freight	Freight is the term used to define the transportation of goods rather than people.
Hybrid vehicle	A hybrid vehicle is one which uses two different energy sources, such as petrol or diesel with electricity.
Internal combustion engine vehicle	An internal combustion engine vehicle is a conventional vehicle which runs by burning a fuel, usually petrol or diesel, inside the engine.
Interoperable	Interoperability refers to the ability of a product or system to operate with other products or systems without any restrictions.
National Grid	A British multinational electricity and gas utility company whose operations include owning and operating electricity transmission network assets and part of the national gas grid
Rapid chargers	Rapid charge points, of 43kW or above, can charge an electric vehicle battery in 20-30 minutes. Some 'fast' chargers, of 22kW, can charge current models of electric vehicle in about an hour.
Road investment strategy (RIS)	The government's investment plans for 5 year periods for the Strategic Road Network of 4,400 miles of motorways and major 'A' roads managed by Highways England. Road investment strategy 1 covers 2015/16-2019/20; Road investment strategy 2 will cover 2020/21 to 2024/25.

Term	Meaning
S-shaped diffusion curve	The diffusion of an innovation is said to follow an S-shaped curve. This involves three phases: slow initial uptake by a few early adopters; uptake rapidly increases as the innovation gains popularity and finally; uptake slows down and levels off as the innovation reaches maturity.
Vehicle to grid	Vehicle to grid systems involve electric vehicles returning power, stored in car batteries, to the electricity grid at peak times.
4. Transport and housing for thriving city-regions	
Brownfield	Brownfield land refers to urban sites that have had previous developments on them but are now vacant, derelict or contaminated.
City	Cities are large urban areas. There is no single definition in use in the UK. Generally, the Assessment uses the 'primary urban area' definition originally established for the State of the English Cities report. Under this definition, there are 63 cities in the UK. This equates to cities with a population of around 110,000 or larger. 'Major cities' refers to the largest UK cities, with a population of around 500,000 or larger (Birmingham, Bristol, Glasgow, Liverpool, Leeds, London, Manchester, Newcastle, Nottingham and Sheffield on a primary urban area definition). However, note that in figure 5.3, the definition of major cities relies on Office for National Statistics rural-urban classification data for 'major' and 'minor' conurbations, which excludes Bristol.
Combined authority	Combined authorities are corporate bodies formed of two or more local government areas.
County council	Many areas in England have two tiers of local government: (1) county councils and (2) district, borough or city councils. County councils cover the whole county and are responsible for services which include transport, education and social care.
Crossrail	Crossrail, also known as the Elizabeth Line, is a new railway running for more than 60 miles from Reading and Heathrow in the west, underneath London and out to Shenfield and Abbey Wood in the east. Crossrail is expected to open at the end of 2018.
Crossrail 2	Crossrail 2 is a proposed new rail line which would run from the south-west to the north-east of London. Construction is expected to start in the early 2020s with the line opening in the early 2030s.
District council	Many areas in England have two tiers of local government: (1) county councils and (2) district, borough or city councils. District councils cover areas within county councils and are responsible for services which include housing and planning applications.
Dockless cycle	Dockless cycle is a service in which bikes can be located, hired and unlocked using a smartphone app and does not require a docking station.
Highways England	The publicly owned organisation which operates, maintains and improves England's 4,400 miles of motorways and major A roads.

Term	Meaning
HS2	High Speed 2 is a planned new high-speed rail network linking London, the West Midlands, Leeds and Manchester. The project is expected to be completed by 2033.
Integrated development plan	A single plan for urban development covering transport, housing and related infrastructure.
Interurban transport	Transport between cities.
Mayoral combined authority	Mayoral combined authorities are corporate bodies formed of two or more local government areas with an elected mayor. There are currently 7 mayoral combined authorities in the UK.
Metro mayor	A metro mayor is a person elected to chair a combined authority with powers to make decisions across the whole city region. There are currently 7 metro mayors in the UK.
Network Rail	Network Rail is the publicly owned organisation which owns and operates the railway infrastructure in England, Wales and Scotland.
Northern Powerhouse Rail	Northern Powerhouse Rail, also known as High Speed 3 (HS3) or Crossrail for the North, is a proposed strategic rail programme to connect the major cities in the North of England.
Transport for London (TfL)	Transport for London is the authority responsible for the transport system in London.
Unitary authority	In some parts of the country, one tier of local government provides all the local services, these are known as unitary authorities.
Urban transport	Transport within cities.
5. Reducing the risks of drought and flooding	
Catchment Flood Management Plans	Catchment Flood Management Plans assess all types of inland flooding from rivers, groundwater, surface water and tidal flooding. Their purpose is to help the Environment Agency and their partners to plan and agree the most effective way to manage flood risk.
Common Agricultural Policy	The Common Agricultural Policy is a European Union system of subsidies and support programmes for agriculture.
Desalination	Desalination is the process of removing salt and other minerals from water.
Drainage and Wastewater Management Plans	Drainage and Wastewater Management Plans are long term plans for drainage and wastewater services. The framework for developing these plans is currently being defined by the 21st Century Drainage Programme.

Term	Meaning
Drought	Drought is defined for this report as a period of such low rainfall that companies have to impose restrictions on households' water supply, by providing water only at certain times of the day or through temporary taps (standpipes) in the streets. The likelihood of a drought occurring is measured by its annual probability. Typically, the lower the chance of a drought occurring, the worse the drought is likely to be. The probabilities mentioned in this report are: 1 per cent annual probability: approximately a 1 in 4 chance of drought by 2050; this is used as a proxy for the worst recorded drought in recent history 0.5 per cent annual probability: approximately a 1 in 7 chance of drought by 2050 0.2 per cent annual probability: approximately a 1 in 17 chance of drought by 2050.
Grey / green infrastructure	Grey infrastructure refers to man-made, constructed assets such as pipes, sewers and dams. Green infrastructure makes use of natural processes to provide infrastructure services, such as wetlands, which can provide flood resilience and wider benefits such as enhancing biodiversity.
Managed retreat	Managed retreat is also known as coastal or defence realignment. It refers to the controlled flooding of a defined area to manage the risk of flooding or coastal erosion in the wider area.
Megalitre per day (Ml/day)	One Megalitre is equal to 1000 cubic metres or 1 million litres.
National water network	Coordinated and strategic transfers to move water between water companies and regions based on their needs.
Price Review	The process undertaken every five years by Ofwat to determine water company price controls for the next five years.
Shoreline Management Plans	Shoreline Management Plans identify the most sustainable approach to managing the flood and coastal erosion risks to the coastline looking up to 100 years ahead.
Surface water	Surface water is rain water that collects on the earth's surface. Surface water flooding occurs when intense rainfall overwhelms the capacity of local drainage systems.
Waste water	Water that has been affected by human use such as flushing and washing.
Water supply	The source, means and process of supplying water for people to use.
Water transfer	Water transfers involve water supply infrastructure to move water from one place to another. They can be made of man-made structures such as pipes and canals or a combination of such structures with rivers or other existing water courses.

Term	Meaning
6. Choosing and designing infrastructure	
Artificial intelligence	The development of machines that can perform tasks normally requiring human intelligence.
Digital twin	A digital model of infrastructure which will be able both to monitor infrastructure in real-time and to simulate the impacts of possible events such as a natural disaster or a new train line.
Hybrid bill	A hybrid bill is a set of proposals for introducing new laws, or changing existing ones. They are generally used to secure powers to construct and operate major infrastructure projects of national importance. Hybrid bills address both public and private matters.
Infrastructure and Projects Authority	The IPA is the government body responsible for supporting the delivery of infrastructure and other major projects, reporting to Cabinet Office and HM Treasury.
Infrastructure Client Group	The Infrastructure Client Group supports the development and exchange of best practice to improve the efficiency of the construction sector and help deliver major cost savings. It is made up of government and industry representatives from the major infrastructure clients.
National Policy Statements	National Policy Statements were established under the Planning Act 2008. They set out national policy for a sector in one place and are intended to provide greater clarity and certainty for the planning process to deliver Nationally Significant Infrastructure Projects.
Nationally Significant Infrastructure Projects	Nationally Significant Infrastructure Projects are large scale developments relating to energy, transport, water, or waste. They require only a single type of planning consent, known as a Development Consent Order, which is designed to be a much quicker process than applying for several individual planning consents separately. This was established under the Planning Act 2008 and amended by the Localism Act 2011.
Natural capital	Natural capital is the 'stock' of natural assets. These include: waters, land, air, species, minerals and oceans
Resilience	The United Nations defines resilience as the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner.
What Works Centre for Local Economic Growth	The What Works Centre for Local Economic Growth was set up in 2013 to analyse which policies are most effective in supporting and increasing local economic growth. It is an independent organisation funded by the Economic and Social Research Council and government.

Term	Meaning
7. Funding and financing	
Capital Gains Tax	Capital Gains Tax is a tax on the profit of the sale of an asset that has increased in value.
Capital markets	The part of the financial system involved in raising long term financing to support investment. It involves the issue and trading of equity (company shares), debt (corporate and government bonds), and other long term financial instruments.
Community Infrastructure Levy (CIL)	A fixed charge based on the development of new floor space. The money can be used to fund infrastructure that is needed as a result of development. It came into force in April 2010.
Economic infrastructure	Economic infrastructure refers to assets which facilitate economic activity such as: transport, energy, digital communications, water supply, waste management and flood risk management.
European Investment Bank (EIB)	The European Investment Bank is the European Union's bank for providing finance and expertise for sustainable investment projects that contribute to EU policy objectives.
Fuel duty	Fuel duty is a tax on petrol, diesel and other fuels used in vehicles or for heating.
Green Investment Bank (GIB)	The UK Green Investment Bank (now the Green Investment Group) was publicly owned, but is now an independent organisation owned by Macquarie Group Limited. The GIB was established in 2010 to increase the UK's ability to meet its environmental targets and commitments by getting green infrastructure projects financed more quickly than would otherwise have been the case.
Housing Infrastructure Fund	The Housing Infrastructure Fund is a government capital grant programme to help unlock new homes in areas with the greatest housing demand. The fund is £5 billion and funds the local infrastructure necessary before homes can be built.
Localism Act 2011	An Act of Parliament which amended powers for local authorities, including housing and planning.
Pooling restrictions	Limits on the number of number of Section 106 agreements which can be used to fund projects or types of infrastructure. According to Regulation 123 of the Community Infrastructure Levy regulations, they must be five or fewer.
Precept	A precept is an additional levy within Council Tax

Term	Meaning
Private finance Initiative (PFI)	The Private finance initiative is a method for the private sector to finance public infrastructure. In the UK, the original private finance initiative has been replaced by 'Private Finance 2'. The private partners invest equity, and take on significant levels of borrowing to finance the upfront costs of infrastructure projects. The project is then leased back to the relevant government body which makes regular payments to the project company, typically over 25 years. More generically, the term 'public private partnership' is used to cover a range of cooperative arrangements between public and private sector bodies, including private finance initiative type arrangements.
Risk-adjusted interest rates	The risk-adjusted interest rate refers to the rate of interest on debt financing that is adjusted to reflect project specific risks, adding a premium to the cost of debt financing.
Section 106 agreements	Legal agreements between local authorities and developers to mitigate the impact of new developments through contributions towards site-specific infrastructure, including affordable housing. They arise from section 106 of the Town and Country Planning Act 1990.
Spending Review 2019	Spending Reviews set out the government's spending plans. The next Spending Review will take place in 2019.
Stamp Duty	Stamp Duty is a tax paid when purchasing a property. It is calculated based on the purchase price of the property.
Whole life cost	The whole life cost is the amount that a product or service costs over its lifetime. It includes the initial capital cost, the costs to run, maintain, repair and upgrade, as well as the eventual disposal costs.

Annex B: Acknowledgements

The Commission is grateful to everyone who has engaged with the National Infrastructure Assessment process. The list below sets out organisations that have engaged with the Commission since publication of its interim report *Congestion, Capacity, Carbon: Priorities for National Infrastructure* through at least one of the following means:

- submitting consultation responses to the interim report
- participating in roundtables
- attending meetings with members of the Commission Secretariat.

Former Commissioners Lord Adonis, Demis Hassabis, Lord Heseltine and Sir Paul Ruddock were all members of the Commission at earlier stages of the Assessment process and contributed to it throughout their tenure.

The Commission would like to thank everyone who responded to earlier consultations (on the Process and Methodology for the Assessment, and the Call for Evidence on the Assessment), commented on the driver papers, and participated in initial workshops and roundtables. The Commission acknowledges the contribution of its expert advisory groups for their input throughout the Assessment process, the Infrastructure Transitions Research Consortium for support with modelling, and the consultants that have been engaged by the Commission and contributed to developing its evidence base.

The Commission is also grateful to those who have engaged with the Assessment in an individual capacity, to officials from across government and to those members of the public that took part in social research workshops and polling.

The Commission would like to acknowledge members of the Secretariat who worked in the Assessment team: Ioannis Andreadis, Matthew Behull, Katie Black, Tom Bousfield, Tom Bradbury, Alexa Bruce, Peter Burnill, Anesu Bwawa, Nathaniel Cowton, Matt Crossman, Manuela Di Mauro, Samuel Downes, Awaritoma Efejuku, Franscesca Fabbri, Jonathan Hale, Ted Hayden, Sarah Hayes, Catherine Jones, Jack Large, Faraz Latif, Bianca Letti, Donna Leong, Greg McClymont, Sharmila Meadows, Chris Newitt, Federica Odifreddi, Sarah Rae, James Richardson, Eric Salem, Dörte Schneemann, Andrea Silberman, Alwyn Spencer, Olivia Stevens, Michael Tran, Siddharth Varma, Tom Wickersham, Stephanie Williams and Ruth Xue.

Organisations engaged

360 Environmental
ABB Group
Adaptation Sub-Committee of the Committee on Climate Change
Adelard LLP
AECOM
Affinity Water
Air Broadband
Airport Operators Association
Alan Turing Institute
Allderdale Borough Council
Allen & Overy
Amey
Anaerobic Digestion and Bioresources Association
Anglian Central Regional Flood & Coastal Committee
Anglian Water
Anthesis Group
Arqiva
Arriva
Ascential
Asian Infrastructure Investment Bank
Association for Consultancy and Engineering
Association for Decentralised Energy
Association for Project Management
Association for the Conservation of Energy
Association of British Insurers
Association of Directors of Environment, Economy, Planning and Transport
Atkins
Atlantic Gateway
Atlantic SuperConnection LLP
Aurora Energy Research
Aviva
BAI Communications
Bath and North East Somerset Council
Biffa
Biofuelwatch
Birmingham City Council
Bit Commons
Blueprint for Water
Borough of Poole
Bournemouth Borough Council
BPP Consulting
Bright Blue
Bristol City Council
British Broadcasting Corporation
British Ceramic Confederation
British Chambers of Commerce
British Glass
British Motorcyclists Federation (Enterprises) Limited
British Plastics Federation
British Ports Association
British Property Federation
British Retail Consortium
British Standards Institute
British Telecom
Broadband for the Rural North Ltd
Broadband Stakeholder Group
Brownsholme Hall
Buckinghamshire Thames Valley Local Enterprise Partnership
Building Research Establishment
Business in the Community
Cabinet Office
Cadent Gas
Cambridge Centre for Smart Infrastructure and Construction
Cambridge Econometrics
Campaign for Better Transport
Campaign to Protect Rural England
Campbell Lutyens

Carbon Capture and Storage Association
Carbon Connect
Carbon Trust
Cardiff Council
Central Bedfordshire Council
Centre for Cities
Centre for Progressive Policy
Centre for Transport Studies, Imperial College London
Centre for Urban and Regional Development Studies, Newcastle University
Chargemaster
Chartered Institute of Highways and Transportation
Chartered Institute of Housing
Chartered Institute of Transport and Logistics
Chartered Institution of Building Service Engineers
Chartered Institution of Civil Engineering Surveyors
Chartered Institution of Wastes Management
Chartered Institution of Water and Environmental Management
Chatham House
Cheshire and Warrington Local Enterprise Partnership
Cheung Kong Hutchison Holdings
Cisco
City and Financial Global
City of Bradford Metropolitan District Council
CityFibre
Clarion Housing Group
Climate Genocide Act Now
Coca-Cola
Commission on Travel Demand
Committee on Climate Change
Committee on Fuel Poverty
Common Futures Network
Community Futures
Community R4C
Compulsory Purchase Association
Confederation of British Industry
Confederation of Paper Industries
Confederation of Passenger Transport UK
Connect Plus
Constructing Excellence in Wales
Construction Industry Research and Information Association
Consumer Council for Water
Core Cities
Cornwall and Isles of Scilly Local Enterprise Partnership
Cornwall Council
Cory Riverside Energy
Country Land & Business Association
Crossrail 2
Cumbria County Council
David Lock Associates
db symmetry
Deloitte
Design Commission for Wales
Design Council
Digital Lancashire
Dorset Local Enterprise Partnership
Drax Group plc
Drinking Water Inspectorate
E.ON UK plc
E3G
East Northants District Council
Eden Council
EDF Energy
EE Limited
EEF Limited
Electric Infrastructure Security Council
Electricity North West
Element Energy

ELEXON
Ellen MacArthur Foundation
Ely Group of Internal Drainage Boards
ENCORE+
Energy & Utilities Alliance
Energy Agency
Energy Insight Limited
Energy Networks Association Limited
Energy Systems Catapult
Energy Technologies Institute
Energy UK
EngineeringUK
Environment Agency
Environmental Change Institute University of Oxford
Environmental Services Association
Essex and Suffolk Water
Essex County Council
Eunomia
European Bank for Reconstruction and Development
European Commission
European Investment Bank
European PPP Expertise Centre
Existing Homes Alliance Scotland
FCC Environment
Federation of Master Builders
FirstGroup plc
Fitch Ratings
Flood Hazard Research Centre Middlesex University
Flood Re
Floow Limited
Food and Drink Federation
Ford
Francis Taylor Building
Freight on Rail
Freight Transport Association
Freightliner Group Limited
Friends of the Earth England, Wales and Northern Ireland
Frontier Economics
FTTH Council
Funding Group for River Thames Flood Alleviation Scheme
Future Cities Catapult
GB Railfreight Limited
Geovation
Gigaclear
Global Change Institute
Global Infrastructure Hub
Global Infrastructure Investor Association
Gloucestershire County Council
Go-Ahead
Greater London Authority
Greater Manchester Combined Authority
Green Alliance
Green Investment Group
Greenpeace
Greenwood Consultants
Hafren Power Limited
Halcyon Tidal Power LLC
Hampshire & Isle of Wight Wildlife Trust
Hampshire County Council
Hastoe Housing Association and Sustainable Homes Limited
Health and Safety Executive
Heart of the South West Local Enterprise Partnership
High Speed Rail Industry Leaders
Highways England
Historic England
Home Builders Federation
Homes England
Horizon Nuclear Power
HR Wallingford
HS2 Limited

Hull City Council
Hutchison 3G UK Limited
Hyperoptic
ifibre
Imperial College London
INCPEN
Independent Networks Cooperative Association
Infrastructure Ontario
Infrastructure Operators Adaptation Forum
Infrastructure Transitions Research Consortium
InLinkUK
Innovate UK
INRIX
Institute for Fiscal Studies
Institute for Government
Institute for Public Policy Research
Institute for Transport Studies
Institute of Asset Management
Institution of Engineering and Technology
Institution of Civil Engineers
Integrated Transport Planning
International Monetary Fund
Ipsos MORI
ITS Technology Group
Jacobs Engineering Group Inc.
Jaguar Land Rover
JBA Consulting
Kent County Council
Kettering Borough Council
Kilbride Rail
Kingspan Insulation Limited
KPMG
Laing O'Rourke
Lancashire Care NHS Foundation Trust
Lancashire County Council
Lancaster & District Chamber of Commerce
Lancaster City Council
Lancaster University
Legal & General
Leicester City Council
Lincolnshire County Council
Liverpool City Region Combined Authority
Living PlanIT
Lloyds Register Foundation
Local Authority Recycling Advisory Committee
Local Government Association
Local Government Association Coastal Special Interests Group
Local Government Flood Forum
Local Government Technical Advisers Group
London and Quadrant Housing Trust
London Councils
London School of Economics and Political Science
Long Term Infrastructure Investors Association
Longbay Seapower Limited
Low Carbon Contracts Company
Luton Borough Council
M&G Investments
Mace
Macquarie Group
Manchester Airports Group
Markides Associates
Marks and Spencer
Mayor of Cambridgeshire and Peterborough
Mayor of Greater Manchester
Mayor of Liverpool City Region
Mayor of London
Mayor of the Tees Valley

Mayor of the West Midlands
Mayor of the West of England
Merseytravel
Met Office
Metronet UK (now M24Seven)
Middlesex University
Midlands Connect
Milton Keynes Council
Mineral Products Association
Mineral Wool Insulation Manufacturers Association
Ministry for the Economy and Finances (France)
Ministry of Transport & Communications (Norway)
Mitsubishi UFJ Financial Group
Mobile UK
Motorcycle Industry Association
Mott MacDonald
MWH Global
National Association of Waste Disposal Officers
National Audit Office
National Energy Action
National Farmers Union
National Flood Forum
National Grid
National Infrastructure Planning Association
National League of Cities
National Nuclear Laboratory
Natural Capital Committee
Natural Energy Wyre
Natural England
NERA Economic Consulting
Nesta
Network Rail
New Civil Engineer
Newcastle City Council
Newcastle University
Nexus
Nissan
North East Combined Authority
North West Business Leadership Team
Northamptonshire County Council
Northern Gas Networks
Northern Ireland Executive
Northern Ireland Fuel Poverty Coalition
Northumberland County Council
Northumbrian Water
Norton Rose Fulbright
Nottingham City Council
Nuclear Industry Association
O2
Ofcom
Office of Road and Rail
Ofgem
Ofwat
Old Oak and Park Royal Development Corporation
OMEGA Centre
Openreach
Orbit Group Limited
Ordnance Survey
Organisation for Economic Co-operation and Development
Ørsted
Packaging Federation
Peabody
Peel Energy
Peel Land and Property
Pegasus Group
Pennon Group
Pensions Infrastructure Platform
Pinsent Masons
Pipe Jacking Association
Plymouth City Council
Policy Connect
Policy Exchange

Pöyry
Prism Consulting Group LLC
Proctor and Gamble
Prospective
RAC Foundation
RAC
Radioactive Waste Management
Rail Delivery Group
Rail Freight Group
Railway Industry Association
Recycling Technologies
Regulatory Economics
Renewable Energy Association
Resource and Waste Solutions Partnership
Resource Futures
Resources and Waste UK
Ricardo
Risk Management Solutions
Road Haulage Association Limited
Rod Rainey & Associates Limited
Rolls Royce
Royal Academy of Engineering
Royal Institution of British Architects
Royal Institution of Chartered Surveyors
Royal Society
Royal Society for the Protection of Birds
Royal Town Planning Institute
RWE Generation UK
SAID Business School
Savills plc
Sayers and Partners
Scottish and Southern Energy Enterprise
Scottish Association for Public Transport
Scottish Carbon Capture & Storage
Scottish Environment Protection Agency
Scottish Federation of Housing Associations
Scottish Futures Trust
Scottish Government
Scottish Power
Severn Trent Water
SGN
Sheffield City Region
Shropshire Council
Siemens
Skanska
Sky
Smarter Cambridge Transport
Society of Motor Manufacturers and Traders
South East England Councils
South East Essex Action Group Alliance
South East Water
South Gloucestershire Council
South West Water
South Yorkshire Passenger Transport Executive
Southern Water
SSE
Stagecoach
Steer Davies Gleave
SUEZ UK
Surrey County Council
Sustainable Energy Association
Sustrans
Sweco
Swindon Borough Council
Tactis
TalkTalk
Tantalum Corporation
Tarmac
Taylor Wimpey
Tech UK
Technical University Bergakademie Freiberg
Tees Valley Combined Authority
Teesside Collective
Tesco

Thames Water
The Infrastructure Forum
The Law Society of England and Wales
The Society for Poole
Three
Tidal Lagoon
Tolvik Consulting
Town and Country Planning Association
Trades Union Congress
Transition Town Brixton
Transport for Greater Manchester
Transport for London
Transport for the North
Transport for West Midlands
Transport Research Laboratory
Transport Systems Catapult
TravelWatch NorthWest
Trees and Design Action Group
Turner & Townsend
UCL Institute for Innovation and Public Purpose
UK Broadband Limited
UK Collaboratorium for Research on Infrastructure and Cities
UK Energy Research Centre
UK Green Building Council
UK Power Networks
UK Rainwater Management Association
UK Regulators Network
UK Water Industry Research
Unilever
Uniper SE
United Kingdom Onshore Oil and Gas
United Kingdom Without Incineration Network
United Utilities
University College London
University of Cambridge
University of Edinburgh
University of Exeter Energy Policy Group
University of Glasgow
University of Hull
University of Leeds
University of Manchester
University of Northampton
University of Oxford
University of Sheffield
University of Sussex Science Policy Research Unit
Urban Transport Group
Urban Water Cycle Solutions
Urbed
Urenco
Valpak
Vattenfall
Veolia
Virgin Media
Viridor
Vivid Economics
Vodafone
Waste and Resources Action Programme
Water Resources East
Water Resources in the South East
Water UK
Waterscan
Waterwise
Welsh Government
West of England Combined Authority
West Yorkshire Combined Authority
Westinghouse Electric Company LLC
Westminster Energy Environment & Transport Forum
Westminster Energy Forum
Wheels for Wellbeing
Wildfowl & Wetlands Trust
Wildlife and Countryside Link
Wiltshire Council
Wood Plc
Woodland Trust

WSP Global
WWF
Yorkshire Water
Zero Carbon Futures
ZTE Corporation

Annex C: Supplementary documents

The Commission has produced or commissioned the reports listed below as part of the analysis supporting the National Infrastructure Assessment. All reports are available on the Commission's website or will be when published.

National Infrastructure Commission reports

National Infrastructure Assessment impact and costings notes, July 2018

Technical annex: Analysis of drought resilience, July 2018

Technical annex: Flood modelling, July 2018

Technical annex: Energy and fuel bills today and in 2050, July 2018

Technical annex: Tidal power, July 2018

Technical annex: Power system effects of electric vehicles, July 2018

Technical annex: Proposed analytical framework for evaluating the performance of private financing and traditional procurement, July 2018

Preparing for a drier future: England's water infrastructure needs, April 2018

Congestion, Capacity, Carbon – Priorities for National Infrastructure, October 2017

Congestion, Capacity, Carbon – Modelling annex, October 2017

Congestion, Capacity, Carbon – Modelling annex data, October 2017

The impact of the environment and climate change on future infrastructure supply and demand, June 2017

Economic growth and demand for infrastructure services, March 2017

The impact of population change and demography on future infrastructure demand, December 2016

The impact of technological change on future infrastructure supply and demand, December 2016

National Infrastructure Assessment: Call for evidence, October 2016

The National Infrastructure Assessment process and methodology: Consultation response, October 2016

Annex: Responses to National Infrastructure Assessment process and methodology consultation overview, October 2016

National Infrastructure Assessment process and methodology: a consultation, May 2016

Reports commissioned for the Assessment

Institute for Fiscal Studies (forthcoming), Property Value Uplift Tool

Arup (July 2018), Congestion, Capacity, Carbon: priorities for national infrastructure, report on consultation responses

Ipsos MORI (July 2018), National Infrastructure Commission phase 2: public research

Anthesis Consulting (July 2018), Waste infrastructure analysis for England

Atkins (July 2018), Analysis of the costs of emergency response options during a drought

Aurora Energy Research (July 2018), Power sector modelling: system cost impact of renewables

Energy Systems Catapult (July 2018), Electric vehicle charging cost analysis

Eunomia (July 2018), Comparative study of national infrastructure financing institutions

Gibbons and Graham (July 2018), National Infrastructure Commission urban capacity economic analysis.

JBA Consulting (July 2018), Flood standards of protection and risk management activities

Lomax and Smith (July 2018), Effect of capacity constraints on population and employment distribution

Prospective (July 2018), Transport connectivity

Publica (July 2018), Design Task Force, Design and Infrastructure – Sector review of attitudes

Publica (July 2018), Design Task Force, Developing design principles for national infrastructure

Regulatory Economics (July 2018), Analysis of the costs of water resource management options to enhance drought resilience

Steer Davies Gleave (July 2018), Urban transport network review

Expedition Engineering and Marko&Placemakers (July 2018), Design Task Force, The value of design in infrastructure delivery

Vivid Economics (July 2018), The role and impact of the EIB and GIB on UK infrastructure investment

Element Energy (May 2018), Cost analysis of future heat infrastructure options

Arup and University College London (December 2017), Infrastructure and digital systems resilience, literature review

Arup and University College London (December 2017), Infrastructure and digital systems resilience

Frontier Economics (December 2017), Future benefits of broadband networks

Tactis and Prism Business Consulting (December 2017), Costs for digital communications infrastructures

Simpson and Ives (November 2017), Scenarios of future water availability in the UK

BritainThinks (October 2017), National Infrastructure Commission report from citizen research

Arup (October 2017), International infrastructure governance report

Cambridge Economic Policy Associates (October 2017), Financing for infrastructure summary report

Cambridge Economic Policy Associates (October 2017), Review of the UK infrastructure financing market

Cambridge Economic Policy Associates (October 2017), UK infrastructure pipeline analysis

JBA Consulting, SDG Economic Development, Temple and GreySky (October 2017), National Infrastructure Commission, performance measures

International Transport Forum (March 2017), Strategic infrastructure planning; international best practice

Annex D: Recommendations

1. Building a digital society

The Commission recommends that government should set out a nationwide full fibre connectivity plan by spring 2019, including proposals for connecting rural and remote communities. This should ensure that full fibre connectivity is available to 15 million homes and businesses by 2025, 25 million by 2030 with full coverage by 2033. To achieve these targets:

- Ofcom should promote network competition to drive the commercial rollout of full fibre, by deregulating where competition is effective and guaranteeing a fair bet on risky investments before regulating any uncompetitive areas.
- Government should part subsidise rollout to rural and remote communities, beginning by 2020, starting with the hardest to reach areas and community self-build.
- Government and Ofcom should allow for copper switch-off by 2025.
- Government and Ofcom should take action to cut the cost of full fibre deployment including:
  - Government should ensure the processes for obtaining wayleaves and connecting new builds are the same for digital infrastructure as other utilities by 2019.
  - Local government should designate 'digital champions' to improve telecoms processes such as street work permissions and access to publicly owned assets.
  - Ofcom should monitor the accessibility of Openreach's duct and pole infrastructure by levels of usage.

2. Low cost, low carbon

The Commission recommends that government should set out a pipeline of pot 1 Contracts for Difference auctions, to deliver at least 50 per cent renewable generation by 2030, as part of the transition to a highly renewable generation mix. Government should:

- Move technologies that have recently become cost competitive, such as offshore wind, to pot 1 following the next Contracts for Difference auction in Spring 2019. Pot 1 should be used for the overwhelming majority of the increase in renewable capacity required.

- Publish indicative auction dates and budgets for the next decade by 2020.
- Over time take whole systems costs into account in Contracts for Difference auctions, as far as possible.
- Consider whether there is a case for a small-scale, pot 2 auction in the 2020s, if there are technologies which are serious contenders for future pot 1 auctions.
- Not agree support for more than one nuclear power station beyond Hinkley Point C, before 2025.

The Commission recommends that government needs to make progress towards zero carbon heat:

- Establishing the safety case for using hydrogen as a replacement for natural gas, followed by trialling hydrogen at community scale by 2021.
- Subject to the success of community trials, launching a trial to supply hydrogen to at least 10,000 homes by 2023, including hydrogen production with carbon capture and storage.
- By 2021, government should establish an up to date evidence base on the performance of heat pumps within the UK building stock and the scope for future reductions in the cost of installation.
- Set a target for the rate of installations of energy efficiency measures in the building stock of 21,000 measures a week by 2020, maintained at this level until a decision on future heat infrastructure is taken. Policies to deliver this should include:
    - Allocating £3.8 billion between now and 2030 to deliver energy efficiency improvements in social housing.
    - Government continuing to trial innovative approaches for driving energy efficiency within the owner occupier market.
    - Government setting out, by the end of 2018, how regulations in the private rented sector will be tightened and enforced over time.

The Commission recommends that government should set a target for recycling 65 per cent of municipal waste and 75 per cent of plastic packaging by 2030. Government should set individual targets for all local authorities and provide financial support for transitional costs. The government should establish:

- Separate food waste collection for households and businesses (to enable production of biogas) by 2025.
- Clear two symbol labelling (recyclable or not recyclable) across the UK by 2022.
- A consistent national standard of recycling for households and businesses by 2025.

- Restrictions on the use of hard-to-recycle plastic packaging (PVC and polystyrene) by 2025.
- Incentives to reduce packaging and for product design that is more easily recyclable by 2022.
- A common data reporting framework for businesses handling commercial and industrial waste by the end of 2019, ideally through voluntary reporting but if necessary by legislation.

3. Revolutionising road transport

The Commission recommends that government, Ofgem and local authorities should enable the roll out of charging infrastructure sufficient to allow consumer demand to reach close to 100 per cent electric new car and van sales by 2030. Government should address the implications of technological innovation in long term transport planning processes, including the next rail control period and road investment strategy.

- Ofgem should take on the role of regulating the interaction between electric vehicle charge points and the electricity network immediately, ensuring that electric vehicle charging and vehicle to grid services contribute to the optimisation of the energy system. Government, industry and Ofgem should work together to set minimum standards for a network of interoperable, smart charge points.
- Ofgem should commission electricity network operators to work with charge point providers to identify potential anticipatory investments required to accommodate public charging infrastructure. Opportunities for investment within the current price control period should be identified by Summer 2019.
- Government should place a requirement on local authorities to work with charge point providers to allocate 5 per cent of their parking spaces (including on-street) by 2020 and 20 per cent by 2025 which may be converted to electric vehicle charge points.
- Government should subsidise, by 2022, the provision of rapid charge points in rural and remote areas, where the market will not deliver in the short term.
- Government should establish a centre for advanced transport technology in the Department for Transport to bring together work on technological innovation and ensure its implications are central to future investment proposals. This should include developing and overseeing the Commission's proposed connected and autonomous vehicles framework.

4. Transport and housing for thriving city regions

The Commission recommends that government should make £500 million a year of funding available from 2025/26 to 2034/35 for local highways authorities to address the local road maintenance backlog.

The Commission recommends that cities should have the powers and funding they need to pursue ambitious, integrated strategies for transport, employment and housing.

- By 2021, metro mayors and city leaders should develop and implement long term integrated strategies for transport, employment and housing that will support growth in their cities.
- By 2021, government should ensure city leaders have the right powers to deliver these integrated strategies, including the power for metro mayors to make decisions on major housing development sites.
- Government should set out devolved infrastructure budgets for individual cities for locally determined urban transport priorities in line with the funding profile set out by the Commission. Budgets for 2021-2026 should be confirmed by mid 2019. Government should pass legislation, by 2020, requiring cities to be given regular five year infrastructure budgets.
- Government should allocate significant long term funding for major capacity upgrades in selected growth priority cities, in line with the funding profile set out by the Commission. Cities benefiting from major projects should make commitments on housing delivery and provide at least 25 per cent of funding. Priority cities should be identified by mid 2019, with long term investment commitments agreed by 2020. Future rounds should take place no more than twice a parliament.

5. Reducing the risks of drought and flooding

The Commission recommends that government should set out a strategy to deliver a nationwide standard of resilience to flooding with an annual likelihood of 0.5 per cent by 2050 where this is feasible. A higher standard of 0.1 per cent should be provided for densely populated areas where the costs per household are lower. To deliver the strategy:

- By the end of 2019, government should put in place a rolling 6 year funding programme in line with the funding profile set out by the Commission. This should enable efficient planning and delivery of projects and address the risks from all sources of flooding.
- The Environment Agency should update plans for all catchments and coastal cells in England before the end of 2023. These should identify how risk can be managed most effectively using a combination of measures

including green and grey infrastructure, spatial planning and property level measures.

- Water companies and local authorities should work together to publish joint plans to manage surface water flood risk by 2022.
- The Ministry of Housing, Communities and Local Government and planning authorities should ensure that from 2019 all new development is resilient to flooding with an annual likelihood of 0.5 per cent for its lifetime and does not increase risk elsewhere.

The Commission recommends that government should ensure that plans are in place to deliver additional supply and demand reduction of at least 4,000 Ml/day. Action to deliver this twin-track approach should start immediately:

- Ofwat should launch a competitive process by the end of 2019, complementing the Price Review, so that at least 1,300 Ml/day is provided through (i) a national water network and (ii) additional supply infrastructure by the 2030s.
- The Department for Environment, Food and Rural Affairs should set an objective for the water industry to halve leakage by 2050, with Ofwat agreeing 5 year commitments for each company (as part of the regulatory cycle) and reporting on progress.
- The Department for Environment, Food and Rural Affairs should enable companies to implement compulsory metering by the 2030s beyond water stressed areas, by amending regulations before the end of 2019 and requiring all companies to consider systematic roll out of smart meters as a first step in a concerted campaign to improve water efficiency.

6. Choosing and designing infrastructure

The Commission recommends that government should publish good quality data on infrastructure costs and performance. All public bodies taking decisions on strategic economic infrastructure should publish the forecast costs and benefits of their major infrastructure projects at each appraisal stage and at a suitable point after completion, by the end of 2019. The Infrastructure and Projects Authority should work with departments to ensure that costs are comparable between sectors.

The Commission recommends that design should be embedded into the culture of infrastructure planning, to save money, reduce risk, add value, support environmental net gain and create a legacy that looks good and works well, by:

- Government ensuring that all Nationally Significant Infrastructure Projects, including those authorised through hybrid parliamentary bills, have a board level design champion and use a design panel to maximise the value provided by the infrastructure.

- Design panels for nationally significant infrastructure projects having regard to design principles to be published by the National Infrastructure Commission based on advice received from the national infrastructure design group.

7. Funding and financing

The Commission recommends that government should deliver long term certainty over infrastructure funding by adopting the funding profile set out in the 'fiscal remit' table in Spending Review 2019 and other future spending plans.

The Commission recommends that government should maintain access to the European Investment Bank if possible. If access is lost, a new, operationally independent, UK infrastructure finance institution should be established by 2021. To enable this, government should consult on a proposed design of the new institution by Spring 2019. The consultation should cover:

- Functions, including provision of finance to economic infrastructure projects in cases of market and coordination failures; catalysing innovation; and acting as a centre of excellence on infrastructure project development, procurement and delivery.
- A clear mandate, including sound banking, additionality and having a wider economic and social impact.
- Governance to safeguard the operational independence of the institution.

The Commission recommends that local authorities should be given further powers to capture a fair proportion of increases in the value of land from planning and infrastructure provision. To enable this, government should:

- Remove pooling restrictions on Section 106 in all circumstances, through forthcoming secondary legislation by 2020.
- Remove the ballot requirement for upper tier authorities' powers to levy a business rate supplement of 2p or less in the pound for infrastructure, except where the supplement exceeds one third of scheme costs by 2021.
- Give local authorities powers to levy zonal precepts on council tax, where public investments in infrastructure drive up surrounding property values by 2021.
- Provide greater certainty in compulsory purchase compensation negotiations by including independent valuations early in the process to be paid for by the acquiring authority by 2021.


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Appendices SE.1

Question SE.1.29

POPE___Meta_2015_Final_210116_-_FINAL

Post Opening Project Evaluation (POPE) of Major Schemes

Main Report

Meta-analysis 2015

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Executive Summary

Highways England (and its predecessor the Highways Agency) is responsible for operating, maintaining and improving England's strategic road network. One its roles is to deliver improvements through investment in the **Major Schemes Programme**, which covers improvements to the strategic road network costing more than £10m. In the Road Investment Strategy published in 2015, the Government committed to investing £15 billion in strategic roads to 2021. This financial responsibility requires Highways England to have the tools available to support effective investment decision making.

Post Opening Project Evaluation (POPE) studies are undertaken for all of the Highways Agency's and now Highways England's Major Schemes. The key objective of POPE is to identify the extent to which the expected impacts of highway schemes have materialised and to inform thinking on current and future national scheme appraisal methods. POPE also forms the mechanism whereby Highways England can determine:

- The extent to which Major Schemes offer value for money; and
- The level of accuracy associated with estimates of costs and predictions of benefits emerging from Major Schemes and the main factors affecting the accuracy.

POPE studies are undertaken for each Major Scheme one and five years after opening. The purpose of this report is to review the whole programme and identify emerging trends in relation to Major Scheme impact and scheme appraisal accuracy. Key points relating to the sample used in this study are as follows:

81	Major Schemes which predominantly opened between 2002 and 2012 provide the evidence base for this Meta-analysis study.
73%	Of these schemes are at the five year after evaluation stage, with 23% of schemes represented at the one year after opening evaluation stage.
1	Smart Motorway is included in the sample. Other smart motorways built by Highways England have not yet entered the POPE process. The remaining schemes are Bypasses (32), widening (25), junctions (16) and upgrade from A road to motorway (4).

This **Meta-analysis** is structured around a number of key questions. The remainder of this Executive Summary is split into 6 sections presenting the key findings relating to each of these lines of enquiry, together with the associated page number in the main report in order to find further detail.

- **Scheme objectives** – Presents results to identify whether the Programme of Major Schemes is achieving its objectives.
- **Traffic** – Presents the impacts of schemes on traffic flows, journey times and journey time reliability, and compares them to forecast.
- **Safety** – Presents the impacts of Major Schemes on the numbers of collisions and compares the impacts to those forecast.
- **Economy** – Presents the outturn economic results and compares them against forecast, together with an assessment of whether Major Schemes are delivering value for money.
- **Environment** – Presents a comparison of forecast vs outturn impacts for the environment objectives together with a consideration of a number of specialist topics of interest to Highways England.
- **Further Analysis** – Presents the findings from detailed investigations of a number of specialist areas.

Scheme Objectives

Are scheme-specific objectives being achieved?

Major Schemes are successful at delivering against their scheme-specific objectives with 93% of objectives being achieved for all schemes and only 2% not achieved. The remainder are either partially achieved (4%) or have insufficient evidence at this stage.

This finding is consistent across all scheme types. A greater proportion of scheme objectives have been achieved at the five year after opening stage when compared to the one year after opening stage.

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Traffic

Do Major Schemes improve journey time reliability?

New bypasses, widening schemes and schemes upgrading A-roads to motorways significantly improve journey time reliability, with bypass schemes showing the greatest improvements.

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Are Highways England traffic models accurately predicting traffic volumes?

A majority (68%) of schemes accurately forecast traffic flows (to within +/-15%), but there is much variability in accuracy between schemes.

There is evidence to suggest that the accuracy of traffic forecasting has improved over time.

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Are Highways England traffic models accurately predicting journey times?

The limited forecast data available indicates that recorded peak hour journey time savings are lower than forecast. Journey time forecasts are more accurate for less congested periods, such as inter-peak and off peak, when compared to busy peak periods.

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Does more complex traffic modelling improve forecasting accuracy?	
Modelling guidance has changed to encourage consideration of the impact road schemes have on the demand for travel. Use of 'elasticity models' has improved forecasting accuracy compared to fixed demand models. There are currently too few variable demand models to draw any conclusions as to any advantage over elasticity models	**Page** **50**

Is there evidence of induced traffic?	
Sometimes road improvements can lead to more people travelling. This is phenomenon is referred to as 'induced traffic'. The majority of schemes, of all types, do not appear to have induced traffic. It should be noted that the lack of induced traffic in recent years may be due to the economic downturn. The reduced background traffic growth may also have masked any induced traffic.	**Page** **53**

Is there evidence of a change in peak spreading?	
The limited data available on peak spreading shows a reduction for the majority of schemes. However, the general rerouting of traffic onto the schemes from other routes, increasing traffic flows for all hours, can mask a reduction in peak spreading.	**Page** **55**

Safety

What impact do Major Schemes have on the number of collisions?	
The sample size available is too small to draw meaningful conclusions. However, there is evidence to suggest that: • Major Schemes with a statistically significant impact on collisions are successful at reducing the numbers of collisions. • Bypass schemes are the most successful type of scheme in terms of improving safety.	**Page** **58**

How accurate are safety predictions?	
Accuracy of collision safety predictions is poor. Less than half of schemes have collision savings within 50% of the prediction.	**Page** **63**

What are the changes in observed collision rates and how does that compare to forecast?

Major Schemes which have involved improvements to A roads have seen a considerable decrease in the collision rate.

Motorways typically have low collision rates compared to other types of road. Major schemes involving improvements to motorways have resulted in little change to these rates. The DfT collision rate forecasts for four lane motorways are broadly in line with those observed.

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Economy

What are the main benefits of Major Schemes?

Journey time benefits are the key monetary benefits derived from Major Schemes, accounting for 79% of all monetary benefits. Safety benefits (as measured by reductions in numbers of injury collisions) form the second largest contribution.

The average total monetary benefit for schemes appraised over the standard 60 years is £117.5million, and £86.7million for schemes appraised over 30 years.

Other impacts which are appraised using a monetary value, positive or negative, include changes to the users' vehicle operating costs, indirect tax impact for the Treasury, and cost of delays during construction and future maintenance periods. In total, these average only an average 1% net impact.

The Treasury is expected to benefit from many schemes through a net increase in indirect tax revenue but, on average, this impact is less than £1million.

Widening schemes have substantially higher average total benefits per scheme than bypass and junction schemes. However, the greatest benefits are seen in the four schemes which were an upgrade to motorway and the one smart motorway scheme; all of these where larger schemes. Safety benefits are the highest for bypass schemes which is due to these types of scheme including the greatest step change in road standard.

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How accurate is the forecasting of Major Scheme benefits?

Benefits arising from journey time savings are moderately accurate for most schemes. 28% of schemes have journey time benefits within 15% of that forecast and 74% of schemes are within 50%.

Safety benefit forecasts, however, are inaccurate for the majority of schemes with only a third having outturn benefits within 50% of forecast.

Net change in Vehicle Operating Costs and indirect tax impacts are mostly lower than forecast.

There is some indication of an improvement in benefit forecasting accuracy since 2000.

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How accurate is the forecasting of Major Scheme costs?

Half of the Major Schemes had estimated costs in the business case within 15% of the outturn cost.

Since 2004, accuracy of cost estimating in scheme appraisal has been consistently improving.

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What is the average cost of a Major Scheme?

Major Schemes cost £39.5million on average and 60% of schemes costs below £50m.

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Are Major Schemes offering value for money?

Post opening evaluation shows that the average Benefit Cost Ratio of major schemes is 2.7, which means that on average, for every £1 spent on the scheme, the return will be £2.70 in long term economic benefits.

73% of schemes achieved high value for money and 88% achieved medium or high value for money. A scheme is high value for money if the benefits are over double the cost.

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Has value for money improved over time?

In recent years, from 2008 onwards, the proportion of schemes achieving high value for money has improved compared with that seen in the earlier part of the decade.

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Do value for money assessments vary between Highways England's regions?

There is no evidence in the outturn value for money assessments of Major Schemes differing between the regions.

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Are Major Schemes stimulating economic development?

There is anecdotal evidence to show that Major Schemes have assisted local and regional economic development through congestion reduction and improved journey time reliability which provides improved access to potential employment centres.

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Environment

How accurate are the forecasts for the environmental sub-objectives?

An evaluation of the performance of each environment sub-objective against the forecast impact shows that overall:

- 70% of environmental sub-objectives are 'as expected'.
- 16% of environmental sub-objectives are 'better than expected'.
- 13% of environmental sub-objectives are 'worse than expected'.

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What are the carbon impacts of Major Schemes?

The majority of Major Schemes result in increased carbon emissions in the opening year. However, in general the observed carbon impact is lower than forecast

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Is Highways England successfully maintaining biodiversity mitigation areas?

Biodiversity mitigation measures have generally been provided for all schemes considered in this meta-analysis. For 44% of schemes, certain elements of mitigation would appear not to have been provided, were no longer required post Environmental Statement, had been slightly amended to suit site conditions, were underestimated or design issues were raised.

Monitoring was available for 57% of schemes.

Based on the site visits for POPE and information provided within the landscape evaluations, it would appear that habitats such as grasslands, woodlands and hedgerows are establishing. These evaluations are based on visual confirmation during POPE site visits and, when available, ecological surveys/reports received. Maintenance and management is generally being undertaken appropriately.

For fauna, issues tend to be scheme-specific caused by vandalism/damage, poor maintenance/management, slow establishment or lack of clarity on responsibilities for the specific features.

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How successful is Highways England in mitigating the landscape and townscape impacts of Major Schemes?

Overall 80% of schemes assessed show that overall landscape objectives set in the ES are set to be achieved. It is noted that when compared with the Meta-analysis 2013 (84%) and Meta-analysis 2010 (93%), a reduction in target achievement is evident.

This evaluation identifies deterioration in landscape scheme target achievements when compared with ES predictions of impacts. It also serves to highlight issues within individual schemes that impact upon growth target achievements.

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Performance of schemes against targets set in their ESs is as follows:

- 7% of schemes had landscape impacts which were ‘better than expected’;
- 73% of schemes had landscape impacts which were ‘as expected’; and
- 20% of schemes had landscape impacts which were ‘worse than expected’.

Additionally, this section confirms that the use of locally appropriate materials within schemes where traditional resources identify location and history makes a positive contribution to scheme design and is generally welcomed by local councils and residents.

Assessment of the impact of schemes on designated sites confirms that 45 (56% of 81 schemes) schemes assessed for this Meta-analysis are located within or adjacent to designated landscapes which have included national designations such as National Parks or Areas of Outstanding Natural Beauty (AONB), greenbelt, historic parks and gardens or historic landscapes, as well as areas designated at a local level such as Areas of Great Landscape Value.

Finally, this section confirms that townscape/streetscape initiatives undertaken particularly during de-trunking and as included in the ES design are generally well received when returning a previously congested urban space to a more locally appropriate village/town.

Further Analysis

Are local communities satisfied with Major Schemes?

Local communities are generally satisfied with Major Schemes with 65% of questionnaire respondents (across 15 schemes) either agreeing or strongly agreeing that the scheme had made their community a better place to live.

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How long does Highways England Major Scheme appraisal take?

The average duration of Major Scheme appraisal is just over four years (for schemes with a construction start date between 2004 and 2009), although there is a wide variety between individual schemes.
There has been little change in the duration of scheme appraisal between 2004 and 2009.

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How accurate are the forecasts for the accessibility objective?

Accessibility is concerned with increasing the ability with which people in different locations and with differing availability of transport can reach different types of amenities such as places of education, worship, leisure, healthcare and employment.

90% of schemes were evaluated ‘as expected’ for accessibility.

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How accurate are the forecasts for the integration objective?

Integration is concerned with ensuring that all decisions are taken in the context of the Government’s transport policy at the time of the scheme appraisal.

89% of schemes were evaluated ‘as expected’ for integration.

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Table of Contents

1. Introduction

1.1 What is Post Opening Project Evaluation and why is it important?

Highways England is responsible for operating, maintaining and improving England's strategic road network. Prior to April 2015, it was an executive agency of the Department for Transport, the Highways Agency. The government has recently launched its first '**Road Investment Strategy**' (December 2014). These documents set out an ambitious, long term programme for the motorways and major roads in England with investment of over £15billion to 2021. The aim is to:

- Provide a **world class strategic network**
- Reduce **congestion**
- Support jobs and **economic growth**
- Improve road **safety**
- Minimise any negative impact on the **environment**.

One of the mechanisms for Highways England to achieve the above objectives is through investment in the **Major Schemes Programme**, which covers improvements to the strategic road network costing more than £10m. In the Road Investment Strategy published in 2015, the Government committed to investing £15 billion in strategic roads to 2021. This financial responsibility requires Highways England to have the tools available to support effective investment decision making.

All Highways England Major Projects are subject to a rigorous planning and appraisal process in order to demonstrate that the scheme is viable, delivers long term economic benefits, and minimises any impact on the environment and surrounding communities. The traffic impacts of Major Schemes are estimated using computer models. The outputs from these models are then used to predict the economic impact of major schemes.

Post Opening Project Evaluation (POPE) studies are undertaken for all of the Highways Agency's and now Highways England's Major Schemes and this was required by the DfT's Strategic Road Network Performance Specification 2013 to 2015. The key objective of POPE is to identify the extent to which the expected impacts of highway schemes have materialised and to inform thinking on current and future national scheme appraisal methods. POPE also forms the mechanism whereby Highways England can:

- **Meet HM Treasury's Green Book requirements** (and Magenta Book guidance)
- **Support the DfT's *'Monitoring and Evaluation Strategy'.***
- Give confidence in appraisal methods
- **Identify improvements** that could be made in appraisal and identify examples of **best practice.**
- Give **accountability** to stakeholders regarding commitments made at Public Inquiry
- Promote **transparency**.

For simplicity, this report uses the name Highways England throughout to include the Highways Agency and Highways England.

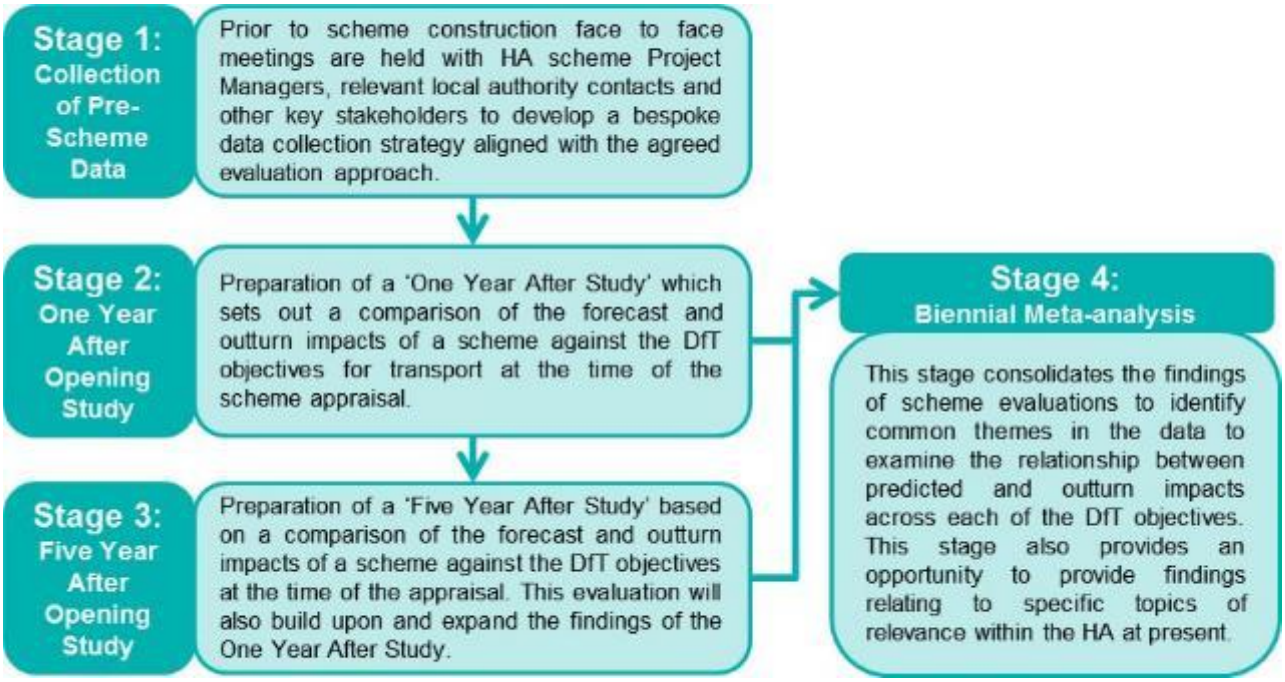
1.2 How are POPE results used?

By undertaking post opening evaluation and openly reporting findings (all evaluation studies are published online), Highways England and the DfT are making the outcomes of the Major Schemes Programme transparent to the public. Specific scheme lessons are fed into Highways England's dissemination processes to be shared by project staff. Highways England maintains a list of all the issues raised by POPE and track its response to them. Often, the follow up is in the form of giving feedback, either about issues or good practice to project managers and specialists.

1.3 What is the approach to POPE?

There are four key stages to the POPE process which are illustrated in Figure 1-1. Stage 4, the Biennial Meta-analysis is this report.

Figure 1-1 Approach to the POPE of Major Schemes



1.4 Structure of the POPE Meta-analysis

Following this introduction, this report is brown down into a further 7 sections and appendices:

- **Section 2:** Data Collection and Availability (page 14);
- **Section 3:** Scheme Objectives (page 19);
- **Section 4:** Traffic (page 23);
- **Section 5:** Safety (page 57);
- **Section 6:** Economy (page 69);
- **Section 7:** Environment (page 96);
- **Section 8:** Further Analysis (page 141);

- **Appendix A:** Environment Issues (page 148);
- **Appendix B:** Glossary (page 153);
- **Appendix C:** List of Tables and Figures (page 157);

2. Data Collection & Availability

Scheme Photo: A30 Bodmin to Indian Queens, Five Years After Opening

2. Data Collection & Availability

2.1 The Schemes

The 2015 meta-analysis has drawn upon the collective findings of all POPE evaluations of schemes which predominantly opened since 2002 and analyses information from 81 schemes. For the purposes of this meta-analysis, where two evaluations have been completed for any given scheme, results have been based on the most recent evaluation (Five Years After, FYA).

The schemes used to form the evidence base for this meta-analysis have been categorised into the following groups:

- **Bypass** schemes;
- Non Bypass schemes, comprising:
  - **Widening**;
  - **Junction Improvements;**
  - **Upgrade from A road to motorway** standard; and
- **Smart Motorways** (see case study opposite).

Figure 2-1 summarises the numbers of schemes that have been used within the 2015 meta-analysis, characterised by scheme opening year and type.

M6 Junction 8 to 10a Smart Motorway

Opened in March 2011, this is the only Smart Motorway which is considered within this meta-analysis.

The scheme comprises Variable Mandatory Speed Limits (VMSL), Hard Shoulder Running (HSR) and Through Junction Running (TJR) as part of a wider strategy to relieve congestion on the highway network in the vicinity of Birmingham.

Smart Motorway projects form a considerable proportion of Highways England's current and future Major Scheme investment. In recognition of the likely interest in the performance of Smart Motorway schemes, this scheme has been given is its own category ('smart motorway') to enable the results to be clearly identified in various sections of this report.

The findings presented in this report should be treated with caution due to the small sample size.

Figure 2-1 Breakdown of Scheme Types by Opening Year[1]

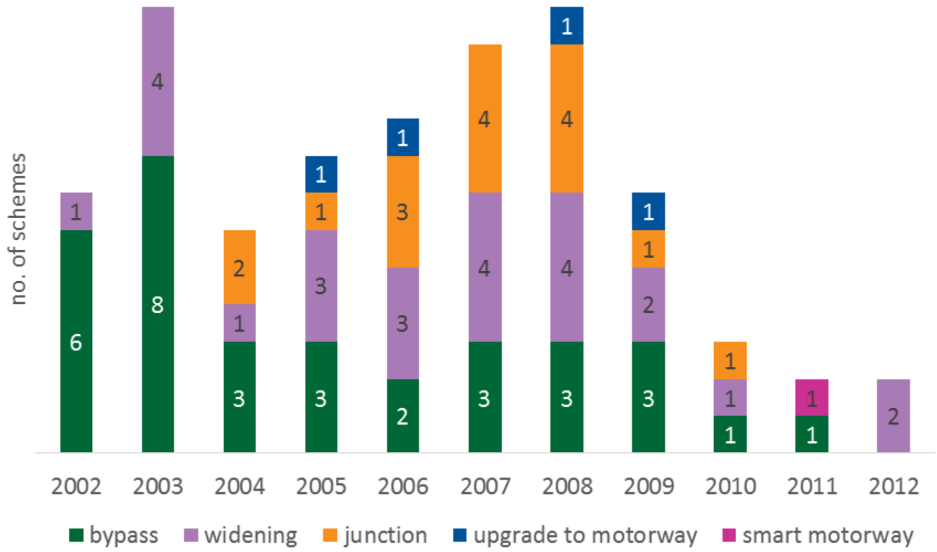
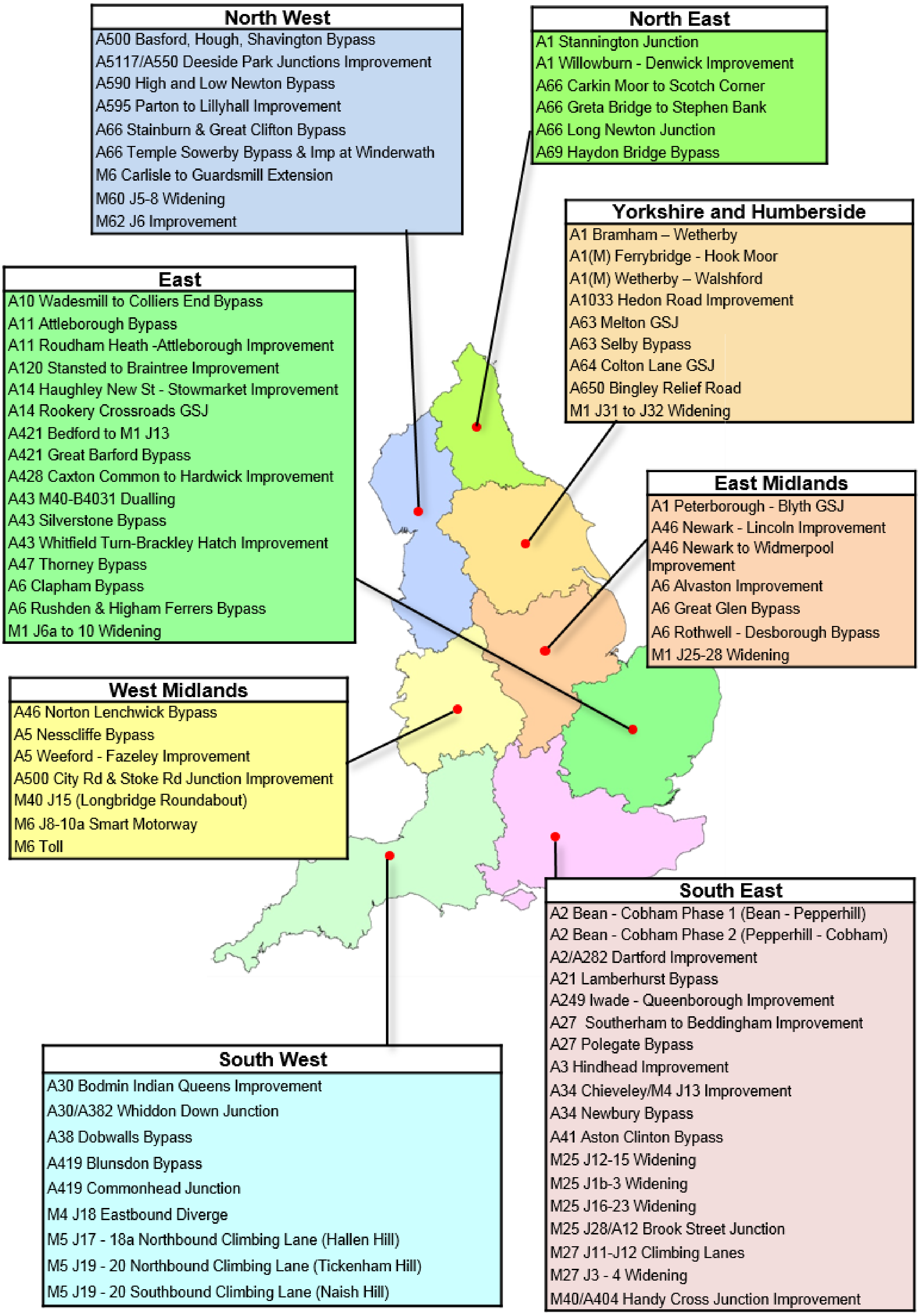


Figure 2-2 shows where the scheme are located. It should be noted that in order to ensure results were not skewed by exceptional examples, a small number of outliers have been removed from the various data-sets used throughout this meta-analysis, as noted in the individual analyses.

[1] A46 Norton Lenchwick Improvement and A34 Newbury Bypass are both excluded from this figure because their opening years were pre 2002.

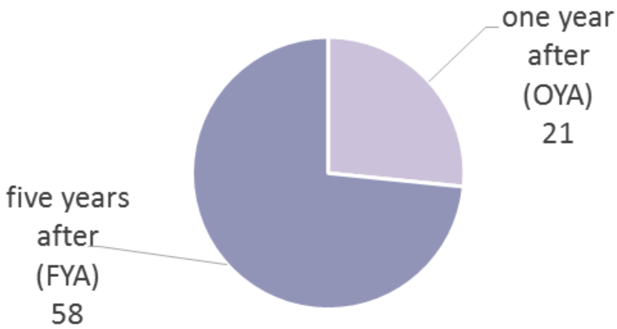
Figure 2-2 Location of Schemes in 2015 meta-analysis



2.2 Post Opening Evaluation Studies

This report is based on the most recent stage of evaluation which has been completed on each of the schemes. Figure 2-3 summarises the totals by One Year After and Five Year after studies.

Figure 2-3 Stages of the POPE reports included in this 2015 Meta-analysis[2]



2.3 Data Sources and Collection

A comprehensive data collection exercise is undertaken for all POPE scheme evaluations. This begins before construction and continues during the OYA and FYA evaluation stages, incorporating new data collection where required.

2.3.1 Forecast Impacts

Information regarding the forecast impacts of schemes is derived from a number of sources produced at the time of the scheme appraisal including:

- Appraisal Summary Table (AST);
- Traffic Forecasting Report (TFR);
- Economic Assessment Report (EAR);
- Environmental Statement (ES); and
- Cost Benefit Analysis files (COBA).

2.3.2 Observed Impacts

The scope of outturn information considered by POPE is determined by:

- Liaison with Highways England's Scheme Project Manager and Local Authority before scheme construction and at each evaluation stage to understand local perceptions and issues;
- Consideration of those areas forecast to observe significant changes due to the scheme, as reported in the appraisal documents, e.g. changes in traffic flows presented in the TFR.
- Ensuring a cost effective and proportional approach to data collection is maintained.

2.3.2.1 Existing Sources of Observed Impacts

Various data is drawn from a range of existing sources to inform POPE evaluations. These primarily include:

- Traffic flow and classified data from:
  - HE Traffic Data System (TRADS) database; and
  - Local Authority traffic monitoring sites.
- Journey time data taken from Highways England Journey Time Database (JTDB) and use of satellite navigation data;
- Personal Injury Collision (PIC) data from STATS19 data collected by the police when attending accidents, sourced from Local Processing Units from either:
  - The Managing Agent Contractor (MAC); or
  - Local Authorities.
- Environmental impacts presented in:
  - Post opening survey, monitoring and reports produced on behalf of HE; and
  - As-built drawings.
- Scheme costs provided by Highways England's Regional Finance Managers; and

[2] A43 Norton-Lenchwick improvement is excluded from this graph because it's a ten year after opening study.

- Local media and Highways England publicity material for the scheme.

2.3.2.2 Additional Data Sources

Having established what information is already available from existing sources, additional supplementary surveys are carried out as required. These primarily include:

- Temporary Automatic Traffic Counts (ATCs);
- Journey time survey (typically ‘moving observer’ surveys or data supplied from satellite navigation systems);
- Site visits;
- Surveys of non-motorised users for certain schemes where a particular requirement is identified; and
- Residents’ surveys where the community impact is high.

3. Scheme Objectives

Scheme Photo: A46 Newark to Widmerpool Improvement, One Year After

3. Scheme Objectives

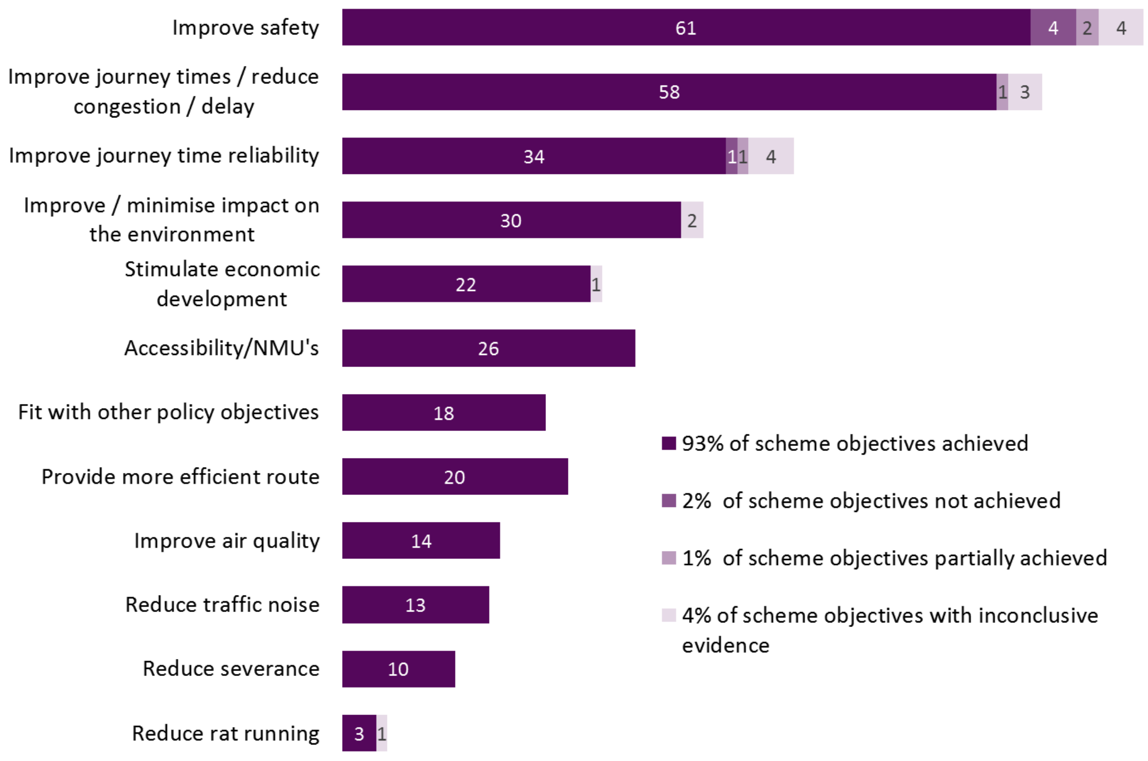
3.1 Are scheme-specific objectives being achieved?

Major Schemes are successful at delivering against their scheme specific objectives with 93% of objectives being achieved for all schemes and only 2% not achieved. The remainder are either partially achieved (4%) or have insufficient evidence at this stage.

This finding is consistent across all scheme types. A greater proportion of scheme objectives have been achieved at the five year after opening stage when compared to the one year after opening stage.

All Highways England's Major Schemes have their own objectives which are generally defined at the option identification and appraisal stage of the project. Figure 3-1 summaries the success of Major Schemes against their own scheme-specific objectives. The numbers in the bars show how many schemes has the objective and how the success has been categorised. It shows that **93% of all scheme specific objectives have been achieved**, with only 2% of objectives not achieved. Some objectives (4%) have inconclusive evidence[3] to demonstrate that whether they have been achieved or not and 1% of objectives are partially achieved[4].

Figure 3-1 Success of Major Schemes against their scheme specific objectives (all schemes)[5]



In order to determine whether the objectives were inconclusive because of the timing of the evaluation, Figure 3-2 presents results from schemes which have been evaluated at both one and five years after.

[3] Objectives that are inconclusive include those with insufficient evidence available at the time of the evaluation to determine whether the scheme has been successful in meeting the objective.
[4] Schemes with objectives that are partially achieved typically show some evidence to show that the objective is being achieved, but it is not possible using the evidence available to draw a firm conclusion.
[5] The numbers presented in this graph are rounded which explains why some figures do not add up to exactly 100%.

Figure 3-2 Success of Major Schemes against their scheme specific objectives (OYA and FYA studies separated)

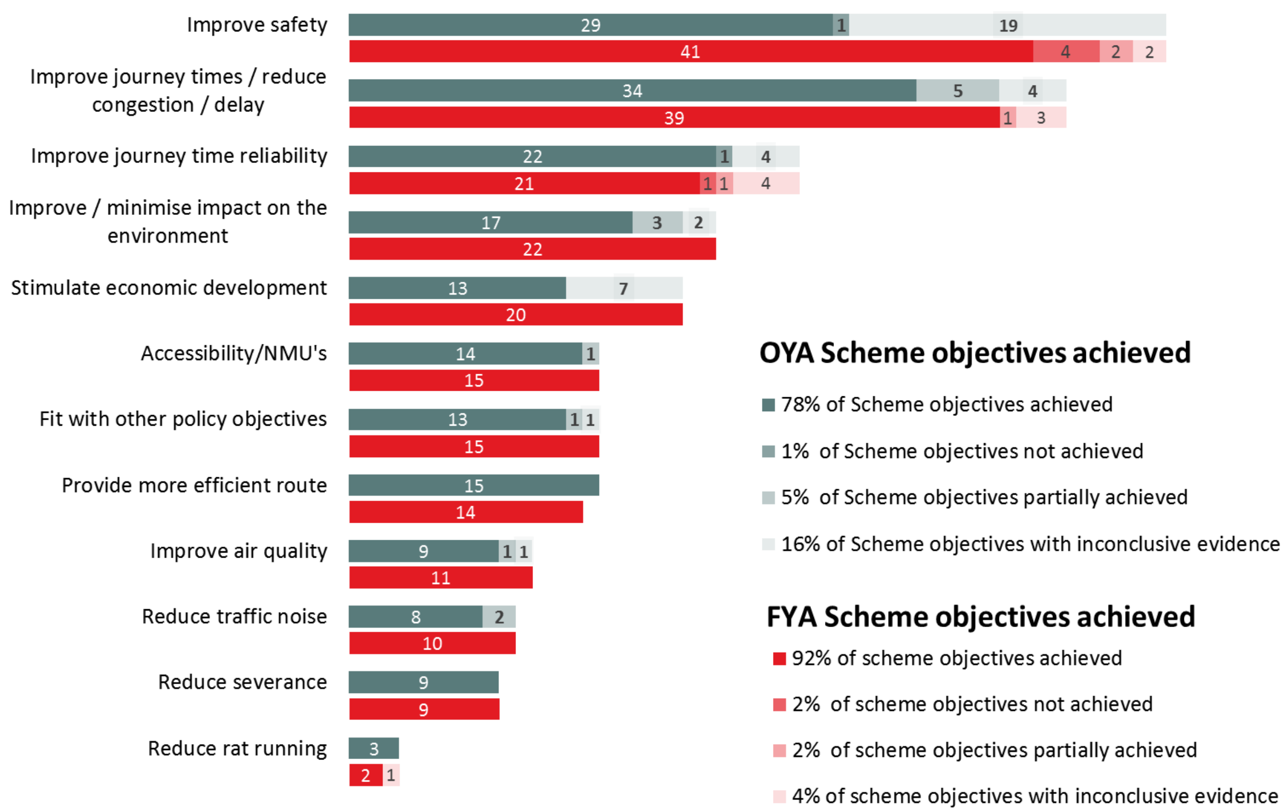


Figure 3-2 shows that a greater proportion of scheme objectives have been achieved at the five year stage, with fewer objectives having inconclusive evidence. The principal reason is due to safety benefits being realised at the five year after opening stage, when at the one year after opening stage the impact was inconclusive (usually do a shortage of sufficient post opening collision data).

In order to determine whether certain types of scheme are more successful than others, Figure 3-3 presents the results of an analysis of success against scheme objectives by scheme type (using the categories previously identified in Section 2.1 on page 14).

Figure 3-3 Success of Major Schemes against their scheme specific objectives by scheme type[6]

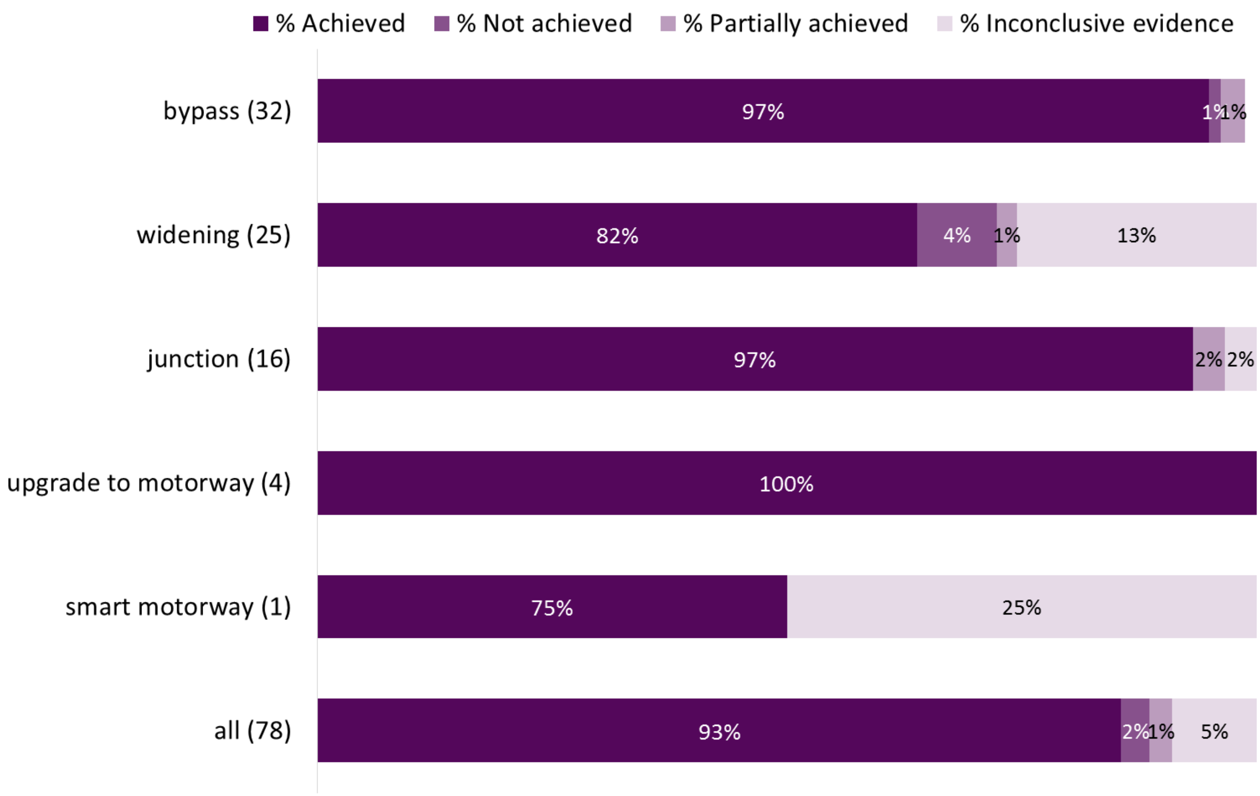


Figure 3-3 shows the following:

- Bypass schemes have achieved 97% of their objectives, with upgrades to motorway and smart motorways achieving all of their objectives (although it is noted that the sample size is small for both of these scheme types).
- For widening schemes 82% of objectives were achieved. 4% of objectives were not achieved. This was mainly due to safety benefits not materialising for 3 schemes.12% of objectives were inconclusive. On closer examination this is primarily due to insufficient evidence to demonstrate that journey times and reliability have improved (3 schemes) and safety benefits being inconclusive (2 schemes).
- The smart motorway scheme achieved 3 of its objectives. One of its objectives is currently inconclusive (safety).

3.2 Summary of Scheme Objectives

The results presented in this section provide strong evidence that Major Schemes are successful in meeting their objectives. However, the objectives for all of the schemes within this Meta-analysis sample are qualitative. Some examples of the types of objectives are given below:

- *'To improve safety'*
- *'To improve journey times'*
- *'To improve journey time reliability'*

In order for a scheme to demonstrate success against the above objectives, only a small change is required. For example, there could be a small reduction in journey times of only a few seconds, and the objective would be achieved.
The following chapters 4 to 7 of this report include the investigation of how effectively the major schemes are achieving the objectives based on the observations in the early years after opening.

[6] The numbers presented in this graph are rounded which explains why some figures do not add up to exactly 100%.

4. Traffic

Scheme Photo: A419 Blunsdon Bypass, One Year After

4. Traffic

4.1 Do Major Schemes improve journey time reliability?

New bypasses, widening schemes and schemes upgrading A-roads to motorways significantly improve journey time reliability, with bypass schemes showing the greatest improvements

4.1.1 Measuring Reliability

Reliability is a sub-objective of the Economy objective within the Government's objectives for transport and is defined as the variation in journey times, at the same time of day, which drivers are unable to predict. It is confined to random effects arising either from day-to-day variability in recurrent congestion or variability in non-recurrent congestion such as incidents.

There are a number of alternative methodologies for assessing reliability depending on the type of road, as detailed in WebTAG (Unit A1.3), including:

- Route Stress;
- MyRIAD(Motorway Reliability Incidents And Delays); and formerly
- INCA (Incident Cost Benefit Assessment).

Highways England's Journey Time Database (JTDB) can be used to determine the standard deviation of average journey times on a road at a given time of day. Satellite navigation data can also be used to evaluate changes in reliability using a range of indexes.

For the schemes included in this meta-analysis, POPE has tended to rely on the 'Route Stress' approach for evaluating reliability as this has been the predominant approach used in the appraisal of the schemes. It is also relatively simple to calculate. Route Stress is the ratio of Annual Average Daily Traffic (AADT) flow to the Congestion Reference Flow (CRF), which is a definition of capacity.[7] Reliability of journey times reduce as flows approach capacity.

Evaluation of the pre-scheme and outturn route stress levels are calculated using the before and after opening traffic volumes, the directional split of traffic and the percentage of HGVs. This methodology enables a direct comparison between the observed and predicted values.

The route stress approach, however, only provides a broad indication of the impact of a scheme on reliability. POPE has been exploring and piloting other methods of evaluating journey time reliability, and the use of satellite navigation data to measure the standard deviation of journey times is a preferred method for schemes which have data available before and after scheme opening. For the majority of schemes considered within this report, however, 'before' journey time data is not available.

The following sections consider the observed impacts on reliability of the POPE schemes using the following methodologies:

- Route Stress;
- Variability in average journey time, utilising Highways England's JTDB; and
- Variability in individual journey times using data from satellite navigation devices.

The difference between predicted and observed route stress is also assessed.

4.1.2 Observed Impacts on Reliability using Route Stress

The changes in observed route stress before and after scheme opening for bypass, widening and 'upgrade to motorway' schemes have been analysed using all observed data, as shown in Figure 4–1. It should be noted that this analysis utilises available data from 26 bypass schemes, 19 widening schemes

[7] The CRF of a link is an estimate of the Annual Average Daily Traffic (AADT) flow at which the carriageway is likely to be 'congested' in the peak periods on an average day.

and 4 ‘upgrade to motorway’ schemes. WebTAG states that where stress values are less than 75% or greater than 125%, values of 75% and 125%, respectively, should be used. However, to demonstrate the extent of the changes in route stress due to the schemes, the values used in this figure and the following figures are based on the unadjusted route stresses.

Figure 4–1 Level of Route Stress before and after scheme opening

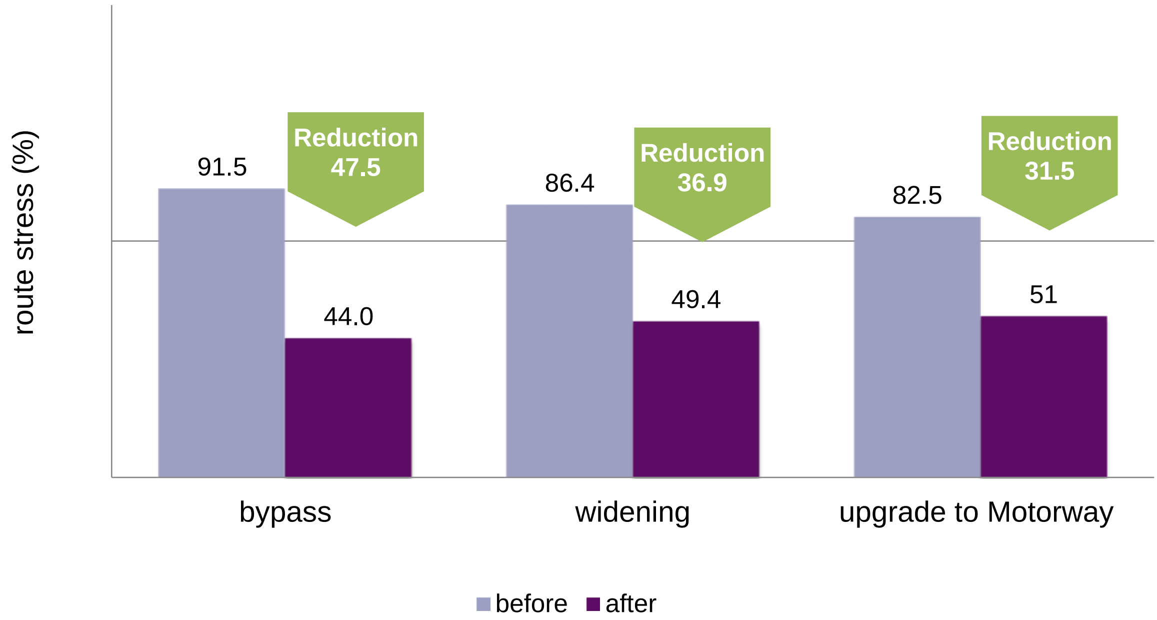


Figure 4–1 demonstrates that all types of scheme significantly improve journey time reliability, with the following key observations:

- Bypass schemes have the greatest reduction in route stress of all road types and the lowest level of route stress in the Do-Something scenario. Schemes of this type have the highest impact on reliability because they generally provide the most additional capacity;
- Widening schemes have a smaller reduction in average route stress than bypass schemes with a higher level of route stress in the Do-Something scenario, due to the generally lower level of additional capacity provided. However, these schemes still reduce route stress to below 50%;
- The ‘upgrade to motorway schemes’ have the lowest level of reduction in route stress. However, again it is clear that the increase in capacity has resulted in decreased congestion; and
- The observed reduction in route stress for all scheme types shows that the additional capacity provided by Major Schemes does result in a decrease in congestion.

4.1.3 Comparison between Observed and Predicted Impacts on Reliability using Route Stress

An analysis of the predicted and observed route stress percentages before and after opening has been undertaken for those schemes which have values for both predicted and observed, to determine the level of forecasting accuracy. These schemes consist of 21 bypass schemes, 13 widening schemes and 4 ‘upgrade to motorway’ schemes. This sample size is smaller than that used for the analysis of observed changes in route stress as there were some schemes without predicted data. Junction schemes have not been included as route stress cannot be determined for schemes of this type.

Figure 4–2 to Figure 4–3 show the level of predicted and observed route stress before and after scheme opening for bypass and widening schemes, respectively. A comparison for ‘upgrade to motorway’ schemes and smart motorway has not been provided due to the small sample size.

Figure 4–2 Level of Route Stress before and after scheme opening – Bypass Schemes

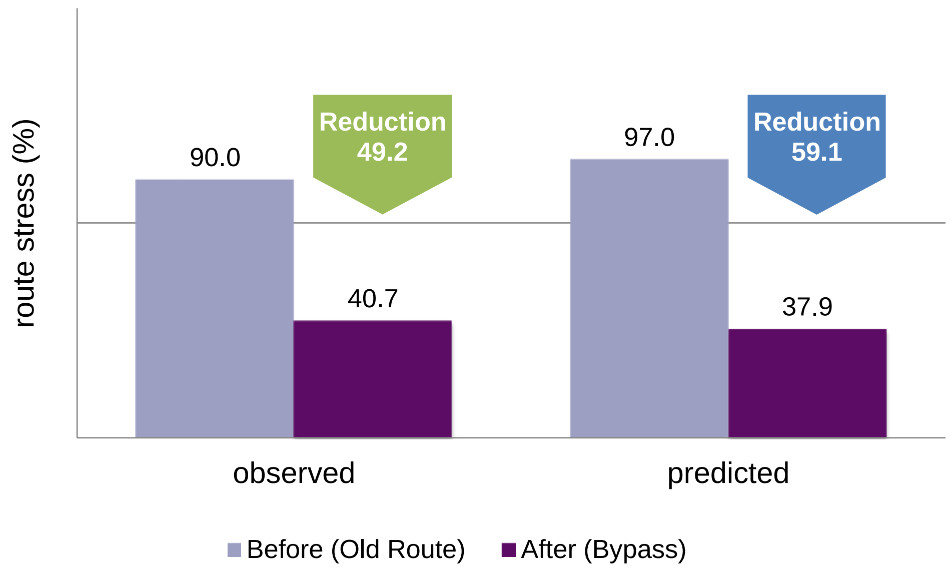
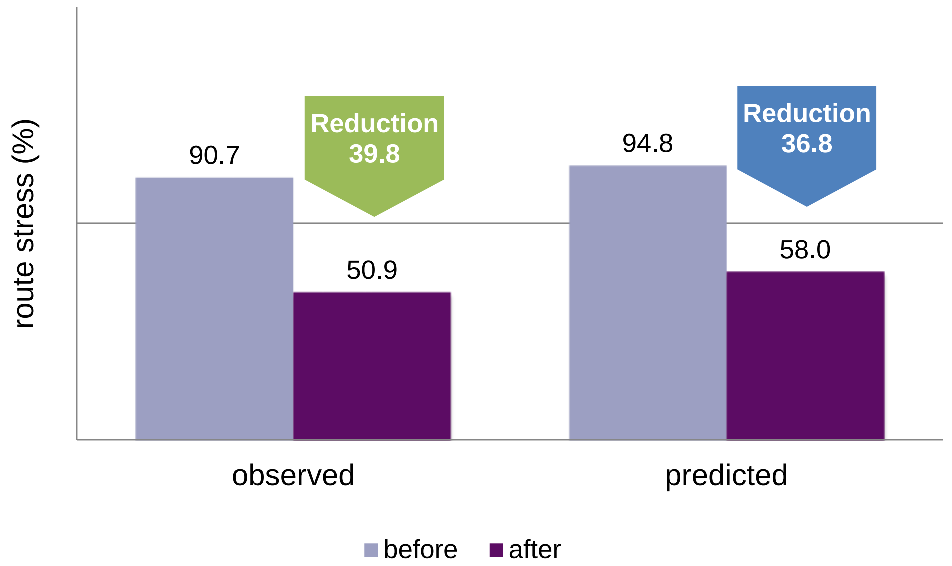


Figure 4–3 Level of Route Stress before and after scheme opening – Widening Schemes



The following can be observed from Figure 4–2 to Figure 4–3 in relation to the differences between the predicted and outturn average route stresses for the different road types:

- There is a good correlation between observed and predicted route stresses for both bypass and widening schemes;
- It is noted that observed levels of route stress are generally slightly lower than predicted. This is likely to be due to observed traffic flows being lower than predicted; and
- The observed reduction in route stress is generally accurate for both widening and bypass schemes. The accuracy for bypass schemes is slightly less than for widening schemes which is likely to be due to the inaccuracy in modelling of re-routing between the old route and the new bypass. This will be discussed in more detail in Section 4.2.

4.1.4 Observed Impacts on Reliability using Journey Time Database (JTDB) data

A proxy for journey time reliability can also be determined by examining the variation of journey times using data extracted from Highways England's Journey Time Database (JTDB). This is undertaken by calculating the standard deviation of mean journey times for each time period for the pre-scheme and one year and/or five year after periods. This approach has limitations because it is based on mean journey times which therefore may hide variation in individual journey times. However, if there is a significant reduction in standard deviations between the before and after opening period then it is reasonable to assume that the Major Scheme has improved journey time reliability.

This extra level of evaluation has been undertaken for a total of thirteen schemes and the results show the following:

- 10 schemes (77%) showed a clear improvement in journey time reliability since the Major Scheme opened.
- For 3 schemes (23%) there was no clear evidence of improved journey time reliability. Although for one of these schemes there was a considerable increase in traffic volumes between the before and after opening periods.

4.1.5 Observed Impacts on Reliability using Satellite Navigation (GPS) Journey Time Data

There are currently only three schemes within the POPE dataset where GPS data has been used to assess the journey time reliability. As previously noted, this is due to the general unavailability of data for the time period before the scheme was constructed.

Although no standard methodology currently stands for comparing journey time reliabilities for different schemes, the Planning Time Index (PTI) has been used for this meta-analysis. The PTI is the ratio of the 95th percentile Journey Time / Free-flow Journey Time. For this analysis the 25th percentile journey time has been used to represent the free-flow journey time.

Table 4–1 shows the change in PTI for the three schemes and the average. A reduction in PTI represents an improvement in journey time reliability.

Table 4–1 Change in Planning Time Index

Schemes	Change in Planning Time Index		
	AM Peak	Inter-Peak	PM Peak
M6 J8-10A Smart Motorway	-14%	-18%	-24%
A421 Bedford to M1 J13	-27%	-5%	-1%
M40 Junction 15 Longbridge Improvement	-67%	-38%	-59%
Average	**-36%**	**-20%**	**-28%**

It can be observed from Table 4–1 that there is an improvement in JT reliability for all three schemes, with the reliability improving most during the AM and PM peaks, as would be expected due to the higher level of congestion.

4.2 Are traffic volumes accurately predicted?

A majority (68%) of schemes accurately forecast traffic flows (to within +/-15%), but there is much variability in accuracy between schemes.

There is evidence to suggest that the accuracy of traffic forecasting has improved over time.

This section examines the accuracy of forecast traffic flows compared to observed flows. In order to determine if there have been any trends in relation to traffic forecasting accuracy, the following have been considered:

- Range of forecasting accuracy levels by scheme type;

- Proportion of schemes with observed traffic flows within a ±15% threshold of those forecast;
- Proportion of schemes with observed flows higher and lower than forecast; and
- Changes in forecasting accuracy over time.

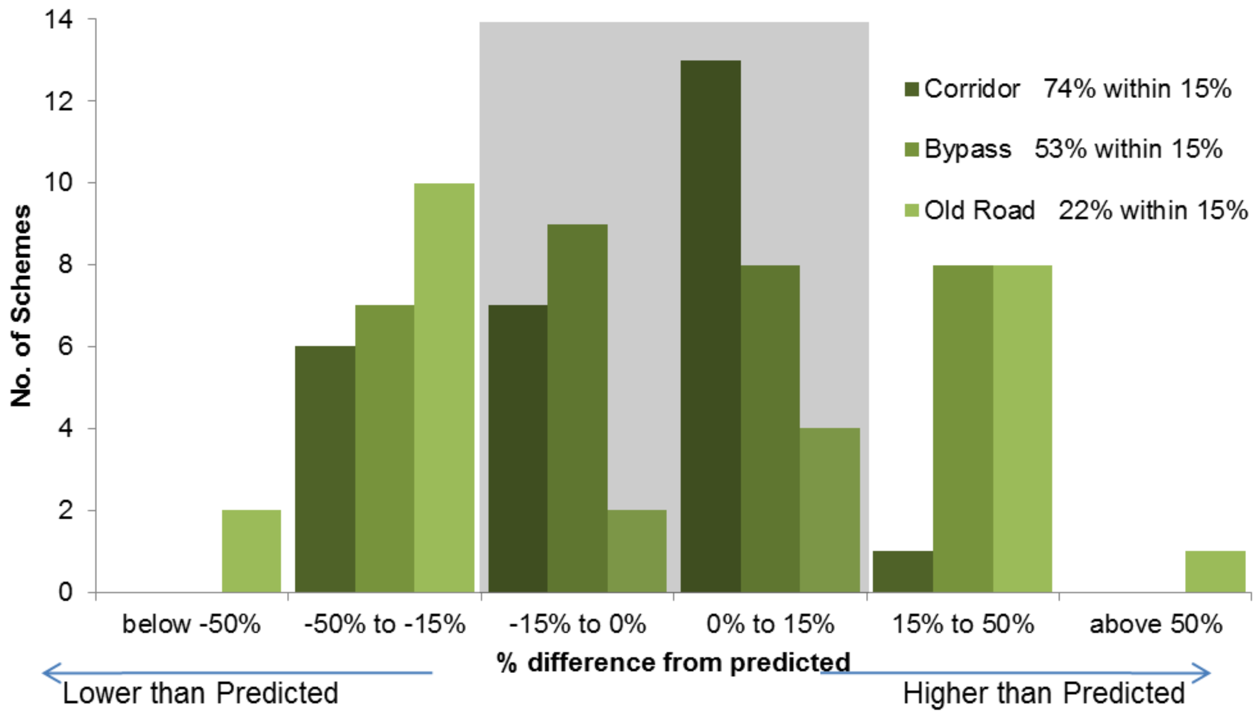
The range of accuracy for different scheme types is considered in more detail in the following sections, as well as any trends for observed flows to be higher or lower than predicted. A difference of less than ±15% between modelled and observed traffic flows is considered to be acceptable for base model validation in WebTAG Unit M3.1 (Table 2) and provides an appropriate threshold for determining accurate modelling in this analysis.

In Figure 4–4 to Figure 4–6 outliers have been excluded to ensure that the results are not skewed by exceptional examples. The Devore's 'Fourth-Spread' method has been utilised to identify and remove the outliers.[8] For bypass schemes, the traffic forecast accuracies have been provided for the old road, the new road and for the corridor (new bypass and old road combined).

4.2.1 Bypass Schemes

Figure 4–4 shows the range of accuracy of traffic flow forecasts compared to observed traffic flows for bypass schemes. The graph shows the range for the new bypass, the old road and the total flow in the corridor (new bypass and old road combined).

Figure 4–4 Accuracy of Traffic Forecasts (Bypass schemes)



It can be observed from Figure 4–4 that the forecasting of the overall traffic flow in the corridor is significantly more accurate than the forecasting of the traffic flows on the bypass and old road. This shows that although the forecast change in the overall traffic flow in the corridor is accurately reflected, the flow of traffic remaining on the old road is much less accurately predicted. This is due to the old road post opening numbers always being low with a greater proportional change than the roads on the strategic

[8] Devore's 'Fourth-Spread' method involves calculating the 25th and 75th percentile of a data-set and uses the differences between these values to exclude data around the median. The equation used to remove outliers is:
Outlier < Median – K(Interquartile Range)
OR
Outlier > Median + K(Interquartile Range), where K has been adjusted to '3'.
No. of outliers removed: 1 for Bypass-Old Road, 3 for Bypass – Corridor.

network hence wider variation from the base flows with 78% outside of ±15% accuracy although the number of bypassed old roads with flows above and below forecast are similar.

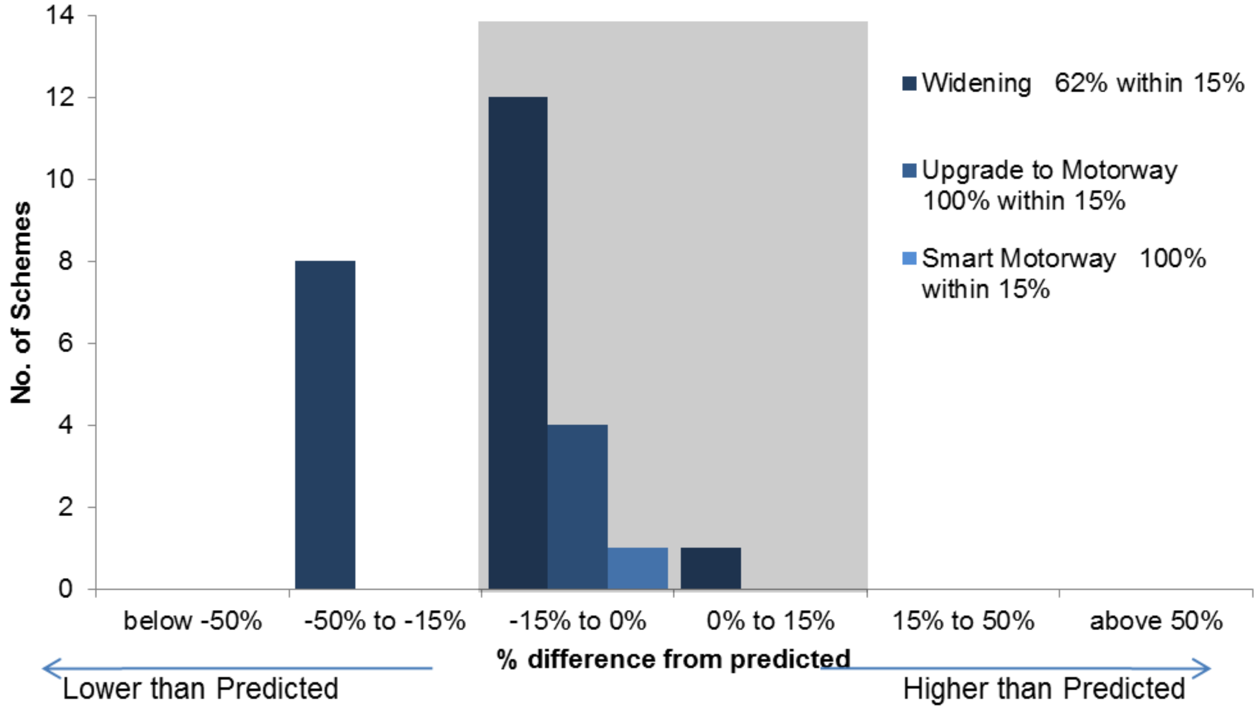
The even distribution of the frequency graphs for the corridor, old road and bypass demonstrates that the numbers of schemes with traffic flows either higher or lower than predicted, are approximately equal. There is, therefore, no identifiable trend in relation to the inaccurate modelling of reassignment between the old road and bypass (e.g. a trend towards predicting higher traffic flows on the bypass and lower traffic flows on the old road).

On average, observed corridor flows are 4% less than forecast, whilst the observed old road flows are 4% lower than forecast and observed bypass flows are 1% lower than forecast. It should be noted, however, that averaging the percentage differences for all schemes results in positive differences cancelling out negative differences and vice versa. As a result, these values should be treated with caution.

4.2.2 Widening and Upgrade to Motorway Schemes

Figure 4–5 shows the range of accuracy of traffic flow forecasts compared to observed traffic flows for widening and 'upgrade to motorway' schemes.

Figure 4–5 Accuracy of Traffic Forecasts (Widening, Upgrade to Motorway and Smart Motorway schemes)



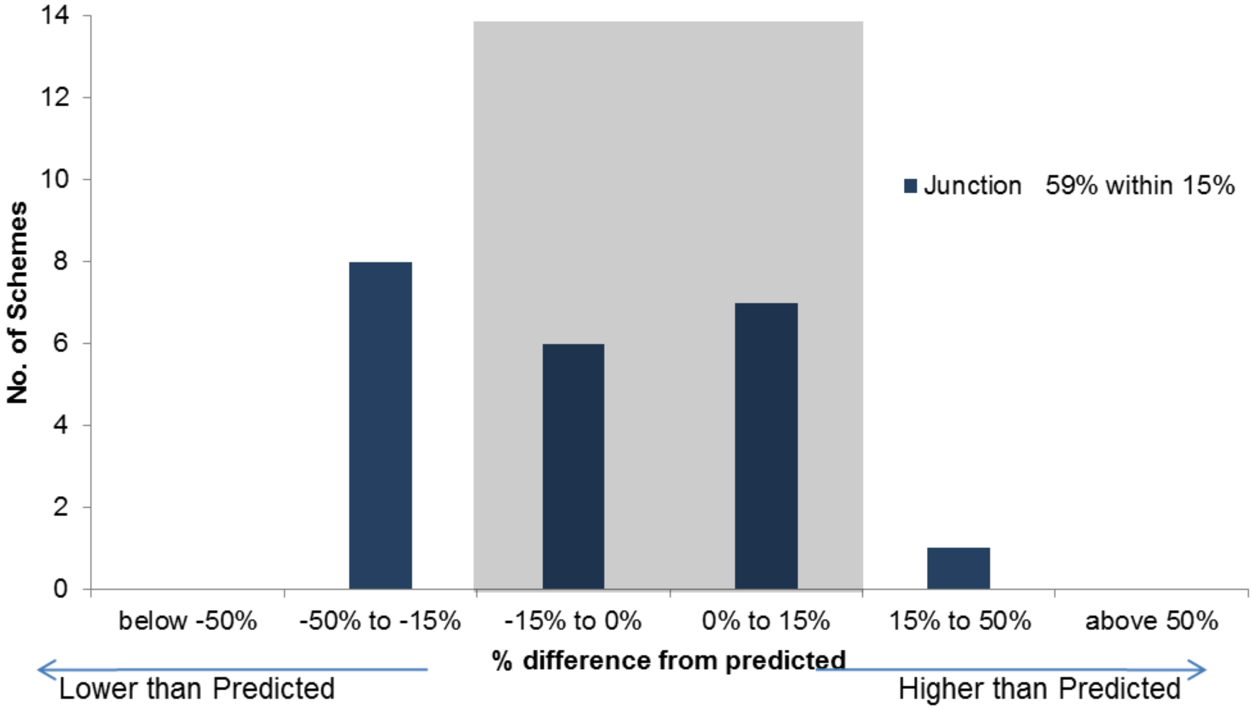
It can be observed from Figure 4–5 that there is a narrower range of frequencies for widening schemes than for the bypass scheme corridors, although only 62% of schemes have forecast traffic flows within ±15% of observed flows compared to 74% for bypass corridors. This is because the majority of widening schemes have observed traffic flows which are lower than predicted due to the overestimation of background growth. This affects widening schemes more than bypass schemes, as they generally have later opening years and have, therefore, been affected by the economic downturn in 2008.

The accuracy of upgrade to motorway schemes is high with forecast traffic flows for all four schemes within 15% of observed. However, it is noted that all of the schemes had lower observed traffic flows than forecast. It should be noted that the observed flows for the one Smart Motorway scheme are within 2% of observed which demonstrates a high level of forecasting accuracy, albeit for a small sample.

4.2.3 Junction Improvement Schemes

The varying degree of accuracy of the forecast traffic flows for junction improvement schemes is shown in the frequency graph of Figure 4–6.

Figure 4–6 Accuracy of Forecasts (Junction Improvement schemes)



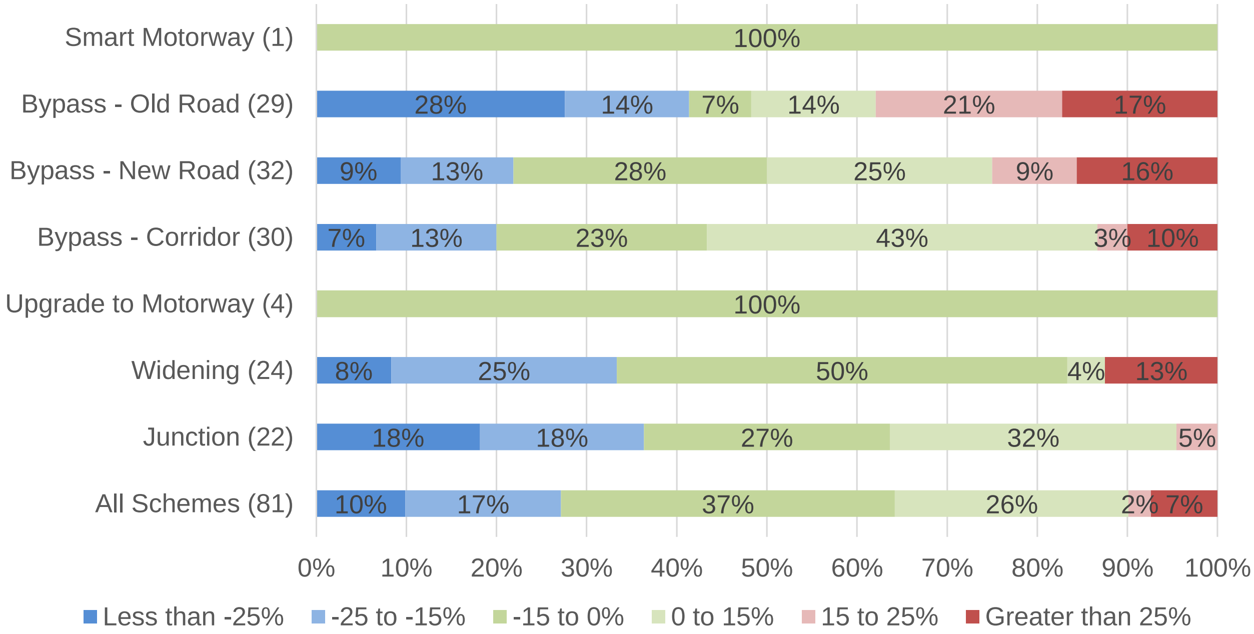
It can be observed from Figure 4–6 that although there is a similar level of accuracy for junction improvement schemes as for widening schemes, shown in Figure 4–5, there is a significant difference in the distribution of differences. Approximately 64% of junction schemes have observed traffic flows lower than forecast compared to 95% of widening schemes. Observed flows for junction schemes are on average 9% less than forecast whilst widening schemes are on average 13% lower. Junction improvement schemes, therefore, have a more even distribution of differences between observed and predicted traffic flows than widening schemes.

4.2.4 Scheme Type Comparison

A comparison of the accuracy ranges[9] for different scheme types is shown in Figure 4–7. It should be noted that the values given in this figure include all schemes where both observed and predicted traffic volumes were available for the Do-Something scenarios, including outliers.

[9] For example, -15 to -25% means the observed flow is 15 to 25% less than predicted

Figure 4–7 Accuracy of Do-Something Traffic Forecasts



The following can be observed from Figure 4–7 in relation to the general level of forecasting accuracy for different types of schemes:

- Other than the small number of upgrade to motorway schemes, bypass scheme corridors have the highest level of forecasting accuracy with 66% of schemes having observed traffic flows within 15% of predicted. However, the forecasting of traffic flows on the old and new roads, for these bypass schemes, are the least accurate with only 21% and 53%, respectively, within the threshold. This demonstrates that although the overall level of traffic flow in the corridor has been accurately modelled for a high proportion of these schemes, the reassignment of traffic between the old road and the new road has been less accurately modelled;
- Approximately 54% and 59% of widening and junction improvement schemes, respectively, have observed traffic flows within 15% of predicted, demonstrating that a large proportion of the forecast traffic flows are inaccurate;
- The majority of bypass schemes have higher observed traffic flows than predicted, whilst the other scheme types all have a larger proportion of schemes with observed flows which are lower than predicted. Some of this difference is due to the fact that many of the bypasses are among the older schemes in this study and therefore less affected by the economic downturn in 2008 and the change in traffic growth trend. Analysis of the change in accuracy over time is considered in more detail later in section 4.2.7 on page 40. It demonstrates, however, that inaccuracies in forecasting for bypass schemes are less related to lower than expected background traffic growth than the other scheme types; and
- The four ‘upgrade to motorway’ schemes and the Smart Motorway all have observed traffic flows within 15% of predicted, demonstrating a high level of accuracy for this scheme type, albeit for a small sample size.

Table 4–2 shows the proportion of schemes within a range of accuracy bands, for different scheme types.

Table 4–2 Proportion of schemes within ranges of accuracy for observed flows compared to forecast

Accuracy Range (Observed compared to Forecast)	**Proportion of Schemes**			
	Bypass – Corridor	**Widening**	**Junction Improvement**	**Upgrade to Motorway**
Within 0% to +15%	43%	4%	32%	0%
Within -15% to 0%	23%	50%	27%	100%
Total Within +/- 15%	**67%**	**54%**	**59%**	**100%**
Within 0% to +25%	47%	4%	36%	0%
Within -25% to 0%	37%	75%	45%	100%
Total Within +/- 25%	**83%**	**79%**	**82%**	**100%**
Within 0% to +35%	47%	17%	36%	0%
Within -35% to 0%	43%	83%	59%	100%
Total Within +/- 35%	**90%**	**100%**	**95%**	**100%**

It can be observed from Table 4–2 that over 79% of schemes for all scheme types have observed traffic flows within ±25% of forecast flows and over 90% of all schemes have observed flows within ±35% of forecast flows. This demonstrates that although a high proportion of schemes have observed flows which are not within ±15% of observed flows, the large majority of these are close to being within this range.

4.2.5 Do-Minimum Forecasting Accuracy

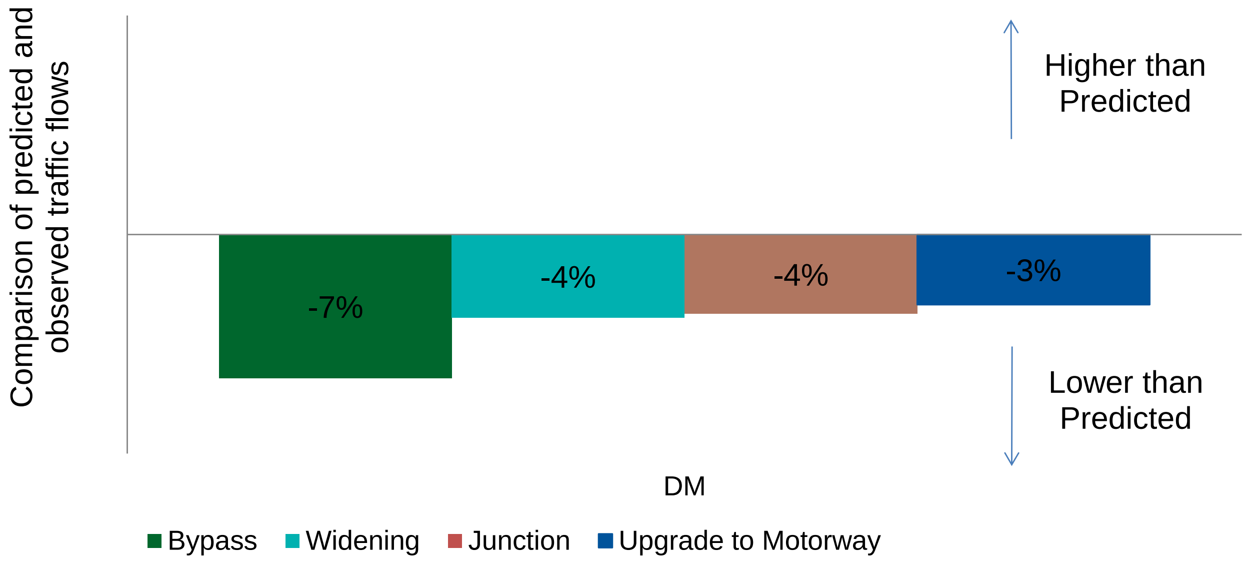
Traffic model forecasts include a prediction of traffic flows for two scenarios: Do-Minimum (without scheme) and Do-Something (with scheme). These are compared against each other to determine the impact of the scheme. The majority of causes of forecasting inaccuracy, discussed in more detail in the following section, will affect the accuracy of the Do-Minimum models and hence the Do-Something models. Traffic growth assumptions, land use assumptions, future highway schemes and modelling accuracy will all impact upon the Do-Minimum forecast accuracy. This section considers the accuracy of the Do-Minimum forecast traffic flows and the relationship between the Do-Minimum and Do-Something accuracies,

It has been possible to collate Do-Minimum data for 67 schemes (27 bypasses, 17 widening schemes, 19 junction improvement schemes and 4 motorway upgrade schemes). It is possible to determine the accuracy of the Do-Minimum traffic forecasts by comparing these to observed traffic flows before the scheme opened (or construction began). [10]

Figure 4–8 shows the average percentage variation between observed 'before' traffic flows and the forecast Do-Minimum traffic flows.

[10] It should be noted that although Do-Minimum forecasts are generally for the opening year, it is not normally possible to obtain observed data for the same year, as construction would have occurred for some time, usually 1-2 years, prior to scheme opening. The background change in traffic over the construction period is considered on a scheme by scheme basis to determine whether or not there is a noticeable impact. In the majority of instances, the rate of traffic growth is sufficiently low so that the time lag does not cause consistency issues.

Figure 4–8 Accuracy of Do-Minimum Traffic Flow Forecasts



It can be seen from Figure 4–8 that:

- On average, schemes have observed traffic flows before construction started that are below the Do-Minimum predictions;
- This indicates that Major Scheme appraisals have generally assumed traffic flows without the scheme to be higher than have actually occurred; and
- This is particularly the case for Bypass schemes which on average have observed ‘before’ traffic flows 7% lower than those predicted.

The reason that Bypass schemes could have shown the largest difference, is that the greater proportion of these schemes were appraised earlier in the years covered in this meta-analysis when NRTF ’89 would have been used to estimate traffic growth. As will be discussed in greater detail in the following section, NRTF ’89 is now considered to have overestimated traffic growth. The change in accuracy of model forecasts over time is considered in more detail in Section 4.2.7.

It should be noted that as the average of all schemes has been used in the analysis above, schemes with higher observed than predicted traffic flows will ‘cancel out’ schemes with lower observed than predicted traffic flows and vice versa. The resultant values, however, are an indication of the overall differences between predicted and observed. Further analysis has been undertaken of the schemes where Do-Minimum forecasts have been collated to determine the proportion of schemes which have observed ‘before’ traffic flows within ±15% of predicted, as shown in Figure 4–9.

Figure 4–9 Accuracy of Do- Minimum Traffic Forecasts

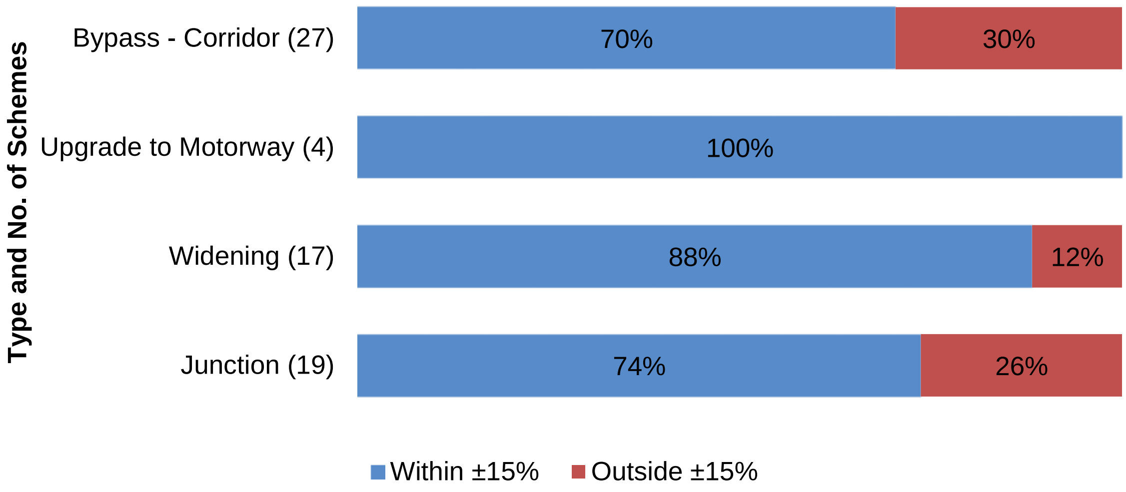


Figure 4–9 shows that:

- Junction and bypass schemes have the lowest proportion with traffic flows within ±15% accuracy. However, many of these schemes (particularly the bypasses) were appraised early on in the timeframe covered by this meta-analysis, when traffic growth forecasts were derived from NRTF ’89; and
- Upgrade to motorway and widening improvement schemes have the highest proportion of traffic flows within ±15% of forecast. Conversely to the previous point, most of these schemes were appraised later in the timeframe covered by this meta-analysis when National Road Traffic Forecasts had been updated from NRTF ’89 to NRTF ’97. Therefore, this could have led to greater levels of accuracy for these scheme types.

Following on from this point, it is necessary to determine the importance of the Do-Minimum forecast accuracy in relation to the Do-Something (with scheme) predictions and to establish if the same proportion of error occurs in both. Figure 4–10 plots the percentage difference between predicted and observed traffic volumes for each scheme, for the Do-Minimum and Do-Something scenarios[11]. The error bars show the difference between the Do-Minimum and Do-Something percentages. Dotted lines mark the range where Do-Something and Do-Minimum forecast accuracies are within 10% of each other. If both the Do-Minimum and Do-Something flows are different to the observed flows by a similar margin, it is likely that it is a problem in forecasting background traffic which has led to the inaccuracy.

Schemes with a similar percentage difference for both the Do-Minimum and Do-Something scenarios will have had the expected impact (or net change effect on traffic). Therefore, regardless of whether the outturn traffic flows were different to forecasts in absolute terms, it can be seen whether the ‘change’ was predicted accurately.

[11] The Do-Minimum percentages have been plotted along the x=y slope. Note that a value of -40% means that the observed flows are 40% less than predicted.

Figure 4–10 Relationship between Do-Minimum and Do-Something Traffic Forecast accuracy

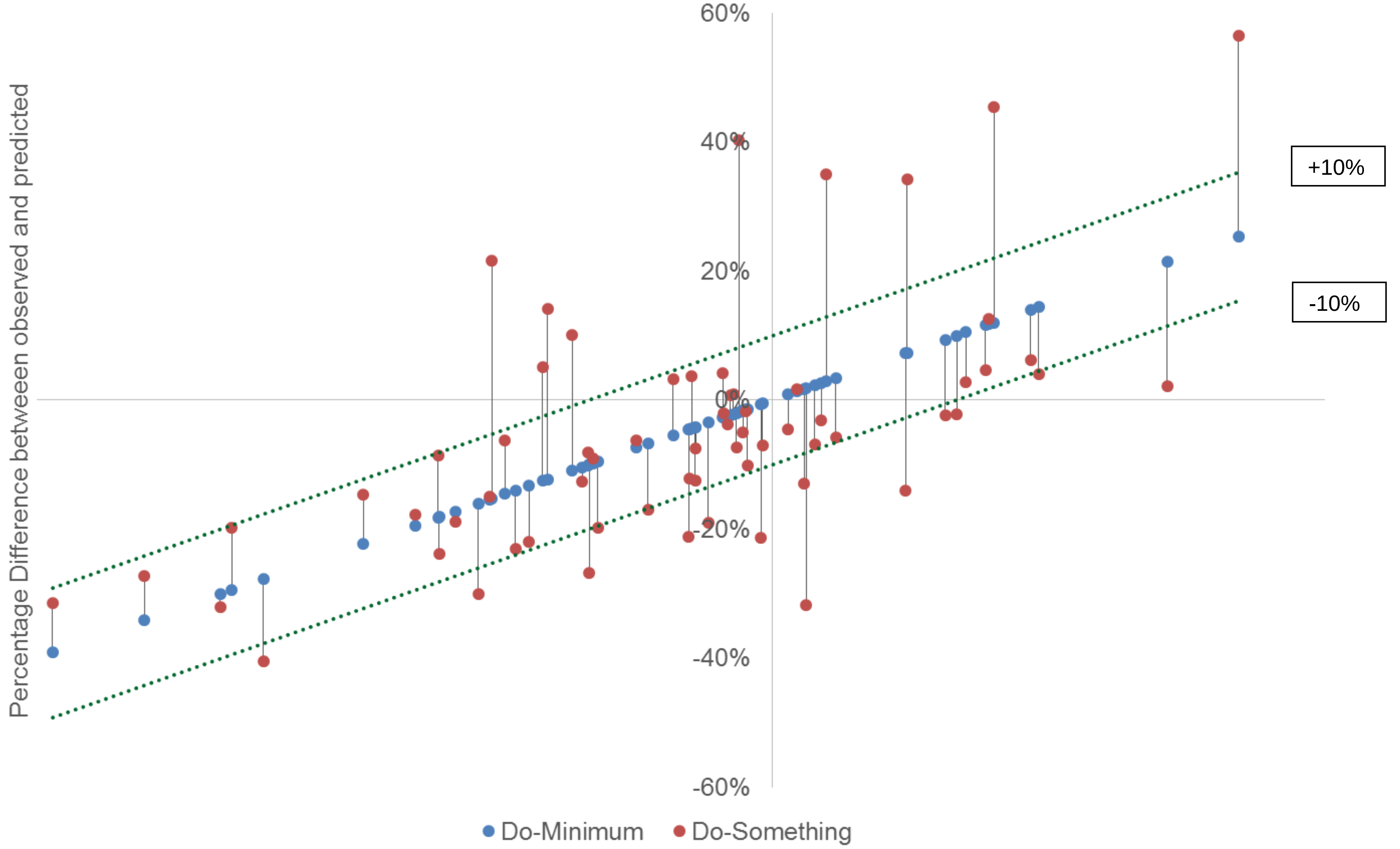


Figure 4–10 shows that:

- Of the sample of schemes where both Do-Minimum and Do-Something forecasts have been included, the vast majority have Do-Something accuracies that lie within 10% of the Do-Minimum level of accuracy. This is indicated by the majority of schemes falling within the dotted lines. This means that these schemes are generally having the expected or near to expected impact on traffic flows proportionally, although not in absolute terms;
- From this it can be inferred that there is a very strong link between Do-Minimum accuracy and Do-Something accuracy.

To conclude, the findings on Do-Minimum forecast accuracy, Figure 4–11 shows for those schemes where the Do-Minimum forecast was outside of the +/-15% threshold, the proportion which achieves Do-Something predictions within +/-15%.

Figure 4–11 Accuracy of Do-Something prediction where Do-Minimum was outside of +/-15%

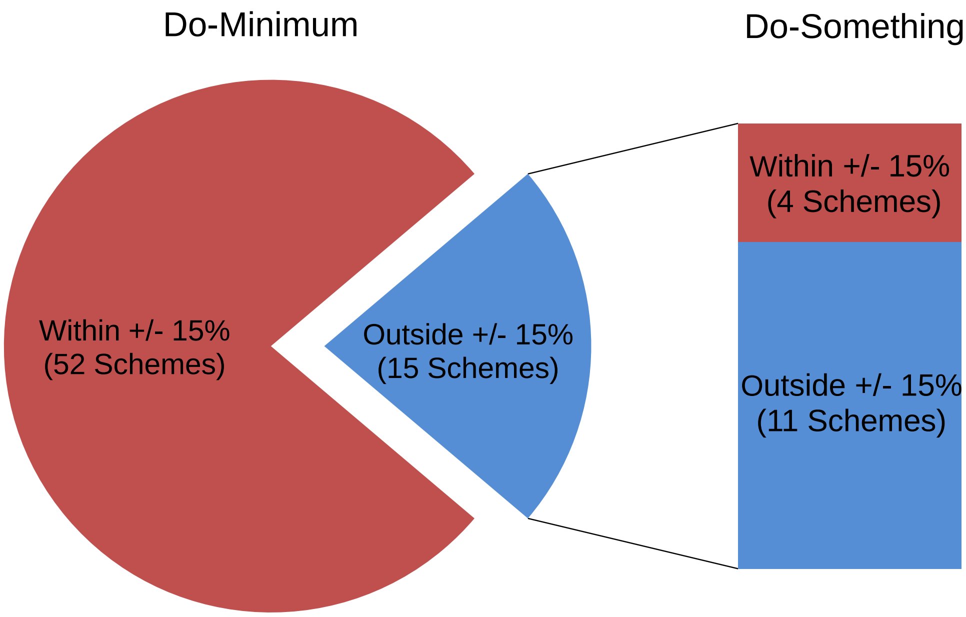


Figure 4–11 demonstrates the importance of the accuracy of the Do-Minimum forecasts, as only 27% of schemes (4 out of 15 schemes) where Do-Minimum forecasts were outside the +/-15% threshold achieved Do-Something accuracy within +/-15%.

It is clear that the accuracy of the Do-Minimum forecasts has an important link with the Do-Something forecast accuracy. The key reasons for this inaccuracy is discussed in the following section.

4.2.6 Key reasons for forecasting inaccuracy

Based on analysis of the traffic forecasting methodologies and forecasts for all of the schemes, the following are considered to have played an integral role where accurate traffic flow predictions have been made:

- Proposed major land use changes in the area of the scheme have been taken into account and realised;
- Model scale and complexity is appropriate and sufficient to capture all possible strategic and local reassignment;
- Do-Minimum traffic forecasts have generally been broadly in line with observed ‘before scheme’ traffic flows; and
- The growth forecast assumptions used have been broadly in line with observed growth, and local growth estimates have been used where appropriate.

A total of 30 schemes (out of 81[12] schemes i.e. 37%) have been identified as having observed traffic flows which differ from predicted flows by more than 15%. An analysis of the causes of these differences has been undertaken for each scheme and the following key factors have been identified:

- Local and strategic routing assumptions;
- Background growth assumptions;
- Land use issues;
- Other highway schemes; and
- Modelling accuracy issues which may stem from the following;
    - base year errors; or
    - network coding errors.

Each of these key factors are addressed in more detail on page The reasons for differences between observed and predicted traffic flows are now discussed in more detail under the following headings. The reasons for differences between observed and predicted traffic flows are now discussed in more detail under the following headings37 onwards, but Table 4–3 summarises the number of schemes where accuracy of traffic forecasts is considered to have been influenced by each factor, and whether traffic flows were under or overestimated. For bypass schemes, the summary relates to the combined corridor flow. It should be noted that the number of reasons does not equate to the number of schemes, as for some schemes, more than one reason was identified.

Table 4–3 No. of schemes and reasons for predicted traffic flows higher or lower than predicted by more than ±15% (including outliers)

Reasons/ outturn flows being > +/-15% higher or lower than forecast	All Scheme types*		Bypass-Corridor		Online Widening		Junction	
	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower
Routing assumptions	7	2	3	1	3	1	1	0
Background growth assumptions	2	17	1	5	1	7	0	5
Land use issues	2	6	2	1	0	2	0	3
Other highway schemes	1	6	1	3	0	1	0	2
Modelling accuracy	0	3	0	2	0	0	0	1
No. schemes outside +/-15%	**8**	**22**	**4**	**6**	**3**	**8**	**1**	**8**
Proportion of all schemes outside +/-15%	10%	26%	13%	19%	12%	32%	5%	36%

*including upgrade to motorway and smart motorway.

Table 4–3 shows the number of schemes influenced by each factor, identified as percentages of the total[13]. This demonstrates the level of importance of each factor for higher or lower forecast flows for each scheme type.

Table 4–4 Reasons for predicted traffic flows higher or lower than predicted by 15% (including outliers), shown as percentages

Reasons/ outturn flows being > +/-15% higher or lower than forecast	All Scheme types*		Bypass-Corridor		Widening		Junction	
	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower
Routing assumptions	58%	6%	43%	8%	75%	9%	100%	0%
Background growth assumptions	17%	50%	14%	42%	25%	64%	0%	45%
Land use issues	17%	18%	29%	8%	0%	18%	0%	27%
Other highway schemes	8%	18%	14%	25%	0%	9%	0%	18%
Modelling accuracy	0%	9%	0%	17%	0%	0%	0%	9%
Total	100%	100%	100%	100%	100%	100%	100%	100%

[12] There are 84 schemes in total. However, two bypass schemes do not have comparable flows between observed and predicted for the corridor and one widening scheme does not have comparable flow.
[13] This is the total of schemes influenced by each factor which is greater than the number of schemes as for some schemes more than one reason was identified for the traffic flows being higher or lower than predicted by more than 15%.

*including upgrade to motorway and smart motorway.

The following can be observed from Table 4–3 and Table 4–4:

- The majority of schemes with observed flows outside the ±15% range have observed flows which are lower than forecast. This is predominantly due to background growth being lower than predicted; and
- For those schemes with observed flows over 15% higher than predicted, the primary reason is routing assumptions. This issue mainly impacts upon bypass schemes, where traffic can route via the new or old route, and widening schemes where the attractiveness of the scheme may be underestimated.

The economic downturn in 2008 has been a key factor in observed traffic flows being lower than forecast, in particular for widening and junction improvement schemes, as they are generally more recent. Assumptions in relation to specific developments have been overestimated with less coming to fruition than expected.

The reasons for differences between observed and predicted traffic flows are now discussed in more detail under the following headings:

- Local and strategic routing assumptions;
- Background traffic growth assumptions;
- Land use issues;
- Other highway schemes; and
- Modelling accuracy.

Local and Strategic Routing Assumptions

A key factor in accurately forecasting traffic flows utilising a scheme is the modelling of reassignment of traffic from other routes. This can be ‘strategic’ rerouting from other major corridors (e.g. motorways and A-roads) or ‘local’ rerouting from, for example, a town centre route onto a bypass. The accurate reassignment of traffic is dependent on a number of factors including modelled journey times and generalised costs (values of time and distance for different journey purposes). There could also be other influences, for example, speed limits, traffic-calming measures, road signage which would influence drivers’ route choices.

Analysis of causes of errors in forecast flows has demonstrated that the inaccurate modelling of rerouting has been a key factors in differences between observed and modelled flows for both bypass and widening schemes. For bypass schemes, the rerouting of traffic from the old road onto the bypass is key for a number of schemes, as demonstrated by the greater accuracy of modelled flows for the overall corridor.

Overall, the accuracy of 9 schemes have been impacted by inaccurate modelling of strategic routing and 6 schemes by local routing issues. These included bypasses, widenings and one junction scheme. All of the schemes impacted by local routing were also affected by strategic routing issues. Approximately 20% of schemes affected by strategic and/or local routing issues had lower observed than predicted flows and 80% had higher. Of the 9 schemes with routing issues, 7 of these were appraised in 2000 or earlier and 6 of the schemes opened in 2002 and 2003. This seems to be an issue, therefore, which affects older schemes.

Model size is an important factor in enabling strategic reassignment to be represented. For a number of schemes assessed, the modelled area was insufficient to enable wider reassignment of traffic to be modelled resulting in inaccurate forecast traffic flows. The model detail is also important as the exclusion of minor roads within a model can result in local reassignment being under-represented.

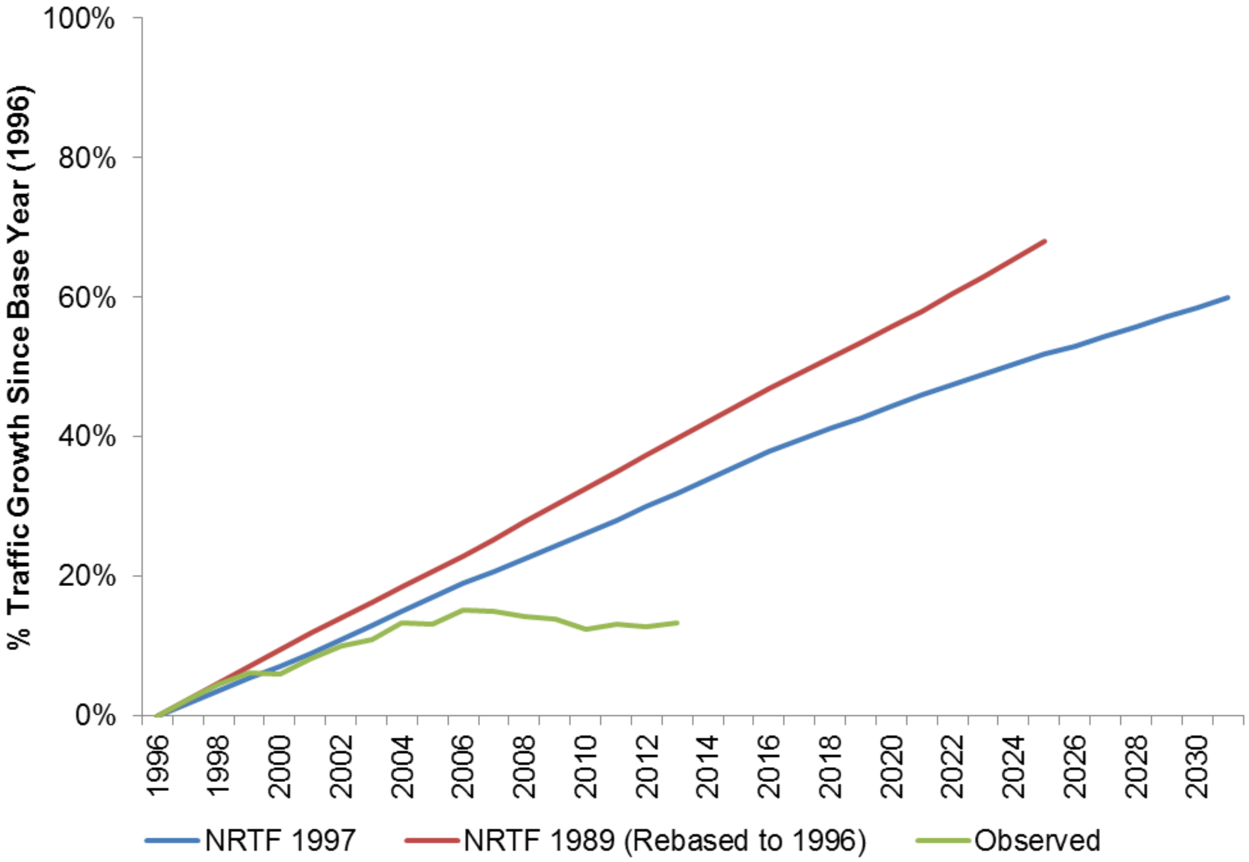
Background Traffic Growth Assumptions

Background traffic growth is the natural growth in traffic flow over time, which would occur with or without a scheme, due to factors such as changes in income and levels of car ownership. Historically, traffic growth has been derived using National Road Traffic Forecasts, with NRTF’89 and NRTF’97 used for a significant number of schemes included in this meta-analysis. More recently, growth forecasts from the National Trip End Model (NTEM) are utilised using TEMPRO which provide more up-to-date forecasts. It is noted that NTEM/TEMPRO produces trip end forecasts and NRTF produces vehicle kilometre forecasts.

It has been noted that a number of schemes in this meta-analysis have observed flows lower than predicted due to background growth forecasts. This is primarily due to the effect of economic downturns in the early 1990s and in 2008 which were not foreseen in the NRTF and NTEM traffic forecasts. It is noted that the impact of these downturns have been taken into account in the latest NRTF and NTEM forecasts.

Figure 4–12 shows the traffic growth profile taken from NRTF ’89 and NRTF ’97 between 1996 and 2030. For information, it also shows the observed national growth in traffic between 1996 and 2013. These values are based on growth in traffic Billion Vehicle Kilometres (bvkm).

Figure 4–12 NRTF ’89 and NRTF ’97 Traffic growth trends



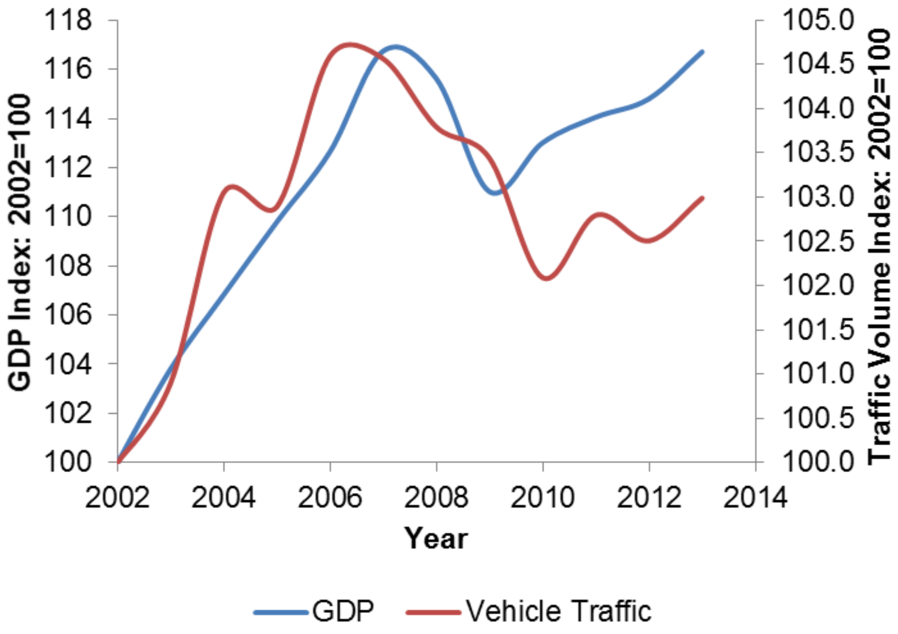
It can be observed from Figure 4–12 that NRTF 1997 has lower predicted growth than NRTF 1989 and that both have significantly higher growth predicted than observed, in particular after 2004. The predicted growth between 1996 and 2013 was predicted to be 40% and 32% for NRTF 1989 and 1997 respectively, whilst observed growth was only 13%.

Traffic growth forecasting has increased in complexity over time, with detailed planning data utilised in the NTEM, and this meta-analysis indicates that it is a critical factor in producing accurate model forecasts.

The observed traffic growth on major roads since 2002 and its correlation with the growth in Gross Domestic Product (GDP) are shown in Figure 4–13[14]. The GDP and traffic levels are indexed relative to the values in 2002.

[14] GDP Data from HM Treasury: The Pocket Databank Table 3 dated 18/3/13. Traffic Growth based on motor Vehicle Traffic (vehicle kilometres) for All Major Roads (Table TRA0202) from Department for Transport Statistics.

Figure 4–13 Relationship between traffic growth and UK GDP



The following can be observed from Figure 4–13:

- GDP grew consistently between 2002 and 2007 before dipping in 2009 during the economic downturn. Since 2009, GDP has continued to grow albeit at a slower rate than before the downturn;
- Traffic volumes on major roads have generally grown between 2002 and 2006, with a slight fall in volume between 2004 and 2005. Between 2007 and 2010, traffic volumes reduced down to 2003-2004 levels. Since 2010, however, traffic volumes have started to increase again; and
- There is a clear correlation between the fall in traffic between 2008 and 2009 and the economic downturn at this time, as well as a growth in traffic following a rise in GDP after 2010.

The difference between the forecast and actual opening year has implications for the comparison of forecast and observed traffic flows for the following reasons:

- Additional background traffic could have accrued between the forecast and actual opening year; and
- Highway schemes and land-use changes could have been implemented which were not included in the appraisal.

For schemes with a different actual opening year to that forecast, POPE evaluations derive a proxy forecast for the actual opening year using interpolation, assuming the same traffic growth assumptions as in the original appraisal. However, this cannot take account of highway schemes and land-use changes that may have occurred.

Land Use Issues

The modelling of major developments is a key factor in the accurate distribution of traffic growth within a modelled area. There are schemes where major developments were not modelled, thus under-predicting the level of traffic flow. There are also schemes where developments have been modelled which have not occurred or have been reduced in size, due to the economic downturn for example.

It is important, therefore, that the modelling of developments is accurately detailed in forecasting reports (which they generally are) so that POPE can assess the extent of the development that has actually occurred and how this has impacted upon the scheme. The provision of uncertainty tests, in line with the latest WebTAG guidance, which consider alternative development scenarios will also be particularly useful for the current economic climate, as development and regeneration may not occur at the pace and proportions initially planned.

Other Highway Schemes

Forecast models include a number of proposed highway schemes in the Do-Minimum scenario. The inclusion or exclusion of highway schemes can have a significant influence on forecast traffic flows due to their influence on capacity and route choice. It is noted that current guidance is to undertake uncertainty testing with sensitivity tests which may include additional highway schemes. These tests should provide additional confidence over the reliability of predicted traffic flows.

Modelling Accuracy

Traffic models are calibrated and validated to a base year, with key indicators of the level of validation being comparisons between modelled and observed traffic flows and journey times. The model development and validation process is detailed in the Local Model Validation Report (LMVR) which provides a valuable source for identifying potential sources of inaccuracies in model forecasting. For example, if modelled journey times are longer in the base year than observed, this could result in overestimated journey times in forecast years and subsequent issues with rerouting resulting in inaccurate traffic forecasts.

It should be noted that LMVRs have only been obtained for a minority of the schemes assessed by POPE to date, although it is expected that the improved availability of these reports for more recent schemes will enable POPE to undertake a more thorough analysis of causes of forecasting inaccuracies. The use of manual counts as a basis for base year traffic volumes could be a factor in forecast flow errors, as these have a lower level of accuracy than long-term counts due to daily variability. This highlights the importance of using permanent count sites where possible, so that the accuracy of the traffic forecasts are not compromised by the use of manual surveys and the methodology used to handle the seasonal characteristics of the roads in question. POPE however uses ATC data, which provides 24 hour traffic flows.

Finally, model coding errors could have been made which influenced the accuracy of both the Do-Minimum and Do-Something forecasts. However, detailed analysis of the individual scheme models which are often no longer available, would be required in order to identify such cases. Whilst this approach was undertaken in the previous version of post opening scheme evaluation (PIES), which evaluated annually 1-2 schemes in great detail, this level of analysis is no longer applied.

4.2.7 Change in traffic flow forecasting accuracy over time

The percentage difference between observed and forecast traffic flows by scheme type and appraisal year is shown in Table 4–5 and Figure 4–14 shows the change in individual and average scheme forecasting accuracy by appraisal year. It should be noted that each bar in Figure 4–14 represents an individual scheme.

It can be observed from Figure 4–14 that schemes appraised between 2001 and 2006 are more accurate than those appraised between 1990 and 2000. However, schemes appraised after 2006 reduce in forecasting accuracy. This is likely to be due to the change in traffic growth resulting from the economic recession in 2008 which had an impact on traffic flows for a number of years as already discussed.

Although it can be observed that the average difference between observed and predicted traffic flows is within 15% for the majority of years, it should be noted that in 1996 and 1997, there are significant over and under-predictions in traffic flows which are averaged out. Table 4–5 shows a clear reduction in the range of scheme accuracies and the standard deviation of differences. This suggests that consistency of modelling forecasts has improved. It is noted that in later years, 2007 onwards, the observed flows are lower than predicted due to lower than expected traffic growth rather than modelling deficiencies.

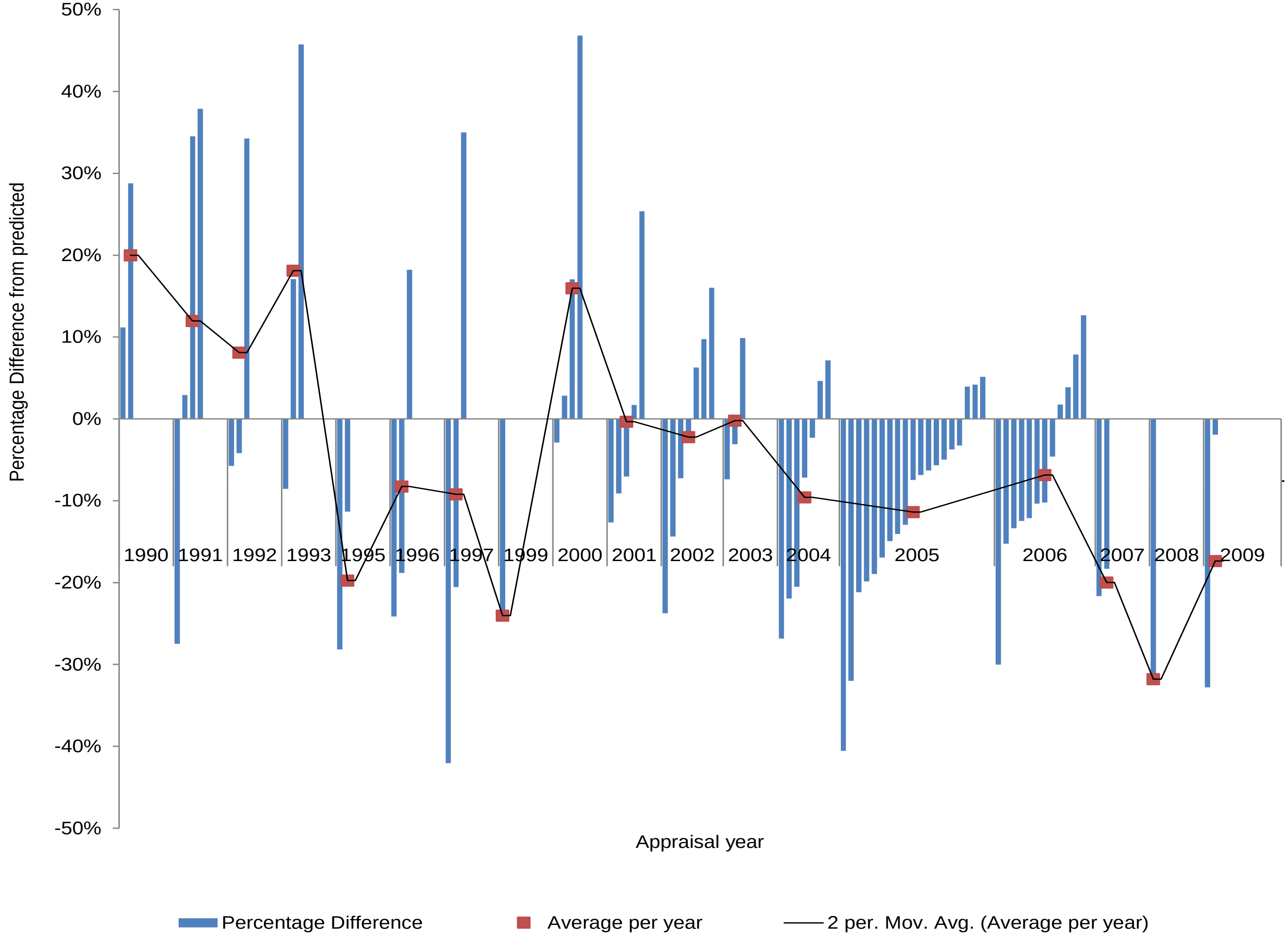
Table 4–5 Standard deviation of observed traffic flows compared to forecast traffic flows

Appraisal Year	Number of Schemes	Lower Bound Percentage Difference	Average Percentage Difference	Upper Bound Percentage Difference	Range	Standard Deviation of Differences
1990 to 1994	12	-27%	14%	46%	73%	23%
1995 to 1999	9	-42%	-13%	35%	77%	24%
2000 to 2004	26	-27%	-1%	47%	74%	16%
2005 to 2009	36	-41%	-11%	13%	53%	12%

There are a number of reasons why the accuracy of forecasts has improved over time:

- Background traffic forecasts have improved with more frequent updates to take account of changes in trends. The introduction of TEMPRO (Trip End Model Presentation Program) in the mid 1990s and its wider use by the late 1990s has enabled planners to access and make better use of the NTEM data, improving forecasting accuracy. Although forecast traffic flows derived shortly before periods of economic downturn are always likely to overestimate traffic flows, uncertainty testing with low growth scenarios should resolve this issue for schemes modelled in line with the latest WebTAG guidance;
- The development of improved guidance, distributed in WebTAG, may have contributed to the improved accuracy of forecasting through the wider use of best practice; and
- The more detailed modelling of scheme impacts may have enabled improved accuracy of forecasts. Fixed demand matrix assessments, which only modelled rerouting, have been replaced by elastic assignments, which also model changes in demand, and more recently by variable demand modelling which model a range of demand responses explicitly (trip frequency, mode choice, distribution and time period choice). These improvements have been made possible through developments in computing software and hardware.

Figure 4–14 Accuracy of Traffic Forecasts by Appraisal Year



Heavy Goods Vehicles Forecasting Accuracy

A total of 23 POPE scheme evaluations have included analysis of HGV impacts (12 bypass schemes, 8 widening schemes, 2 junction improvement schemes and 1 'upgrade to motorway' scheme). For many schemes there has not been classified traffic flow data before scheme construction in order to allow a meaningful comparison with data collected after opening. Changes in the classification of HGVs within Highways England's TRADs system from 5.2m length to 6.6m has also made it more difficult to evaluate HGV impacts on a like-for-like basis.

POPE has also found that there is often a lack of information in the scheme Traffic Forecasting Reports about the predicted changes in HGV volumes.

A comparison between observed and forecast HGV traffic flows has only been undertaken for four schemes which is an insufficient sample from which to draw any clear conclusions. This analysis, however, demonstrates that, for three of the schemes, observed HGV levels were approximately in line with predictions, whereas they were considerably different for one scheme.

4.3 Are Highways England's traffic models accurately predicting journey times?

The limited forecast data available indicates that recorded peak hour journey time savings are lower than forecast. Journey time forecasts are more accurate for less congested periods, such as inter-peak and off peak, when compared to busy peak periods.

This section examines the accuracy of forecast journey times and savings. It should be noted that there is limited data available for this analysis as the majority of schemes only provide Design Year journey time savings in their appraisal. When an opening year journey time saving is provided in the AST, it is often unclear which peak period (AM or PM) and in which direction the estimates are for, what hours represent the inter-peak, and what the start and finish points are for the journey measured.

Although WebTAG guidance[15] formerly suggested that the AST could include "the total vehicle hours saved, and the opening year peak and inter-peak journey time changes in minutes" to demonstrate the magnitude and source of benefits, a number of schemes included in the meta-analysis predate this guidance and others do not adhere to it.

Due to these limitations, it has only been possible to make comparisons between forecast and observed journey times for 43 schemes. It should be noted that some schemes only have journey time savings data, rather than Do-Minimum and Do-Something journey times. As with the traffic flow forecasting accuracy analysis, outliers have been excluded from the journey time analysis to avoid the results being skewed by a small number of exceptional examples.

In order to determine if there have been any trends in relation to journey time forecasting accuracy, the following have been considered:

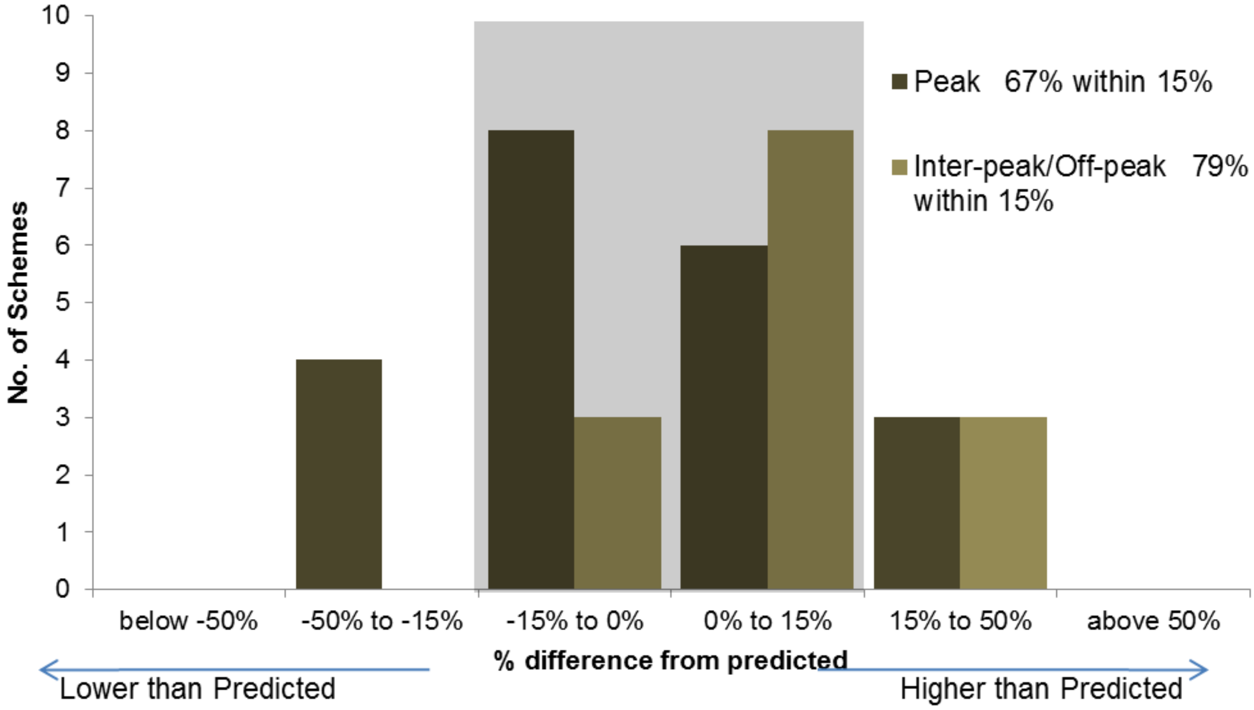
- Accuracy of forecasting for AM and PM peaks compared to Inter-peak and Off-Peaks;
- Accuracy by scheme type; and
- Changes in forecasting accuracy over time.

Journey Time accuracy by time period

The varying degree of accuracy of the forecast journey times for the peaks (AM and PM) and the Inter-Peak/Off-Peaks for the Do-Minimum scenario is shown in the frequency graph of Figure 4–15. This figure is based on data from 11 bypass schemes, 7 widening schemes and 3 junction improvement schemes for the peak periods. For the Inter-peak/Off-Peak periods, the data is based on 9 bypass schemes, 4 widening schemes and 2 junction schemes (one of which is an outlier).

[15] WebTAGUnit 3.5.2 has now been superseded by Unit A1.1 which only states that "total vehicle hours saved" should be included.

Figure 4–15 Accuracy of Journey Time Forecasts for Do-Minimum Scenario by Time Period

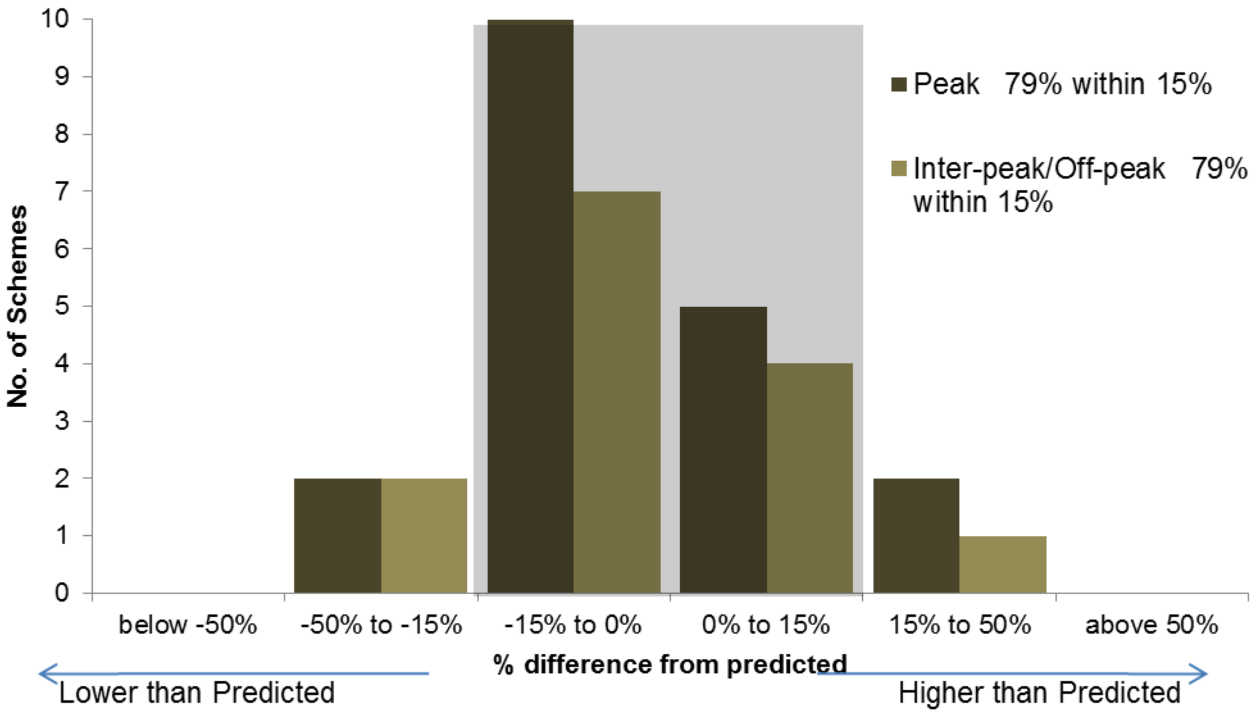


It can be observed from Figure 4–15 that the forecast journey times for the Do-Minimum scenario are more accurate for the Inter-Peak/Off-Peak than for the peak periods. The journey times for the Inter-peak/off-peak are more predictable than the peak periods as traffic conditions are less congested and more free-flowing. Delays increase significantly when traffic flows are close to the road or junction's capacity so small changes in traffic flow can have a significant impact on journey times.

It is noted that the majority of observed journey times for the peak hours are shorter than predicted. This is in line with the observed traffic flows being lower than predicted, thus reducing the level of delay.

Figure 4–16 shows the varying degree of accuracy of the forecast journey times for the peaks (AM and PM) and the Inter-Peak/Off-Peaks for the Do-Something scenario. This figure is based on data from 10 bypass schemes, 7 widening schemes and 3 junction improvement schemes (one of which in an outlier) for the peak periods. For the Inter-Peak/Off-Peak periods, the data is from 9 bypass schemes, 4 widening schemes and 2 junction improvement schemes (one of which is an outlier).

Figure 4–16 Accuracy of Journey Time Forecasts for Do-Something Scenario by Time Period



A high level of accuracy is achieved for the forecasting of journey times for the Inter-Peak and Off-peak time periods for the Do-Something scenario, as in the Do-Minimum.

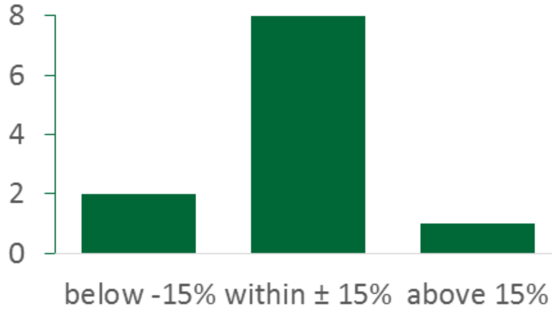
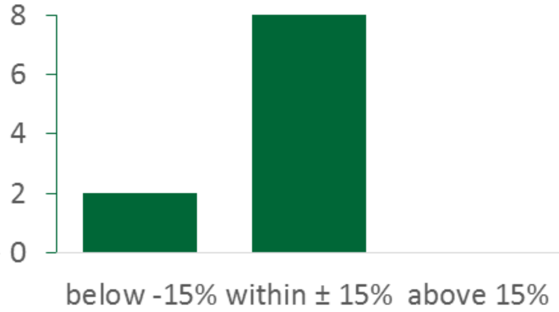
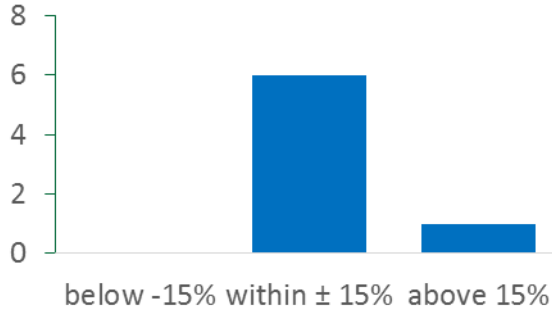
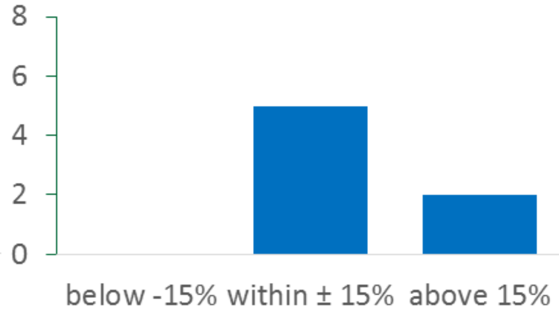
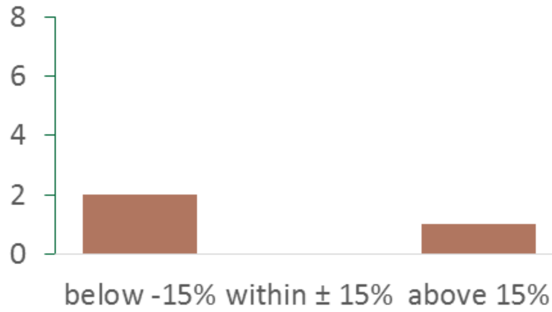
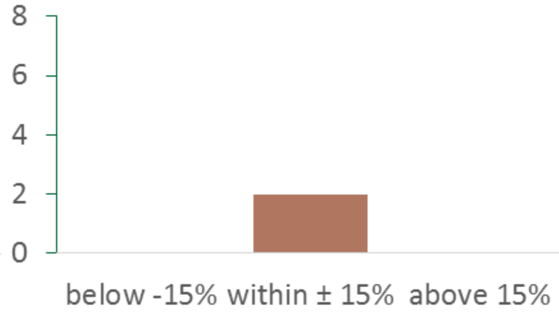
It can also be observed from Figure 4–16 that a higher level of accuracy is achieved for peak period journey times forecasts for the Do-Something scenario than for the Do-Minimum scenario, shown in Figure 4–15. This is due to the lower level of congestion in the Do-Something scenario, compared to the Do-Minimum, increasing the ease of predictability.

Journey Time accuracy by scheme type

Figure 4–17 shows the journey time forecast accuracy by scheme type for the Do-Minimum and Do-Something scenarios, for the peak periods. For the Do-Minimum scenario, the data is based on 11 bypass schemes, 7 widening schemes and 3 junction improvement schemes. For the Do-Something scenario, the data is based on 10 bypass schemes, 7 widening schemes and 3 junction improvement schemes, one of which is an outlier.

For bypass schemes, the journey times on the new road have been utilised. It should be noted that as only two junction improvement schemes have been included in this analysis, these do not necessarily provide a representative sample of all schemes of this type.

Figure 4–17 Accuracy of Journey Time Forecasts by Scenarios and Type

Type	Do Minimum accuracy : Number of schemes	Do Something accuracy: Number of schemes
Bypass	 73% within ±15%	 80% within ±15%
Widening	 86% within ±15%	 71% within ±15%
Junction	 0% within ±15%	 100% within ±15%

The following can be observed from Figure 4–17

- The journey time forecast accuracy for widening schemes is higher than for bypass schemes, for the Do-Minimum scenario. This is due to the higher level of traffic flow forecasting accuracy for widening schemes than for old and new roads for bypass schemes;
- The observed journey times for bypass schemes are predominantly shorter than forecast for the Do-Minimum and Do-Something scenarios. This is because on average, those bypass schemes have lower observed than forecast traffic flows; and
- The number of junction improvement schemes included in the analysis is too small to draw any conclusions.

Journey Time Savings

Figure 4–18 and Figure 4–19 show the relationship between observed and predicted journey time savings for the peak periods and the Inter-Peak/Off-peak, respectively. The schemes have been ordered based on increasing predicted journey time savings. The peak hour analysis is based on data from 16 bypass schemes, 19 widening schemes, 5 junction improvement schemes and one Smart motorway scheme. The inter-peak/off-peak analysis is based on data from 16 bypass schemes, 11 widening schemes and 3 junction improvement schemes.

Figure 4–18 Accuracy of Peak Hour Journey Time Savings (seconds)

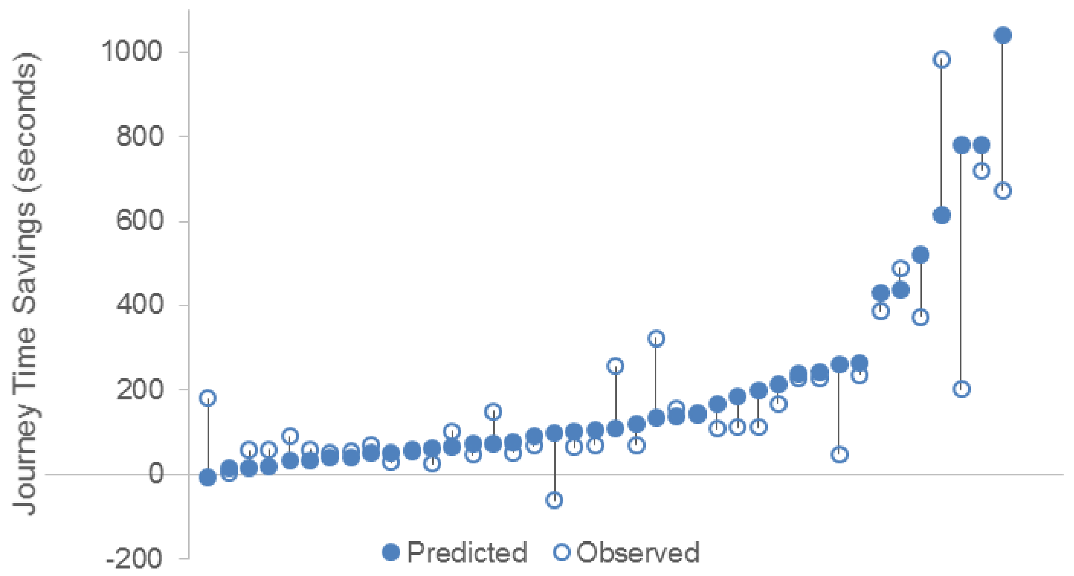
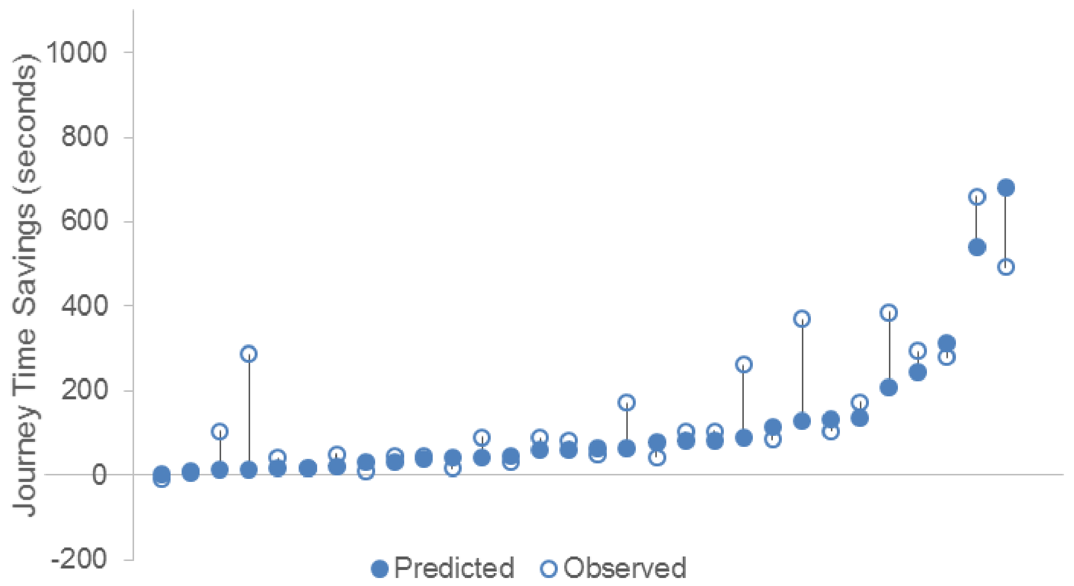


Figure 4–19 Accuracy of Inter-Peak/Off-Peak Journey Time Savings (seconds)



The following can be observed from Figure 4–18 and Figure 4–19:

- There is a good correlation between the predicted and observed journey time savings during both the peak hours and the inter-peak/off-peaks;
- The largest difference between observed and predicted journey time savings mainly occur for those schemes with the highest predicted savings. These are likely to be highly congested routes where journey times are less predictable;
- There are a number of significant differences in predicted and observed savings during the inter-peak/off-peak, when journey times should be easier to predict due to the lower levels of congestion. For the majority of these schemes the observed journey time savings are higher than predicted;
- 65% of the observed peak hour journey time savings are less than predicted, whilst only 32% of observed inter-peak/off-peak journey time savings are lower than predicted.

For the single Smart Motorway scheme, only journey time savings in the peak periods have been compared between forecast and observed. This demonstrates that the observed savings during the AM peak were lower than predicted and savings occurred during the PM peak when an increase in journey times had been predicted. This shows a low level of forecasting accuracy which is connected with the much higher than expected frequency of activation of the Hard Shoulder Running including the setting of the 60mph signals. However, a larger sample size would be required to draw any conclusions.

Reasons for variance between observed and forecast journey times

There are a number of reasons for differences between observed and forecast journey times, including:

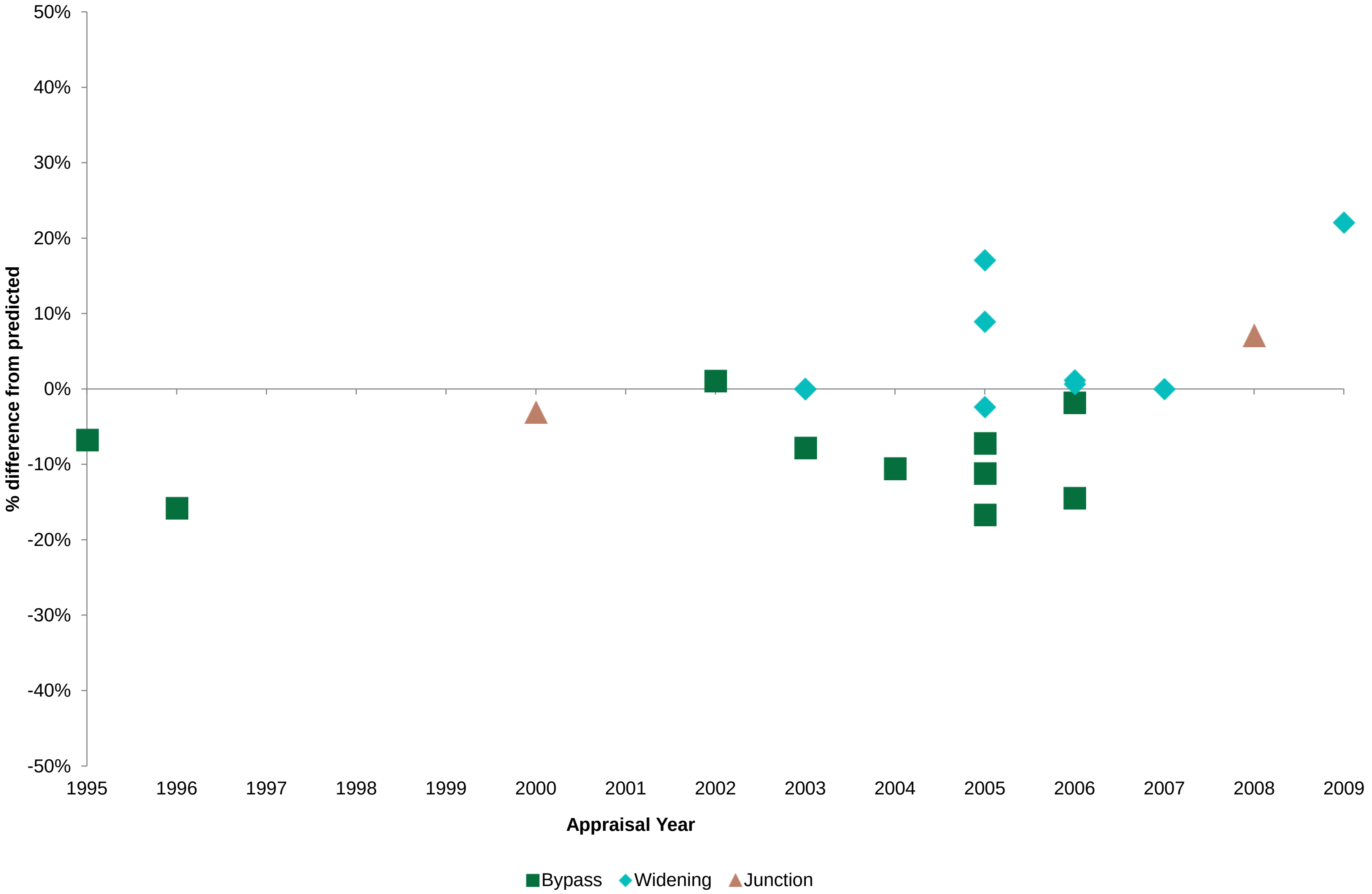
- Traffic flows notably higher or lower than forecast;
- Speed limit enforcements, such that observed speeds are limited to different speeds to those modelled; and
- COBA coding errors, such that junction delays are not modelled accurately.

It is noted that some schemes are affected by more than one of these reasons. It should also be noted that there is not a direct relationship between differences in traffic flows and journey times. For example, a higher observed than predicted journey time may be caused by higher traffic flows than predicted or the cause of lower traffic flows.

Accuracy of forecast journey times over time

The percentage difference between observed and forecast journey times by scheme type and appraisal year for the Do-Something scenario is shown in Figure 4–20. It can be observed that there has been no notable improvement in accuracy of journey time forecasting over time, although there is insufficient data from a wide enough range of years to draw any firm conclusions.

Figure 4–20 Accuracy of Journey Times Predictions for Do-Something Scenario by Scheme Type and Appraisal Year



4.4 Does more complex traffic modelling improve forecasting accuracy?

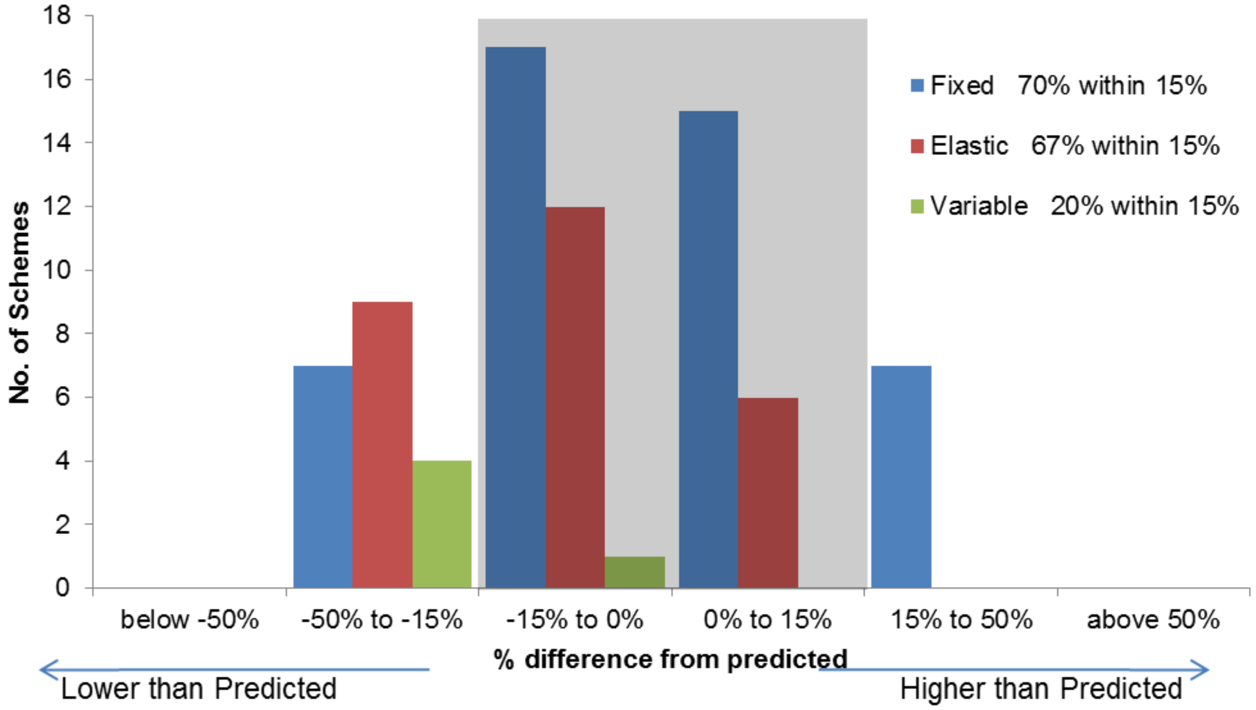
Modelling guidance has changed to encourage consideration of the impact road schemes have on the demand for travel.

Use of 'elasticity models' has improved forecasting accuracy compared to fixed demand models. There are currently too few variable demand models to draw any conclusions as to any advantage over elasticity models.

This section considers how the use of elastic assignments and variable demand modelling has affected the accuracy of forecast traffic flows. It should be noted that, at present, only five schemes using variable demand models are included in the schemes analysed. The comparison, therefore, is predominantly between fixed demand models and elasticity models, with 48[16] and 27 schemes, respectively.

Figure 4–21 shows the varying degree of accuracy of the forecast traffic flows for the Do-Something scenario for fixed demand, elastic and variable demand model approaches.

Figure 4–21 Accuracy of Forecast Traffic Flows by modelling methodology



It can be observed from Figure 4–21, that both fixed demand and elasticity models have approximately 70% of schemes with observed traffic flows within 15% of observed. It is noted that observed flows for fixed demand assignments are equally higher and lower than forecast. For elastic assignments however, observed flows are predominantly lower than predicted. Although this could indicate that elasticity is overestimating the increase in traffic flow due to a scheme, it is also likely that these schemes have been affected to a greater extent by the economic downturn which began in 2008.

The frequency graph for elasticity models has a narrower bandwidth than for fixed demand models, demonstrating that elastic assignments are more accurate. For example, 93% of observed traffic flows

[16] Including one outlier.

for elastic assignment schemes are within 25% of forecast flows. For fixed demand model schemes, however, only 81% of observed traffic flows are within 25% of forecast flows.

Schemes utilising variable demand models have the highest difference between predicted and observed traffic flows, with only 60% of observed traffic flows within 25% of forecast flows. It should be noted, however, that the sample size is small and as these schemes are the most recent they are likely to have been affected by the economic downturn more than the schemes undertaken using fixed and elastic models.

Figure 4–22 shows the percentage difference between observed and forecast traffic flows by modelling methodology and appraisal year for the Do-Something scenario.

Figure 4–22 Accuracy of Traffic Flow Forecasts for Do-Something Scenario by Modelling Methodology and Appraisal Year

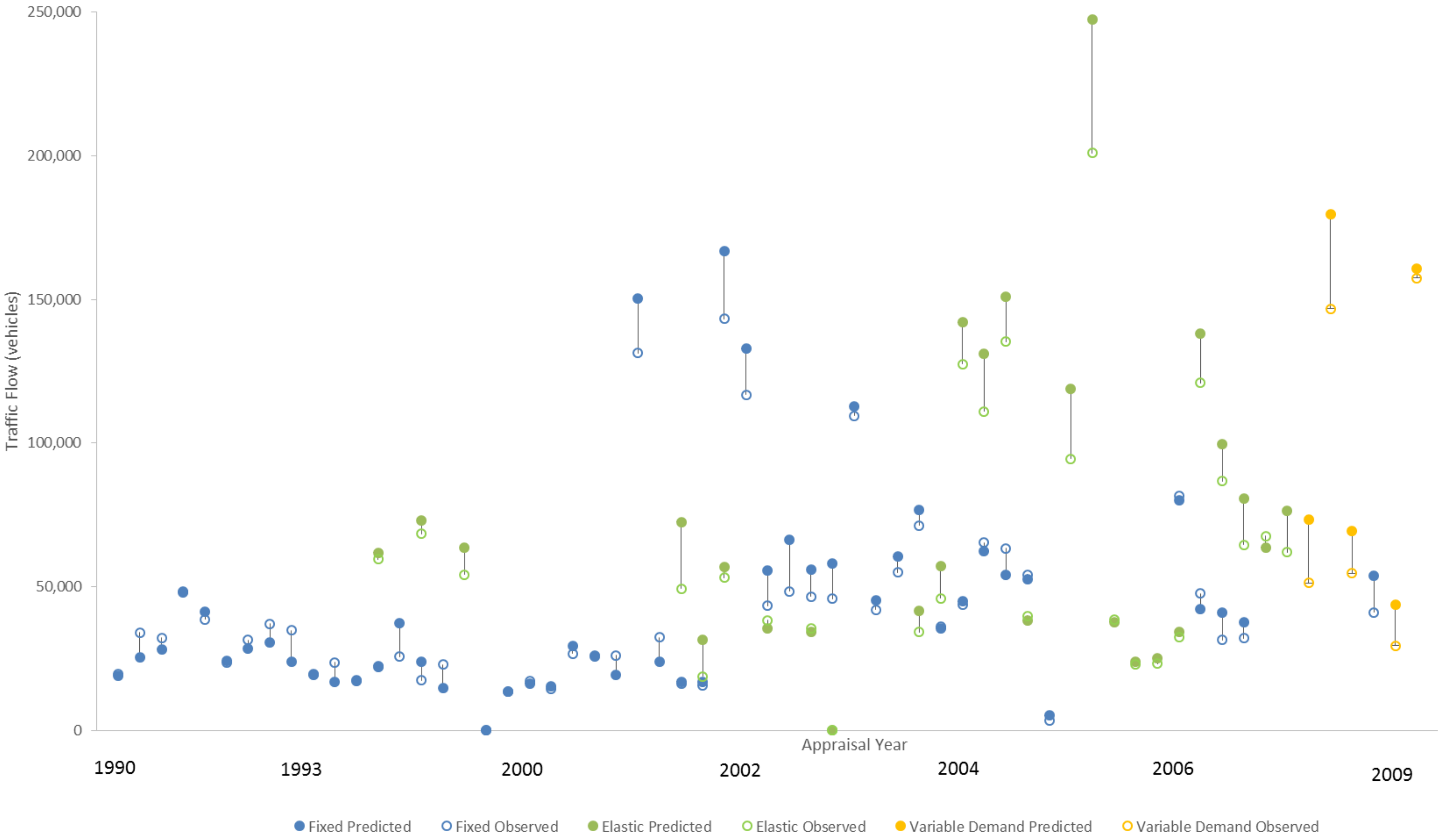


Figure 4–22 shows that due to the wide range of model forecasts, it is difficult to draw any firm conclusions over whether forecasting accuracy has improved over time for fixed, elastic or variable demand models.

4.5 Is there evidence of induced traffic?

Sometimes road improvements can lead to more people travelling. This is phenomenon is referred to as 'induced traffic'.

The majority of schemes, of all types, do not appear to have induced traffic. It should be noted that the lack of induced traffic in recent years may be due to the economic downturn. The reduced background traffic growth may also have masked any induced traffic.

Highway improvement schemes can impact upon traffic patterns over a significant area, leading to a number of demand responses. Changes in traffic flows on a road after the implementation of a scheme could be for a range of reasons including:

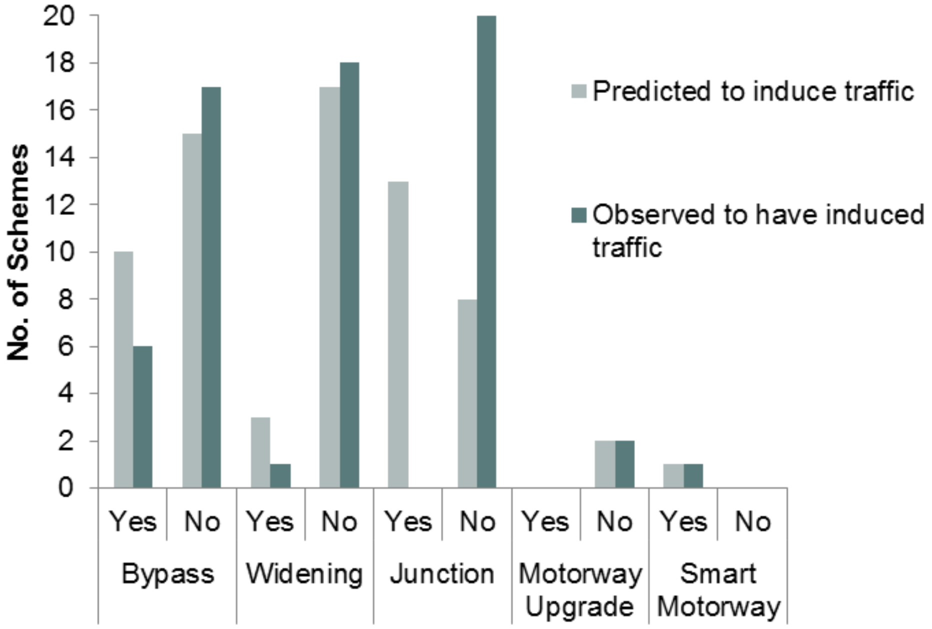
- General background traffic growth (that would have happened with or without the scheme);
- Reassigned traffic (people changing their route);
- Mode change (i.e. switching to or from public transport);
- Destination change;
- Time of travel change;
- Trip frequency increase; and
- Generated or new trips (e.g. from different land use patterns).

In the context of POPE, changes in background traffic growth and reassigned traffic can be identified using observed data. It is not possible, however, to distinguish between the other reasons for traffic flow changes listed above. For the purpose of this analysis, therefore, additional traffic due to changes in mode, destination, time and frequency, as well as new trips, are considered to be 'induced' traffic.

A review of individual scheme evaluations has been undertaken to determine whether induced traffic was predicted and observed. The predicted the level of induced traffic (if applicable) is usually referred to in the Traffic Forecasting Report. The level of observed induced traffic is generally derived through the analysis of pre and post opening 'screenlines' which aims to capture changes in traffic movements across a series of roads. It should be noted that there are limitations to the extent and confidence of conclusions that can be drawn from the data available. However, a considered approach has been taken in order to identify the most likely reasons for traffic flow increases and whether induced traffic has contributed to this increase.

Figure 4–23 shows the number of schemes with predicted and observed induced traffic for each scheme type.

Figure 4–23 Numbers of Schemes by Induced Traffic Prediction and Observation and Scheme Type



The following can be observed from Figure 4–23:

- Bypass schemes have the highest number of schemes observed to have induced traffic, with a total of 6. It is noted, however, that this is less than predicted and significantly less than the number of schemes which did not induce traffic;
- Almost all of the widening schemes were predicted not to induce traffic and this was observed to be the case. Similarly the 'upgrade to motorway' schemes were not predicted or observed to induce traffic; and
- For junction improvement schemes, the majority (13 No.) were predicted to induce traffic but none were observed to do so. In contrast, 20 junction improvement schemes were observed not to induce traffic.

The majority of all scheme types, therefore, were observed not to induce traffic. The following should be noted:

- Induced traffic may not have been realised for some schemes with later opening years due to the impacts of the economic downturn; and
- Induced traffic may have been masked by the reduced background growth due to the downturn. Hence this analysis should be treated with caution.

For the eight schemes that were observed to induce traffic, further analysis has been undertaken to determine the type of modelling undertaken (fixed, elastic or variable demand) and the level of forecasting accuracy for traffic flows. This shows that elastic and variable demand assignments were undertaken for 62% of the schemes with observed induced traffic. Of the five schemes using elastic and variable demand assignments, 60% had forecast traffic flows within 15% of observed. There is no clear evidence that the use of elastic or variable demand models have improved forecasting of induced traffic based on the POPE schemes available.

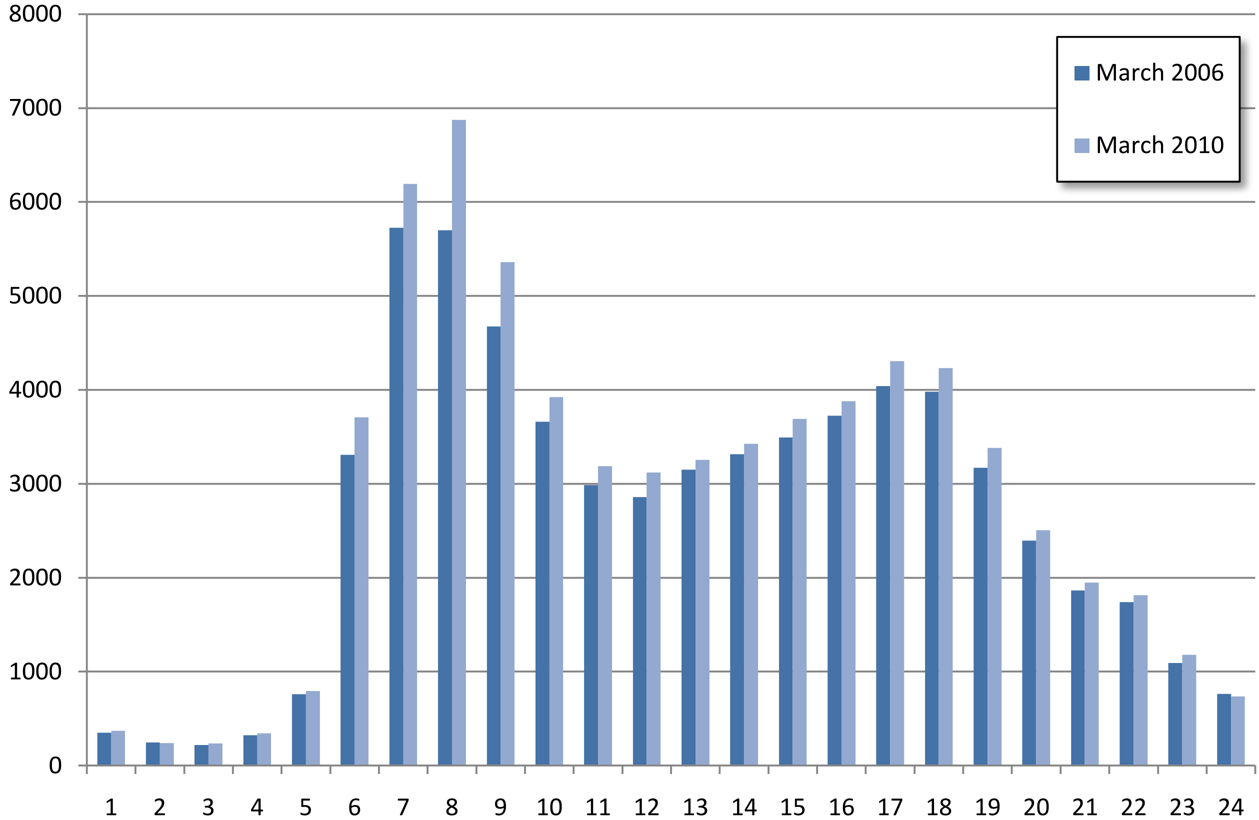
4.6 Is there evidence of change in peak spreading?

The limited data available on peak spreading shows a reduction for the majority of schemes. However, the general rerouting of traffic onto the scheme road from other routes, increasing traffic flows for all hours, can mask a reduction in peak spreading.

The 'before' and 'after' hourly traffic flows have been analysed for 15 schemes to determine whether there has been a change in peak spreading. It should be noted that for the majority of schemes, there is an increase in traffic flow for all hours of the peak periods and inter-peak due to rerouting of traffic onto the scheme from other routes. This rerouting can mask a reduction in peak spreading which is identified as a sharpening of the peak (i.e. more traffic during the peak hours and less traffic on the peak shoulders or inter-peak).

An example of a reduction in peak spreading is shown in Figure 4–24 for the A2-A282 Dartford Improvement scheme.

Figure 4–24 A2 westbound between M25 J2 and Bean hourly flows (weekdays in early March)

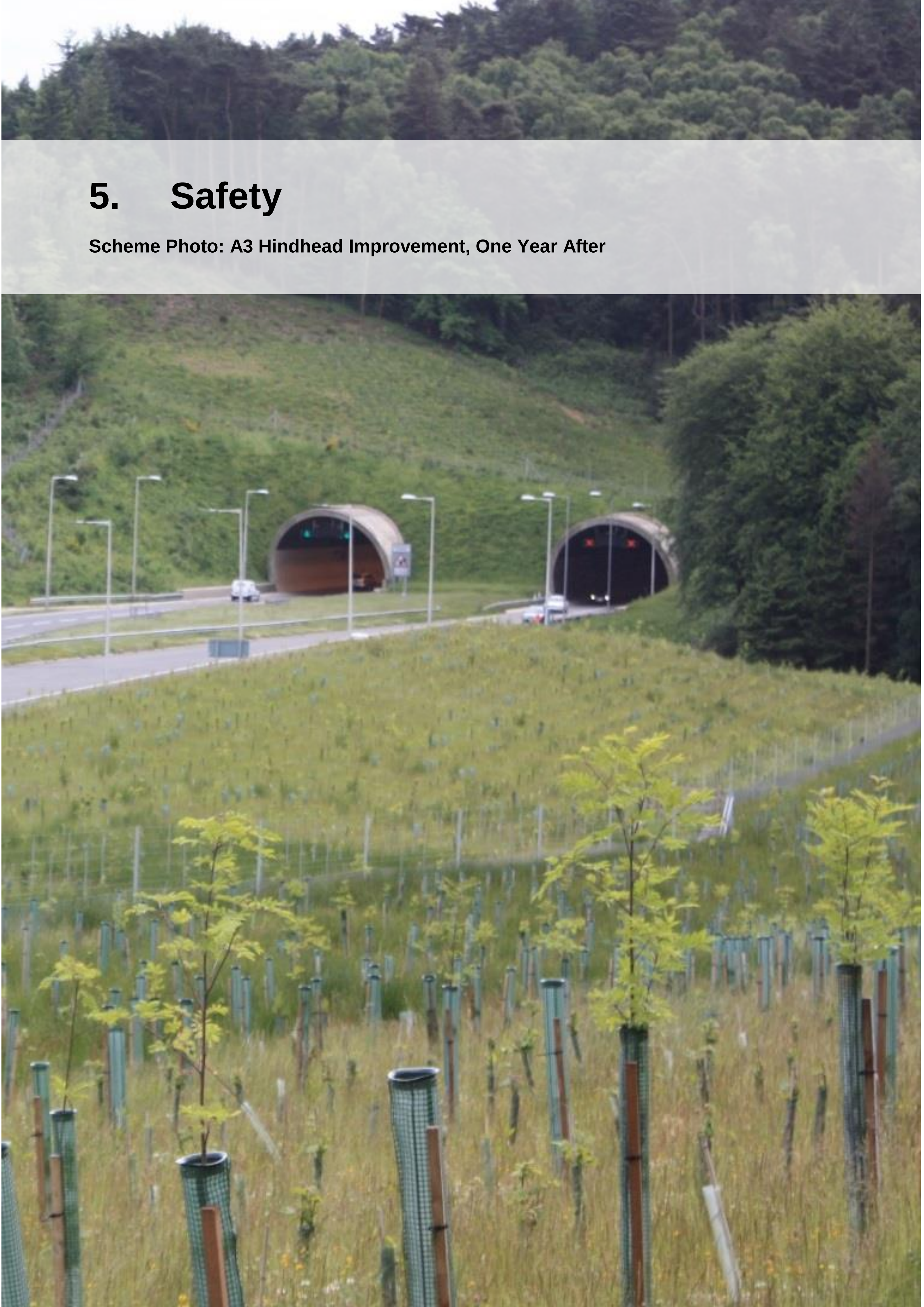


It can be observed from Figure 4–24 that during the 2006 AM peak, the traffic volume flow profile has flattened due to a lack of capacity. Following the scheme improvement, in 2010, there is a sharper peak with the traffic flow at 07:00-08:00 significantly higher than 06:00-07:00. This demonstrates that the level of traffic during the peak hour is suppressed in the Do-Minimum scenario resulting in traffic travelling during other hours. The scheme provides additional capacity enabling more traffic to travel at its preferred time.

For the 15 schemes analysed (5 bypass schemes, 7 widening schemes, 2 junction improvement schemes and 1 smart motorway), nine of the schemes potentially reduced peak spreading. These consisted of 4 bypass schemes, 4 widening schemes and 1 junction improvement.

5. Safety

Scheme Photo: A3 Hindhead Improvement, One Year After



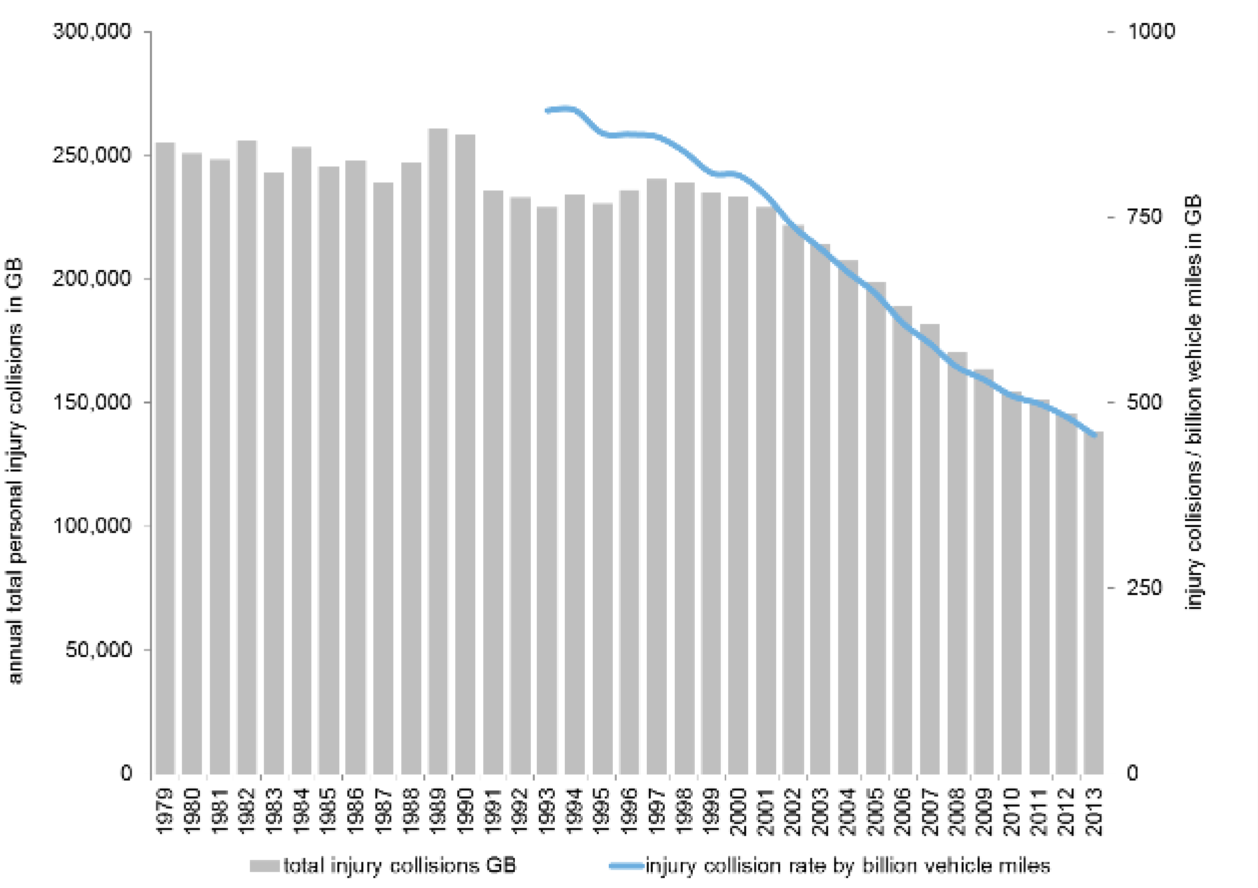
5. Safety

The DfT guidance on the appraisal of transport schemes (WebTAG) has a specific objective relating to considering the safety impacts of transport interventions. Also, one of the objectives contained within the Highways Agency Business Plan 2014-2015 is to 'ensure the safe operation of the network'. The majority of Major Schemes have a scheme-specific objective relating to safety.

POPE assesses the impact of Major Schemes on safety primarily through the use of accident data collected by the police. This data, known as STATS19, only covers personal injury collisions, not damage only collisions. Although the data used is not necessarily derived from the nationally validated statistics provided by the DfT, as it is sourced from Local Processing Units through either the HE's Managing Agent Contractors (MACs) or Local Authorities, it is considered sufficiently robust for use in this context.

The POPE approach to the evaluation of safety impacts compares the annual average number of injury collisions in a defined road network in the five year period prior to the start of construction with the annual average for the same area, including any new road sections constructed as part of the Major Scheme, in the post opening period. Previously, the net change in the annual average number of injury collisions has been deemed to be primarily attributable to the scheme as that is typically the greatest change to have occurred to the road network during that time period. This assumption used as the basis of the POPE approach was reasonable at the time POPE commenced in 2001. Long term trends in collision numbers only became clear with hindsight, and it is now clear that that there has been a substantial year-on-year reduction in the collision rate since 1998. This trend is shown in Figure 5-1 for the numbers of collisions and the rate taking into account traffic levels.

Figure 5-1 National trend in Personal Injury Collisions 1979-2013[17]



[17] Source: DfT tables RAS10002, RAS10013 Reported personal injury road accidents, by severity, Great Britain, 1979-2013.

Further investigation of data collected by the DfT shows that this reduction applies to all road types and across the country.

Now that the background decline in collisions in an established trend, it is clear that POPE scheme evaluations should not be ignoring this trend. In theory, if the Major Scheme had not been built the chances of collisions occurring and resulting in injury would have reduced due to a range of factors unconnected to the scheme including improved vehicle safety and a reduction in younger drivers. The POPE methodology for the evaluation of collisions has now been revised. For the before and after comparison, a counterfactual scenario is now created for the ‘without scheme’ in which, if the scheme had not been built, it is assumed that the collision rate within the study area would be that observed in the before period but reduced in line with the national trend. This adjustment is based on the national trend derived from the DfT collision data between the middle years of the two time periods being compared. The reported net impact on collision numbers now becomes the difference between the before data (adjusted for background trend) and the observed after data. It should be noted that this approach of including the national trend data will mean that collision benefits of Major Schemes are reduced and in some cases there may be net disbenefits.

Fifteen schemes have been evaluated using the new collision methodology. To ensure consistency, the majority of the analysis presented in this section of the report is based on the fifteen schemes. Any conclusions drawn from this analysis should be taken with caution due to the small sample size involved. For sections of the analysis where the entire dataset has been used, this will be clearly indicated.[18]

The remainder of this section considers the following lines of inquiry:

- What impact do Major Schemes have on the number of collisions?
- How accurate are safety predictions?
- What are the changes in observed collision rates by road type?

5.1 What impact do Major Schemes have on the number of collisions?

The sample size available is very small to draw meaningful conclusions. However, there is evidence to suggest that

- **Statistically significant reductions in collision numbers, as noted for some Major Schemes, confirms the safety benefit.**
- **Bypass schemes are the most successful type of scheme in terms of improving safety.**

Figure 3-1 on page 19 earlier in this report shows that 71 schemes had an objective relating to safety, and 62 (87%) of these schemes were successful in achieving their safety objective. It should be noted that the majority of these schemes were evaluated using the POPE methodology which ignored the background change in injury collisions shown in Figure 5-1 earlier.

This section looks in more detail at the 15 schemes which were evaluated using the new POPE approach of taking account the background reduction.

Figure 5-2 presents the annual change in collision numbers (and percentage change) by scheme type for all 15 evaluations, irrespective of whether the POPE evaluation is a one or five year after opening study. This does include results from a number OYA reports, some of which are not statistically significant. These were included to increase the sample size.

[18] The Meta-analysis 2013 contained a bigger sample size because it considered all Highways England Major Schemes evaluated at this stage, with no schemes removed due to a change in evaluation methodology. All the schemes excluded here were included in the 2013 report.

Figure 5-2 Annual change in collision numbers by scheme type (OYA and FYA evaluations)

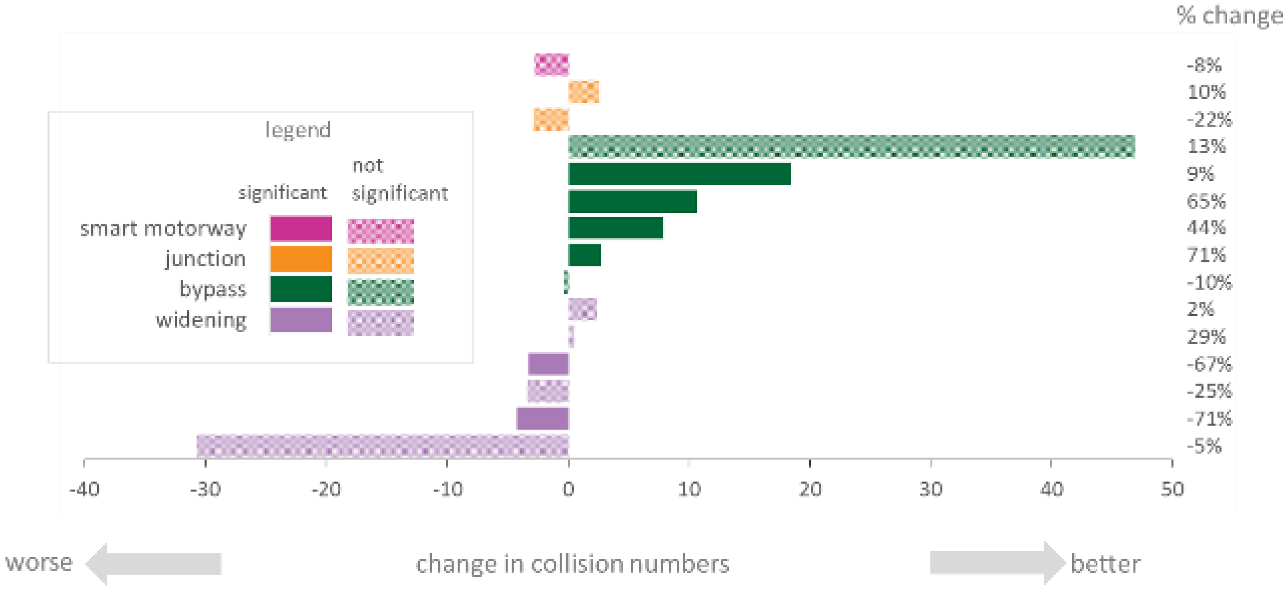


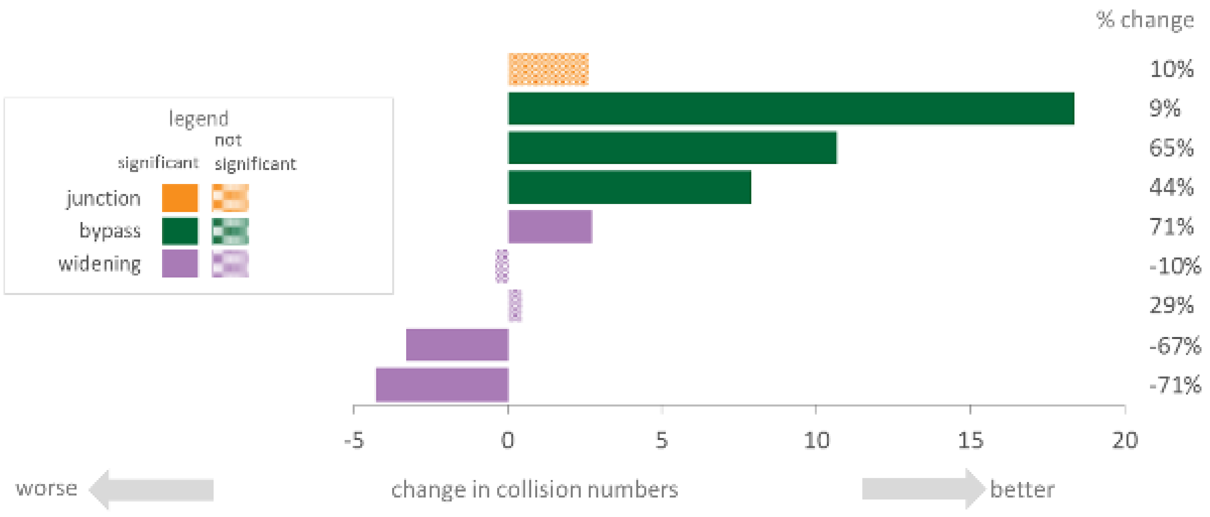
Figure 5-2 shows that:

- Eight schemes have experienced a reduction in collision numbers. Seven schemes have experienced an increase. (However, some of these changes are not necessarily statistically significant[19]).
- It is clear that bypass schemes have been the most successful in reducing the numbers of collisions. These types of schemes typically provide savings for users of both the new route and former route, and for the roads in the wider network due to traffic rerouting to the safer road. Therefore it is not surprising that bypass schemes are providing a large benefit.
- The collision numbers have typically increased on the widening schemes. This category encompasses many different sizes of scheme ranging from climbing lanes to major motorway widening schemes.
- The sample size for junctions and smart motorways is too small to draw meaningful conclusions.
- Four of the six schemes with statistically significant results experienced a reduction in collision numbers.

Collision data observations are generally considered to be more robust when observed over a greater time period and it may be the case for some schemes that, in the first year post opening traffic behaviour may be atypical of long term trends. Figure 5-3 therefore presents the results for the FYA evaluations within this dataset. This reduces the sample from 15 to nine schemes. This shows that the patterns relating to bypasses showing an improvement and widening schemes showing a worsening remains.

[19] Statistical significance of changes in collision numbers is assessed through the use of the chi squared test.

Figure 5-3 Annual change in collision numbers by scheme type (FYA evaluations only)



5.1.1 Are collision savings improving over time?

Figure 5-4 presents the annual collision saving over time (using scheme opening year) for all 15 schemes. This shows that although the two largest net changes in collision numbers occurred on schemes opened in 2012 (OYA studies), the small sample size means that there is no clear evidence to suggest that collision savings derived from Highways England's Major Schemes are getting better or worse over time.

Figure 5-4 Annual collision saving by scheme opening year

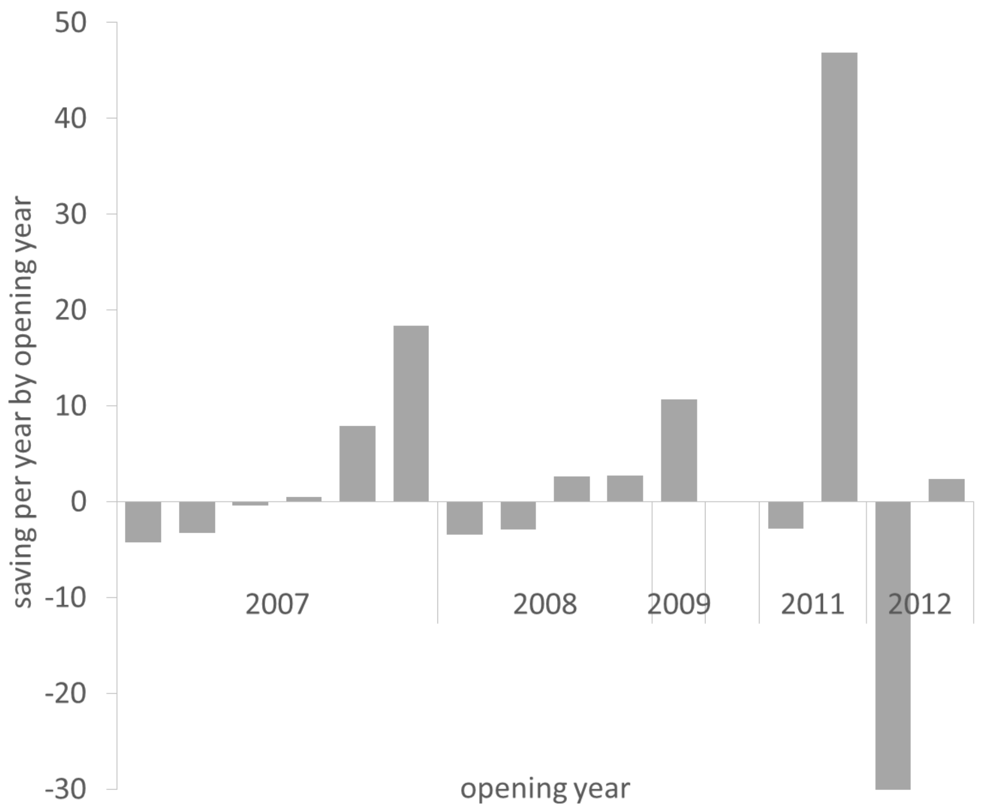


Figure 5-5 presents the median savings in fatal and serious collisions by opening year for all the schemes within this Meta-analysis sample. However, it should be noted that that no allowance has been made for the background reduction in collisions in this analysis. The recent schemes have had their opening years grouped together to ensure a sufficient sample size.

Figure 5-5 Median savings in fatal and serious collisions by scheme opening year (all schemes)

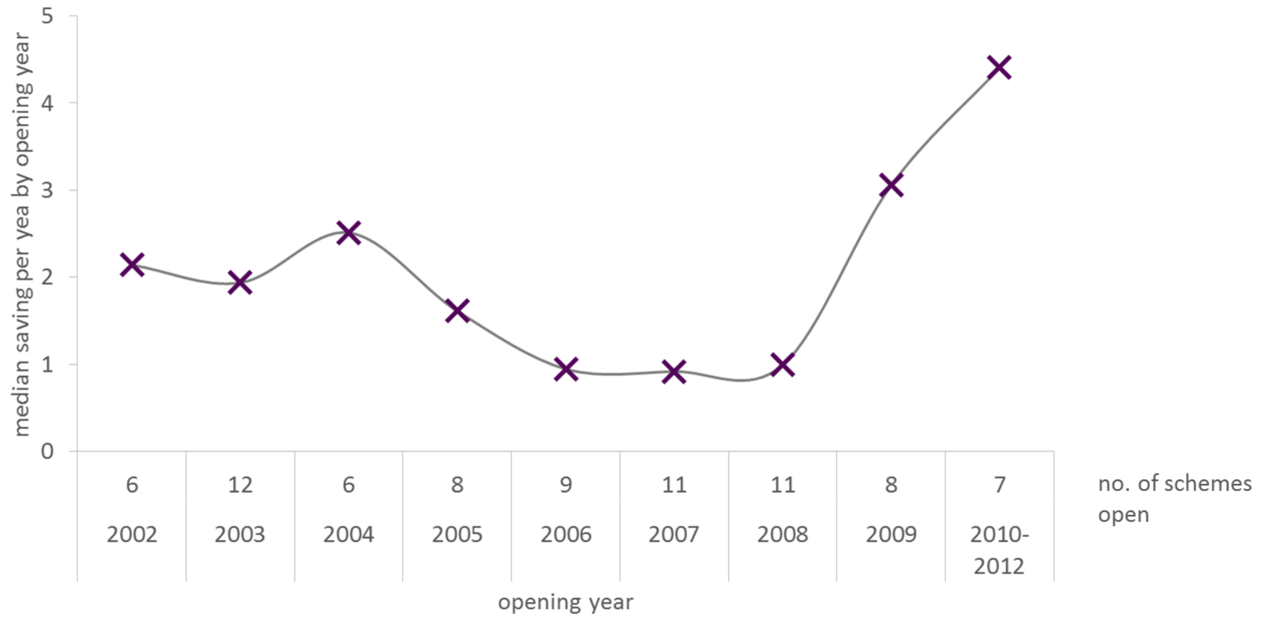


Figure 5-5 shows that the schemes with more recent opening dates have experienced a greater reduction in the numbers of serious and fatal collisions.

5.1.2 Collision savings by area

Where possible, the POPE evaluation will undertake an analysis of the before and after collisions over the following areas:

- Study area – This is typically the same area (or as close as possible) as that used for the appraisal of the collision impacts.
- Narrow area – These are for the ‘key links’ which are all of the roads which have been altered as part of the scheme.

It is not always possible to undertake a POPE analysis over both areas because of one or more of the following factors:

- The study area used in the appraisal of collision impacts may be unknown.
- The study area used in the appraisal may be very large making it impractical to collect observed data over such a large area.
- The study area used in the appraisal may be very small because the impacts are localised. (I.e. the study area is the same as the narrow area).

Figure 5-6 presents the collision savings for each scheme by opening year. Nine of the schemes have results for both the study area and the narrow area. Six of the schemes have results for the narrow area only because of one or more of the reasons outlined above.

Figure 5-6 Comparison of collision savings over study area and narrow area by opening year

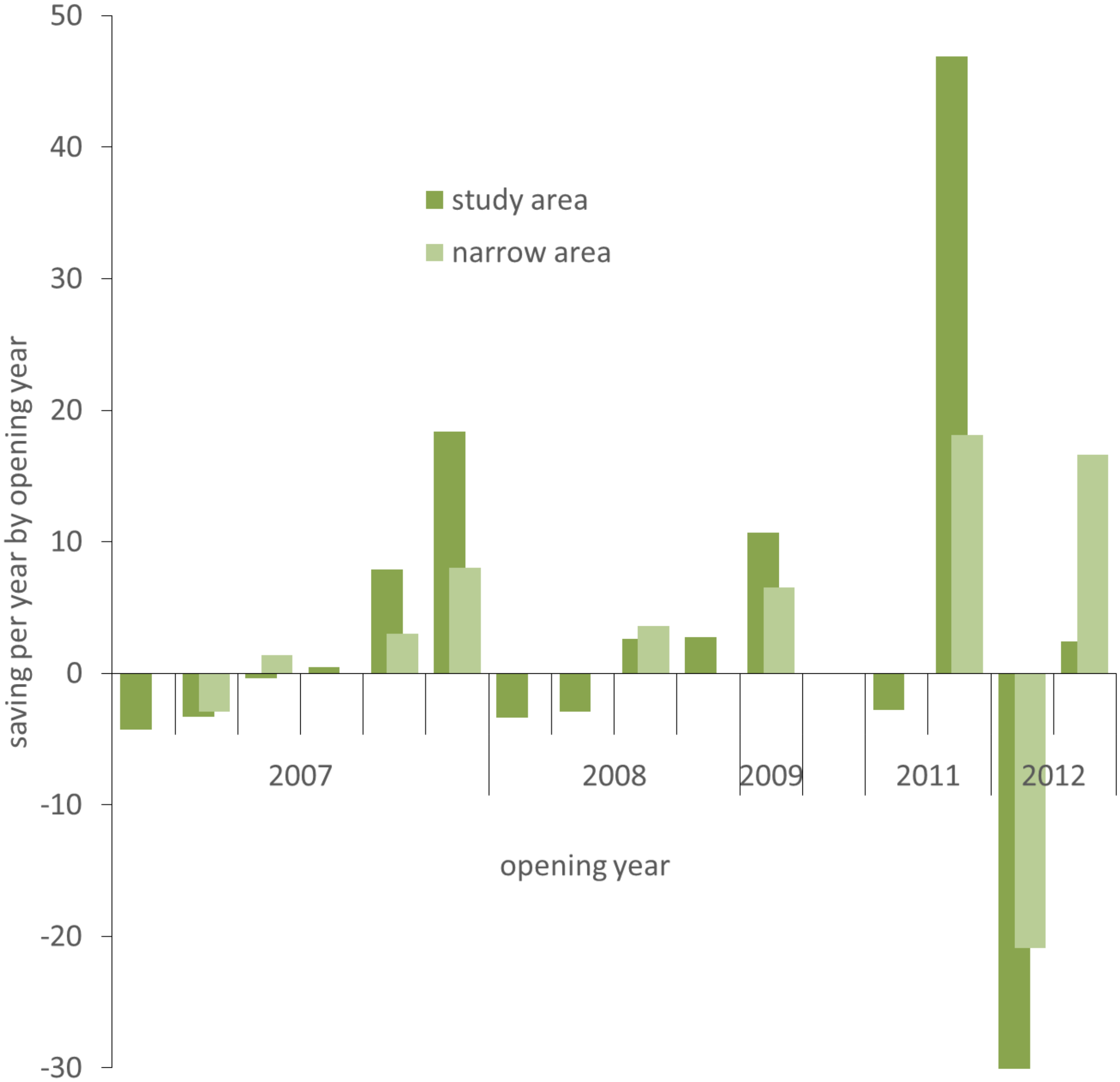


Figure 5-6 shows little pattern in the results for those schemes where a wide/narrow area analysis has been undertaken. Of the nine schemes with analysis carried out over the two areas, 5 have better results within the narrow area of the scheme's key links, meaning that the wider area showed a net increase in collisions over the same period.

5.1.3 Statistical significance of collision savings

The statistical significance of collision savings is presented in Figure 5-7. This shows that six schemes did not have a significant saving, so the change could have occurred by chance and may not necessarily be attributed to the scheme. Six schemes had collision savings over the wider area and three of schemes had a saving over the narrow area (but not the wider area).

Figure 5-7 Statistical significance of collision savings

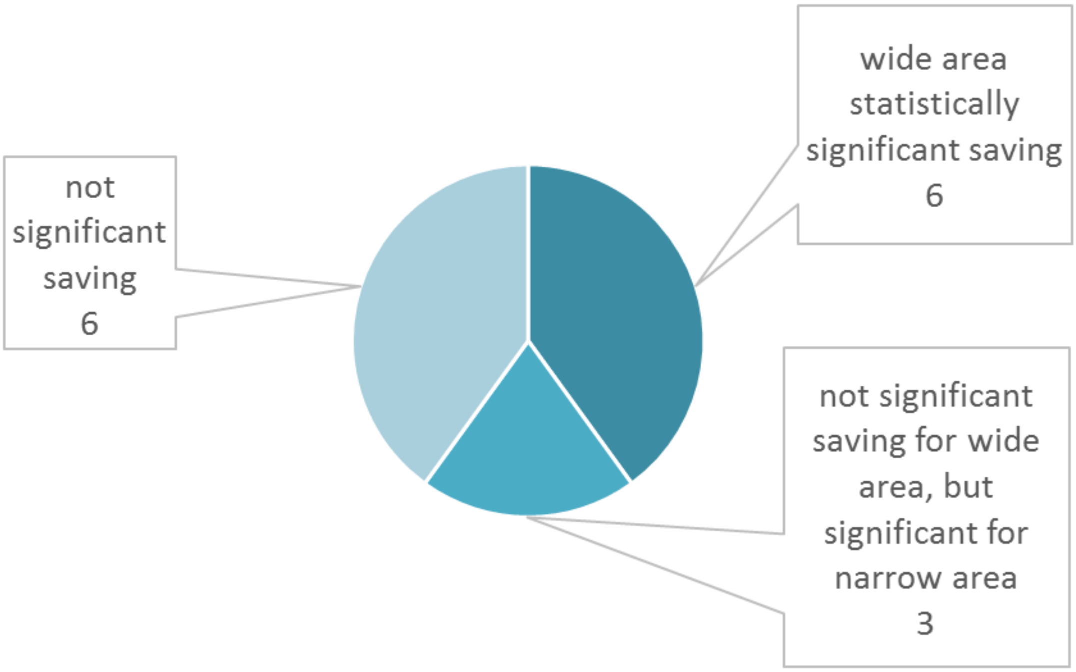
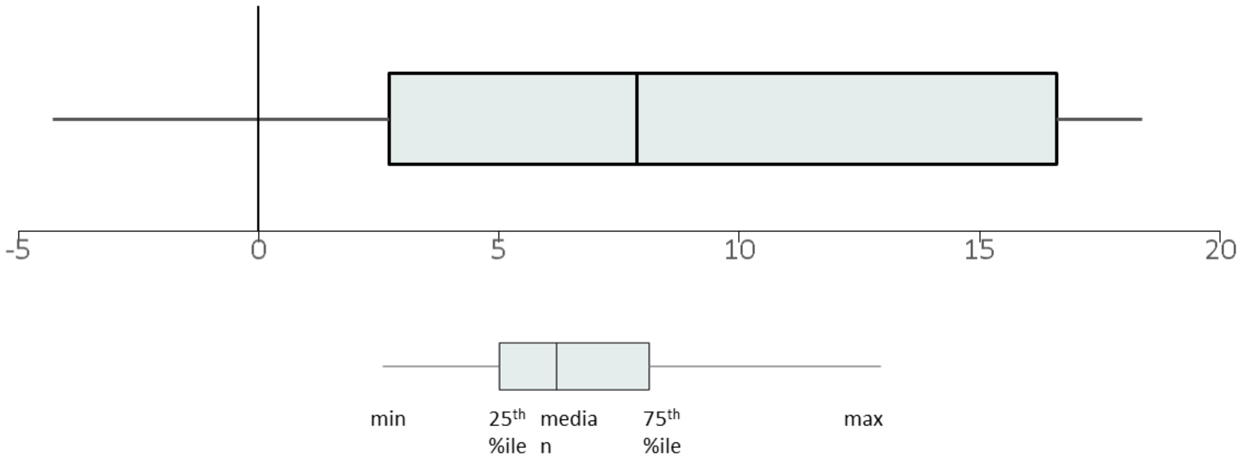


Figure 5-8 presents the collision savings for the nine schemes with statistically significant impacts. This takes the savings from the wide area if statistically significant, if not statistically significant, then it considers the savings from the narrow area (but only if this is statistically significant). This shows that these schemes are delivering safety improvement with a median saving of 8 collisions per year. The range of collision impacts is quite large with -4 saving on one scheme and +17 saving on another scheme.

Figure 5-8 Range of collision savings for the schemes with statistically significant impacts



5.2 How accurate are safety predictions?

Accuracy of collision safety predictions is poor. Less than half of schemes have accident savings within 50% of the prediction.

POPE evaluations undertake a comparison of the observed collision savings with the forecast collision savings made at the time of the scheme's appraisal to determine if the forecasts were accurate. The meta-analysis of safety impacts explores the accuracy of the forecasts to determine if there are any trends, such as under or over prediction of collision savings. The 2013 Meta-analysis included an analysis of forecasting accuracy by scheme type. This analysis has not been repeated because the sample size is not sufficient to undertake a robust assessment.

Collision savings for Major Schemes are typically forecast using modelling software called COBA (**CO**st **B**enefit **A**nalysis). This gives predictions of the numbers of injury collisions. This gives predictions of the numbers of injury collisions in a defined network of roads with and without the scheme in place (known as Do-Minimum and Do-Something scenarios). Although this tool is primarily for predicting the longer term impacts of the scheme, it does also provide forecasts for the impacts in the opening year and design year (15 years after opening). From these forecasts, POPE has identified that the predicted annual savings for each of the first 15 years tend to be very similar, this is reasonable to assume for POPE FYA studies to compare the predicted opening year saving with the average annual saving in the first five years post opening.

Figure 5-9 presents the accuracy of collision savings by scheme type. Positive numbers denote a saving, negative numbers denote a disbenefit.

Figure 5-9 Accuracy of collision saving forecasts by scheme type

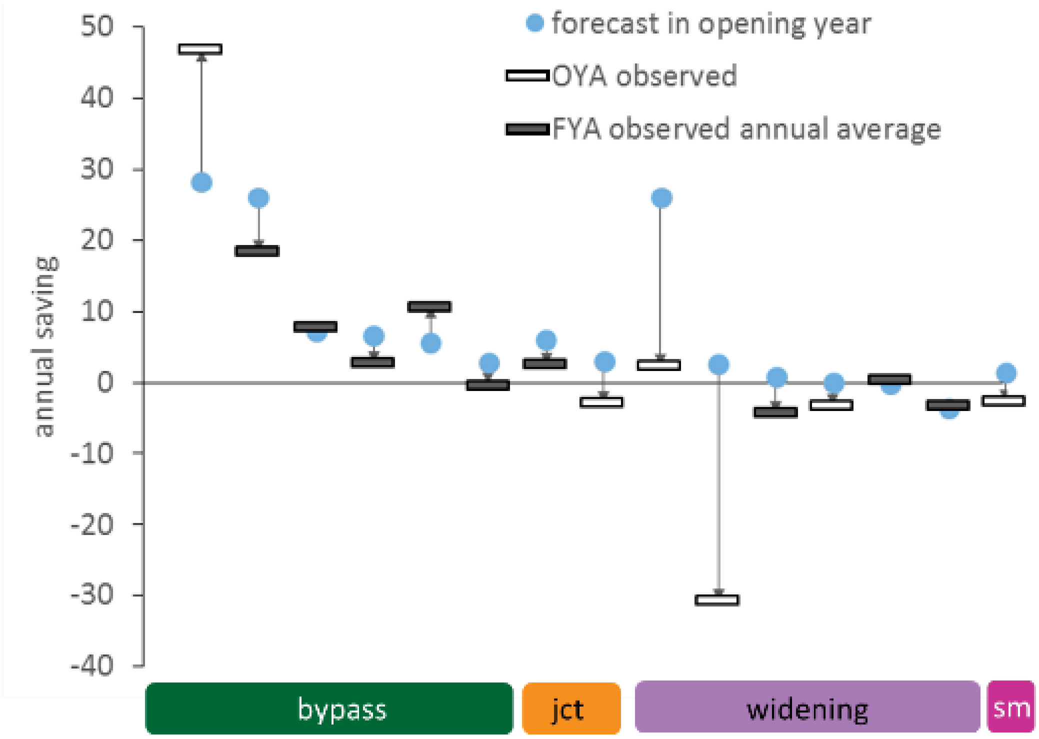


Figure 5-9 shows that:

- There is high degree of variability between the forecast opening year collision saving and the observed annual average saving, particularly for bypass schemes.
- Four (27%) of schemes had collision impacts which were better than expected. Eleven (73%) of schemes had collision impacts which were worse than expected. The background collision reduction factor applied to the observed data will have impacted upon these results.

Although not shown on the graph, these results show that two schemes have a forecasting accuracy between ± 15% and three schemes within ± 50%. The majority of schemes (67%) are worse than 50% out.

5.3 What are the changes in observed collision rates and how does this change compare to forecasts?

Major Schemes which have involved improvements to A roads have seen a considerable decrease in the collision rate.

Motorways typically have low collision rates compared to other types of road. Major schemes involving improvements to motorways have resulted in little change to these rates. The DfT collision rate forecasts for four lane motorways are broadly in line with those observed.

The collision rate is produced by dividing the number of personal injury collisions by the number of vehicle kilometres travelled (PIC/mvkm).

5.3.1 Observed collision rates

Excluding one junction scheme[20], the before and after collision rates for the 14 schemes with the background collision reduction considered are shown in Figure 5-10. The results have been grouped by post opening road type.

Figure 5-10 Change in observed collision rates by road type

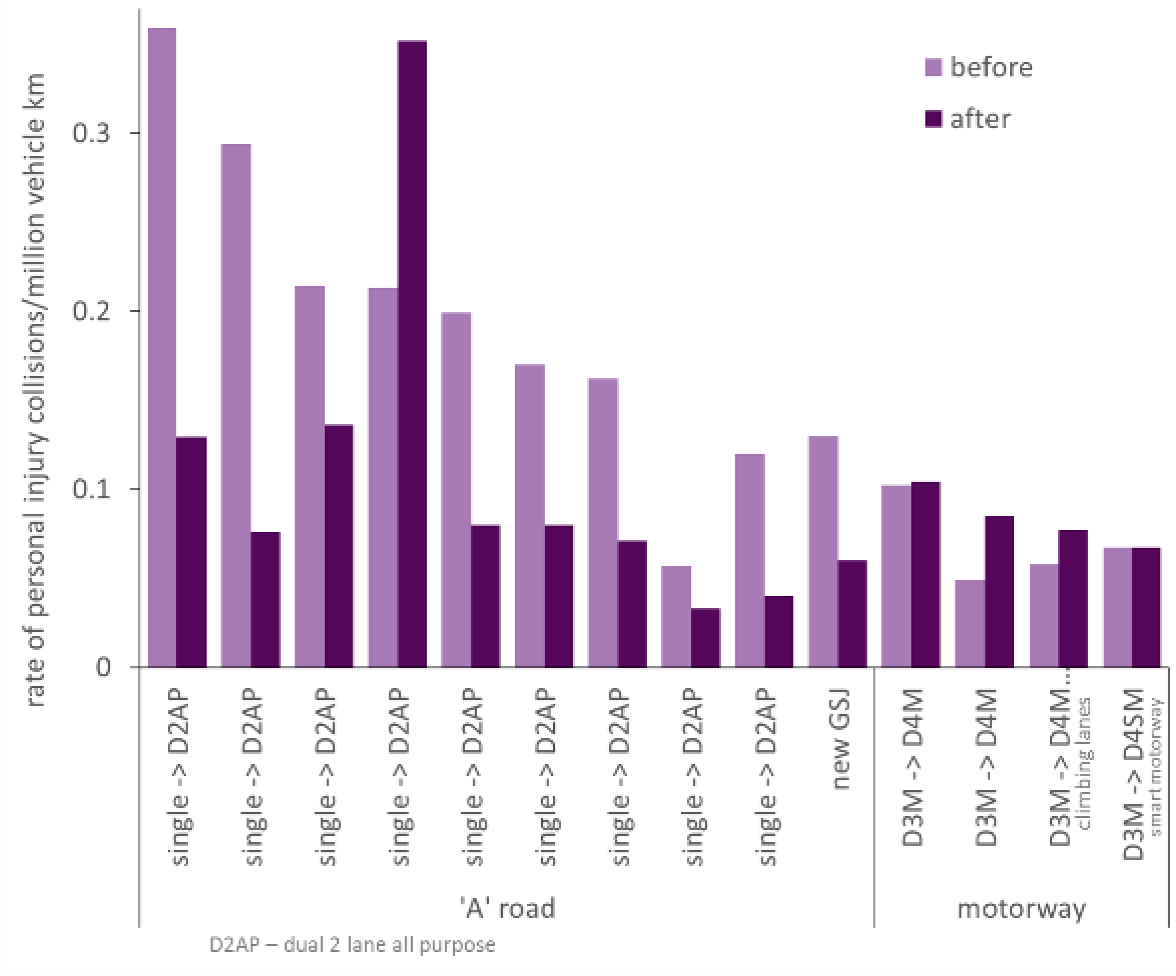


Figure 5-10 shows that:

- Nine out of 10 (90%) of schemes involving improvements to A-roads have been successful in reducing the collision rate. In many instances it can be seen that the collision rates have more than halved. This is likely to be due to the nature of the schemes implemented in this category which often involve a considerable change to the quality of the route through segregating traffic

[20] It is not possible to calculate a collision rate by distance for a junction scheme.

by direction, improved junctions, removal of local road accesses and improved alignment and visibility of the road in line with modern standards.

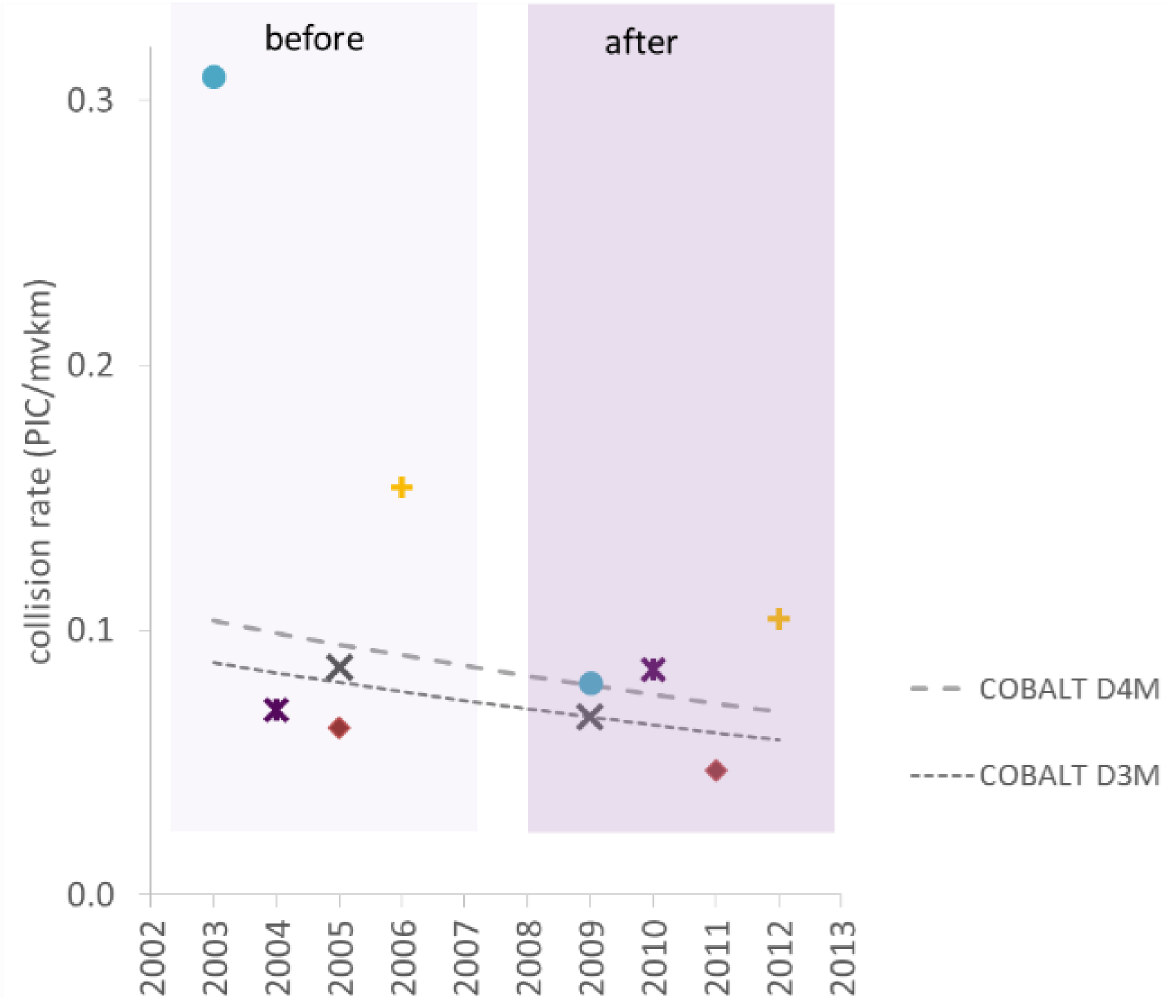
- Motorways typically have lower collision rates than ‘A’ roads, even dual carriageways, due to restricted access and full grade separation and the four schemes here were not showing higher collision rates in the before period.
- The impact of Major Schemes on motorway collisions rates is negligible with two schemes showing little change and two schemes showing a worsening. This is likely to be due to the fact that the motorway schemes (such as widening and climbing lanes) do not result in such a step change in the quality of the network compared to the ‘A’ road improvement schemes.

5.3.2 Comparison of observed and forecast collision rates on motorways

COBALT (**Co**st and **B**enefit to **A**ccidents – **L**ight **T**ouch) is a computer programme developed by the DfT to undertake the analysis of the impact on collisions as part of the economic appraisal for a road. It was introduced in 2013 to supersede COBA and is the current package used by Highways England to appraise the safety impacts of Major Schemes in line with the DfT’s webTAG guidance

Figure 5-11 presents a comparison of the observed before and after collision rates for the five motorway widening schemes which were from three to four lanes (D3M to D4M) and compares these rates to the current assumptions used in the COBALT[21] software. Collision rates by road type are a key input into COBALT and these are provided by the DfT to ensure consistency in analysis across multiple schemes. The collision rates are modelled to change through time (as shown by the dashed lines presented in Figure 5-11 which shows that the COBALT collision rate for motorways depends on the number of lanes).

Figure 5-11 Comparison of observed collision rates[22] compared to the modelled collision rates within the COBALT software



[21] COBALT version 2014.3.
[22] The observed before scheme collision rates in this graph have not been adjusted to take into account the background change in collisions. This adjustment is not required in this instance because the results are presented by year.

Figure 5-11 firstly shows that the observed collision rates for three lane motorways (D3M) before construction of the widening schemes vary considerably which may be due to the impact of problems experienced on all of them, as identified by their inclusion within the Major Scheme programme. Congestion issues are generally the primary objective behind motorway widening schemes, rather than safety but the before scheme collisions rate may be untypically high as a consequence of the congestion problems.

6. Economy

Scheme Photo: A2/A282 Dartford and M25 Junction 1b-3 Improvement, Five Years After

6. Economy

6.1 What are the main benefits of Major Schemes?

Journey time benefits are the key monetary benefits derived from Major Schemes, accounting for 79% of all monetary benefits. Safety benefits (as measured by reductions in numbers of injury collisions) form the second largest contribution.

The average total monetary benefit for schemes appraised over the standard 60 years is £117.5million, and £86.7million for schemes appraised over 30 years.

Other impacts which are appraised to have monetary benefits, positive or negative, include changes to the users' vehicle operating costs, indirect tax impact for the Treasury, and cost of delays during construction and future maintenance periods. In total, these average only an average 1% net impact.

The Treasury is expected to benefit from many schemes, through a net increase in indirect tax revenue but on average, this impact is less than £1million.

Widening schemes have substantially higher average total benefits per scheme than bypass and junction schemes. However, the greatest benefits are seen in the four schemes which were an upgrade to motorway and the one smart motorway scheme; all of these where larger schemes. Safety benefits are the highest for bypass schemes which is due to these types of scheme including the greatest step change in road standard.

Highways England's Major Schemes are subject to cost-benefit analysis (CBA) when they are appraised. This compares the costs of building the scheme against the monetised long term impacts following the completion of the scheme, here termed benefits.

The period in question is defined by the Treasury for major Government investments. During the period in which the Major Schemes within this Meta-analysis were appraised, the time period has changed from 30 to 60 years. The post opening evaluation of the benefits for each scheme has been undertaken on the basis of using the same period as that in the appraisal, to allow a like-for-like comparison between predicted and outturn benefits

The post opening economic evaluation is based on using observed outturn data (including traffic flows, journey times and collision information) to calculate a reforecast of the benefits stream now expected over the appraisal period. This reforecast is termed the 'outturn benefit'. These figures for outturn benefits are critical to answering the question as to whether the scheme will be value for money discussed later in Section 6.4.

The cost benefit analysis of transport schemes is based on monetising a range of impacts in line with the current DfT guidance set out in WebTAG. The impacts which are applicable for highway Major Schemes and the POPE evaluation are summarised in Table 6-1. For highway schemes, the predicted monetised benefits are normally positive, but can also be negative, in which case they are termed disbenefits.

Table 6-1 shows the main benefit streams associated with highway schemes and briefly explains how they are considered as part of the POPE process.

Table 6-1 Monetisation of Major Scheme Benefits

Period	Impact	Post Opening Project Evaluation approach	
		Outturn evaluation	**Background**
Construction phase	Delays to journey times for road users Change in collision numbers and severity	No	Study of the observed impacts construction period is not covered by POPE as changes in journey times can vary widely during construction phases and changes in collision numbers are sufficiently significant to conclude a robust trend.
Appraisal period (30 or 60 years)	Change in journey times for users	Yes	Based on observed data on traffic flows, journey times and speeds.
	Change in collision numbers and severity	Yes	Based on observed data on personal injury collisions.
	Change in Vehicle Operating Costs for users	Some	Generally small compared to journey time impact. Evaluated where impact is larger.
	Change in road operating cost for HE	No	Only important in the appraisal of a few schemes. In these cases, assume that original forecast for long term impact still holds true.
	Change in carbon emissions	No	Introduced in recent guidance but only included in few appraisals of the schemes evaluated to date.
	Change in noise impact on local community	No	Introduced in recent guidance but this was not included in original appraisals of the schemes evaluated to date.
	Change to indirect tax revenue	Yes	Although treated as a costs impact in most appraisals, it has presented as part of the benefits for the results for all schemes in this meta-analysis in line with current guidance.
	Change in Journey Time Reliability	No	No reliable source of long term incident data that is comparable with previous years
Future maintenance periods within appraisal period	Change in net cost of maintenance works	Assessed to be same as forecast	Only important in the appraisal of a few schemes. In these cases, assume that original forecast for long term benefits still holds true.
	Change in collision numbers and severity		
	Delays to journey times		

As shown in Table 6-1, the key monetary benefits of the Major Schemes as measured in POPE are derived from changes in safety (measured by the net change in the recorded number of personal injury collisions) and journey times (measured in savings for road users).

POPE studies mainly focus on these elements of benefit as they constitute a majority of the monetised benefits and disbenefits measured in scheme appraisal. These benefits are forecast to accrue over the whole appraisal period of 60 or, in the case of older schemes, 30 years. As POPE evaluation is at the stages of one and five years after opening, these outturn benefits are essentially reforecasts of the long term benefits based on evidence from the observed impacts from the post opening period.

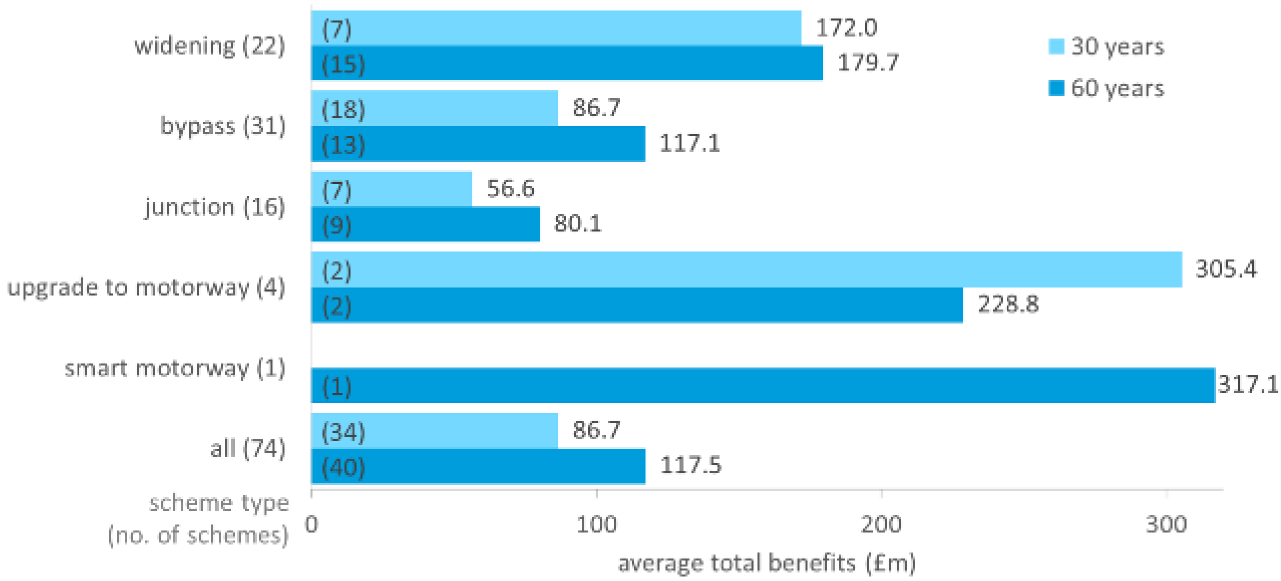
Section 5 of this report commencing on page 57 outlined that the POPE approach to the evaluation of safety benefits has changed to account for the general background reduction in collisions over time. This section of the report includes all schemes regardless of the collision evaluation methodology used. The reasons for this are twofold:

- To ensure that the sample size is sufficient for the findings to be meaningful.
- Because the safety benefits only form a small proportion of overall scheme benefits (as shown later in Figure 6-2), so the impact of the change of methodology is minimal.

Cost benefit analysis of a Major Scheme requires the costs to be considered for the whole of the appraisal period and they need to be expressed on a like-for-like basis with the benefits. This basis is termed Present Value. Present Value is the value today of an amount of money in the future. In cost-benefit analysis, values in differing years are converted to a standard base year by the process of discounting giving a present value. Discounting is defined by the Treasury Green Book and under current guidance uses a discount rate of 3.5% for the first 30 years and 3% thereafter. All the results presented here are expressed in terms of present value of 2002 prices and values using this discount rate. A small number of schemes are omitted from the results presented in the economic results section here as their benefits were assessed in older time periods and discounting rates.

For the 74 schemes where the results are presented in 2002 prices and values, the average (median) total benefits by scheme type are summarised in Figure 6-1. These include the benefits are set out in Table 6-1 and include indirect tax revenue impact, where it was covered.

Figure 6-1 Average Total Outturn Monetised Benefits per scheme (£m)

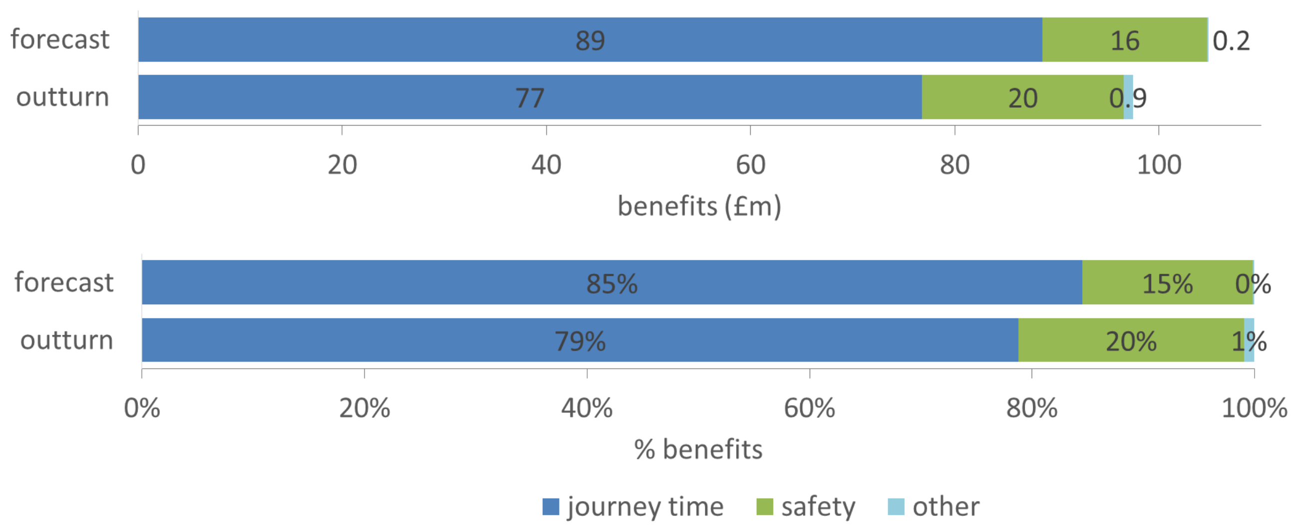


The key points of interest on the average benefits are:

- Junction schemes show the lowest benefits due almost all of them to being smaller in scale.
- Upgrade to motorway and the one smart motorway scheme were assessed as having the greatest benefits, but as noted later in the costs section 6.3, these are the most expensive schemes.
- Widening schemes also had above average benefits, but likewise this group included many of the more expensive schemes, for example motorway widening.

The breakdown of these benefits by benefit type is shown in Figure 6-2. These are the average (median) benefits. The category 'other' refers to the additional types of the users' vehicle operating costs, indirect tax impact and others as listed in Table 6-1; this is based on only those schemes in which these other benefits were assessed.

Figure 6-2 Average Benefit split by type (£m) and proportion (%)

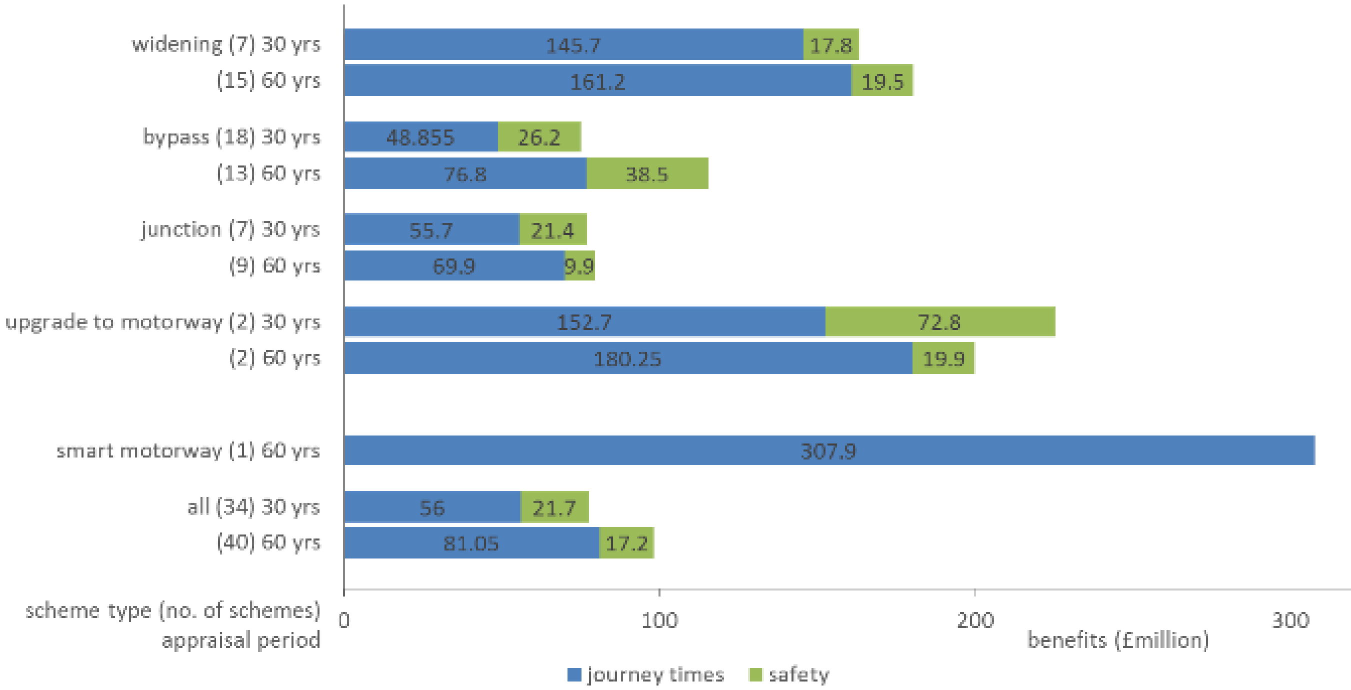


From the split of benefits presented here, the main points are:

- Journey time provide the majority of benefits. An outturn average of £77m per scheme.
- Safety benefits are the remainder of the benefits, on average 20% in the outturn assessment which is greater than the average forecast.
- The net total of the other benefits forms a very small proportion of the overall benefits, even considering only those evaluated impacts. However the low net impact obscures the fact that unlike the journey time benefits which are overwhelmingly assessed to be positive benefits, these other benefits include both positive and positive benefits as discussed later.

For the two key benefits types of journey times and safety, the level of benefits varies between schemes, which can be partly understood by examining the average level of outturn benefits by type of schemes as shown in Figure 6-3.

Figure 6-3 Outturn Benefits split by scheme type and benefit type (£m)



This shows:

- The greatest level of safety benefits is found in bypasses and upgrade to motorway schemes. This safety benefit is clearly associated with the greater change in road standard which is a key aspect of most of these schemes. For example, bypasses replacing single carriageways in built up areas and motorways replacing older dual carriageways.
- Of the three most common types of schemes (widening, bypasses, and junctions), widening schemes include the highest average benefits, despite lower safety benefits.

The range of benefits achieved for the individual schemes of all types and evaluation periods in shown in Figure 6-4, Figure 6-5, Figure 6-6 and Figure 6-7.

Figure 6-4 Journey Time benefits (£m)

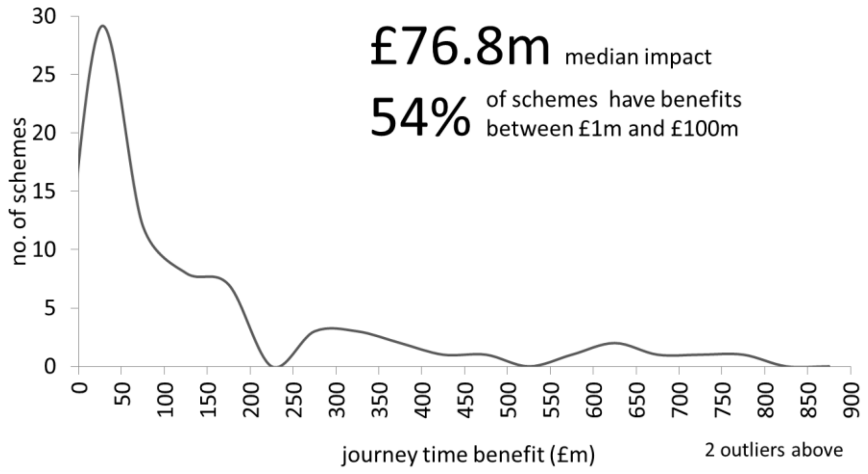


Figure 6-5 Safety Benefits (£m)

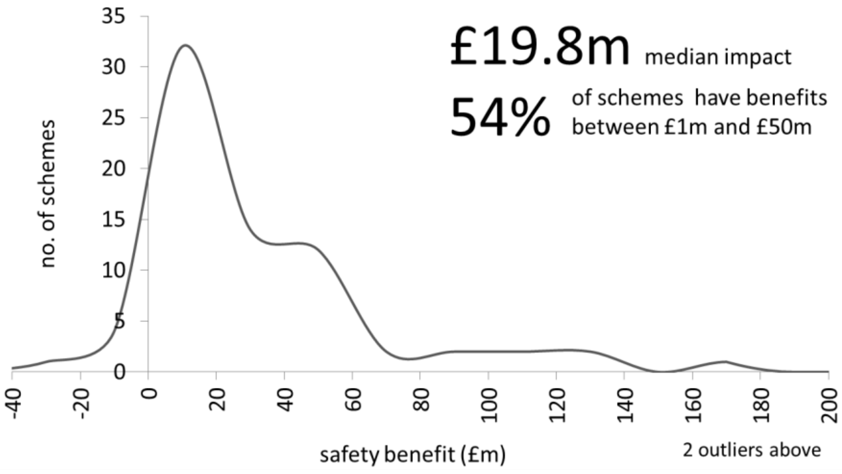


Figure 6-6 Indirect Tax impact on Benefits (£m)

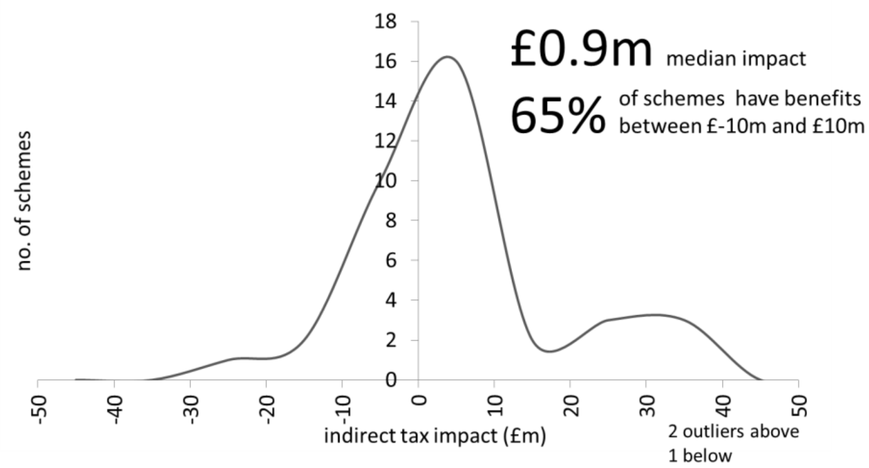
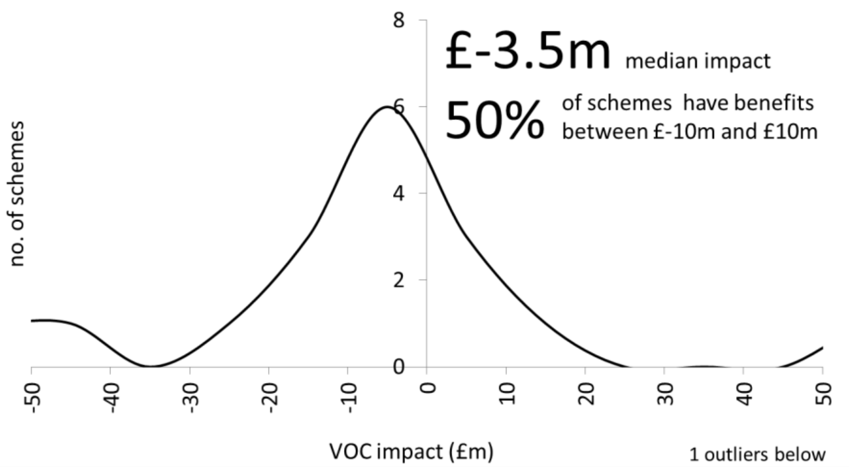


Figure 6-7 Vehicle Operating Costs (VOC) Benefits (£m)



Journey time and safety results are based on the evaluations undertaken for all schemes, whereas indirect tax results are based on 40 schemes and VOC for 18.

As noted earlier, the greatest benefits are from the journey time impact. This has produced only positive results. Safety benefits are positive for the large majority of schemes.

The impact of other types of benefits varies considerable between the positive and negative impacts as shown in Figure 6-6 and Figure 6-7. The indirect tax impact is the net impact for the Treasury on taxation revenue, primarily fuel duty and VAT.

A further impact which is important for some schemes is the impact of the construction period and future maintenance periods. Of those schemes where this has been considered, the median impact is £-2.6m but the range includes large negative benefits (e.g. due to delays to road users during the construction period) and large positives (future periods of maintenance will cause less delay to road users e.g. due to the wider road).

6.2 How accurate is the forecasting of Major Scheme benefits?

Benefits arising from journey time savings are moderately accurate for most schemes. 28% of schemes have journey time benefits within 15% of that forecast and 74% of schemes are within 50%.

Safety benefit forecasts, however, are inaccurate for the majority of schemes with only a third having outturn benefits within 50% of forecast.

Net change in Vehicle Operating Costs and indirect tax impacts are mostly lower than forecast.

There is some indication of an improvement in benefit forecasting accuracy over time since 2000.

This section examines the differences between the forecast monetised benefits and POPE calculation of the outturn benefits on a like-for-like basis.

All figures presented here are given according to the guidance on expressing monetary values for an appraisal period in terms of present value. When the evaluations included in this Meta-analysis were undertaken this was 2002 prices and values through the use of discounting. Differences between the forecast and outturn benefits have been measured by the percentage difference between the forecast figures in the schemes' appraisals and the latest POPE outturn evaluations for each scheme.

The benefits considered here have been split by the benefits for journey times and for safety in Figure 6-8 and Figure 6-9. Note that a number of motorway widening schemes predicted no monetary benefits arising from safety, thus, although benefits have been evaluated in POPE, the percentage difference from the forecast cannot be shown.

Figure 6-8 Accuracy of forecast monetised journey time benefits

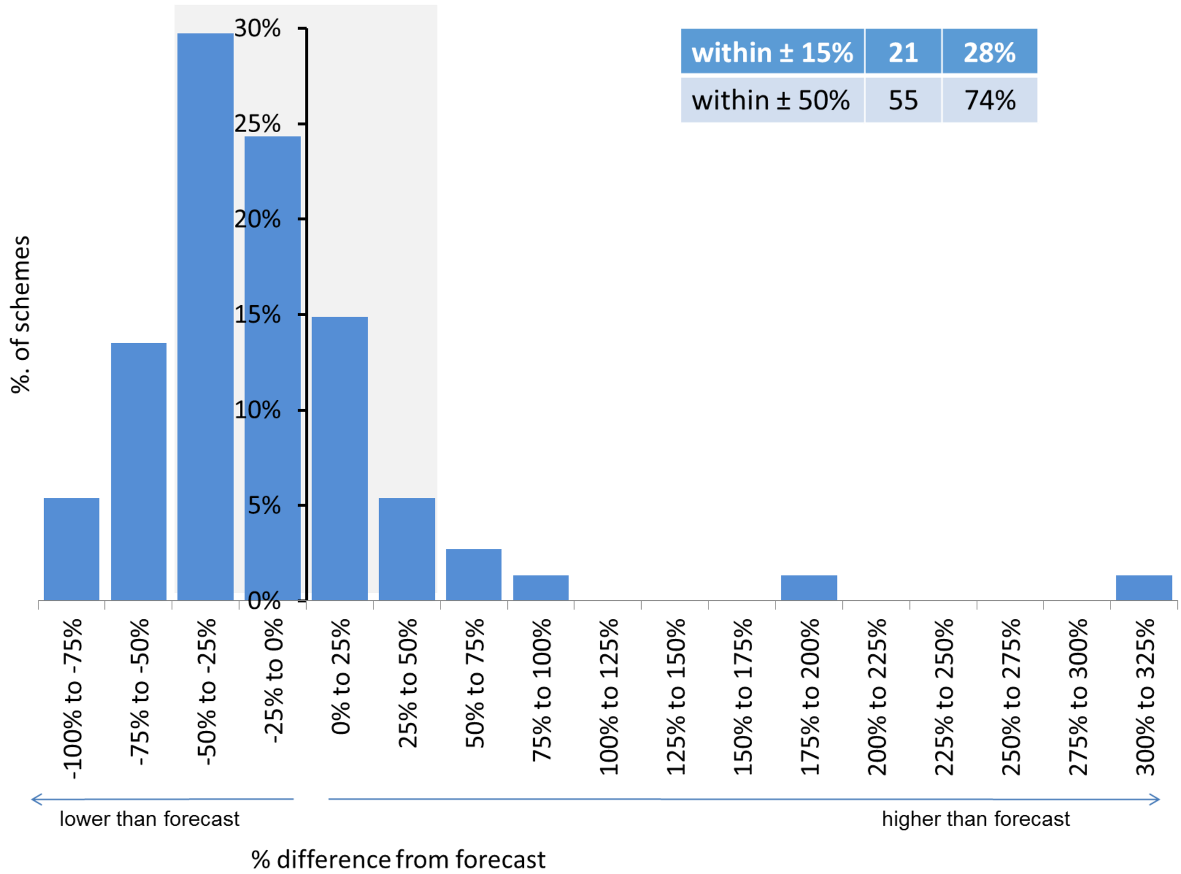
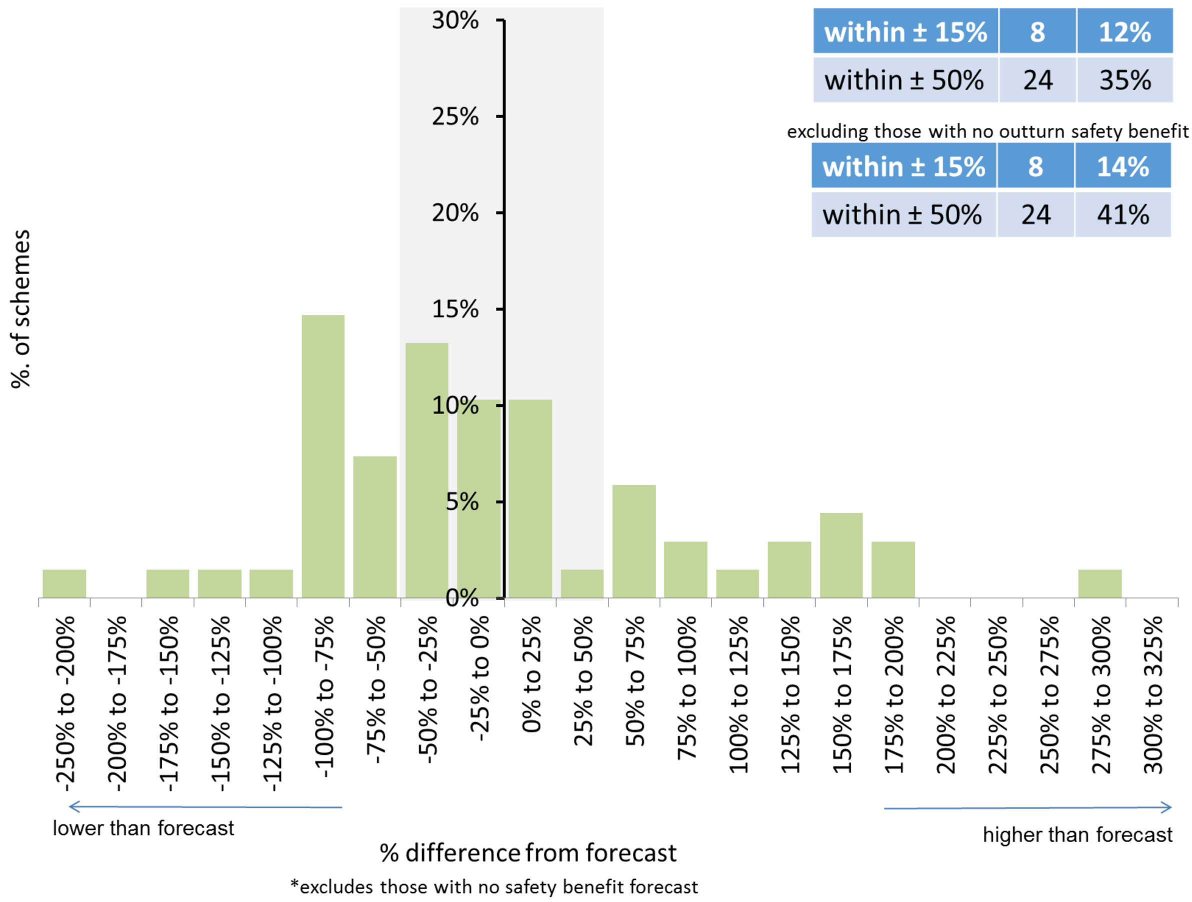


Figure 6-9 Accuracy of forecast monetised safety benefits



This analysis of the journey time and safety benefits forecasting accuracy shows:

- Journey time benefits are clearly more accurately forecast than safety benefits for most schemes;
- Journey time benefits for the majority of schemes (74%) are within 50% of the original forecasts;
- A greater proportion of schemes had journey time benefits which were rather lower than predicted. However it should be noted that the economic downturn in recent years has reduced the observed measure of benefits and that POPE outturn evaluation takes a conservative approach to the calculation of journey time benefits over the wide area as these are likely to be small impacts which are difficult to confidently attribute to the one change in the road network when there have been other changes affecting traffic patterns over the same time period.;
- A minority of schemes have journey time benefits which are substantially higher than predicted.
- Safety benefit forecasts have a much lower level of accuracy than those for journey times, with less than a third having outturn benefits within 50% of the forecast; and
- Assessment of outturn safety benefits accuracy shows an even split between half above that forecast and half below.

Reasons for the size of the differences between the forecast and outturn assessments of the safety benefits are as follows:

- For some schemes, the sample size of the available observed data is too small for confident prediction of long term trends. Safety benefits are based upon the monetisation of the net difference in the numbers of injury collisions with and without the scheme and of the changes in the severity levels of the casualties from these collisions. These predictions are based on established national data on such rates by type of road, (for example single carriageways with national speed limit have higher rates of fatal and severely injured casualties per collision than dual carriageways) and observed trends on the key roads when the scheme was appraised. These predicted impacts are monetised based on costs assigned to the casualties, with fatalities having the highest cost. Savings in the numbers of fatal and seriously injured casualties are recognised as being of high importance but, because these collisions only comprise a small proportion of all recorded collisions, long term trends in reduction of these severe collisions can only be based on national figures based on the road type.
- Where the collision forecasts are based on a small area, the strategic road does not have high traffic flows, or in a scheme with a low safety impact, the relatively low numbers for the net change mean that random variation plays a part in the observed results, especially for the more recent schemes which only have a year of post opening data, therefore under- or over-indicating the possible long term trend. To guard against this, the POPE methodology uses tests of statistical confidence in the findings and where net change is not significant, no monetised benefits are attributed. These are omitted from the results presented in Figure 6-9 as are the scheme which had a zero predicted monetised safety benefit.
- Appraisals of schemes' safety impacts were undertaken using the collision modelling software (COBA) which included the expectation of a collision rate reduction over time, except for motorways. However, the observed trend in collision reduction seen nationally as set out in section 5 has been falling substantially more steeply than expected for over a decade meaning it is likely that in many locations, collision rates could have reduced even without the scheme in place. The POPE methodology has been revised to more conservatively attribute safety benefits using national trends in collision reduction by road type. As the original predictions were based on higher rates of collisions in the COBA modelling based on the earlier national defaults by road type or as observed on key links within the scheme network, there was a greater safety impact. Outturn evaluations of the safety benefits taking the new trends into account are mostly lower than expected due to this.

Safety and journey time benefits make up the large majority of the benefits of Major Schemes and have been evaluated in all the POPE studies. Of the other benefits of schemes which are monetised and can be evaluated using post opening data, the assessment of the indirect tax impact and vehicle operating cost (VOC) have been undertaken for a number of schemes and findings are summarised in Figure 6-10 and Figure 6-11. Note that these plots only include the results where an evaluation was made based on observed data and omits schemes where it was not included or cases in which the impact was assumed to be as forecast.

Figure 6-10 Accuracy of forecast Vehicle Operating Cost (VOC) benefits

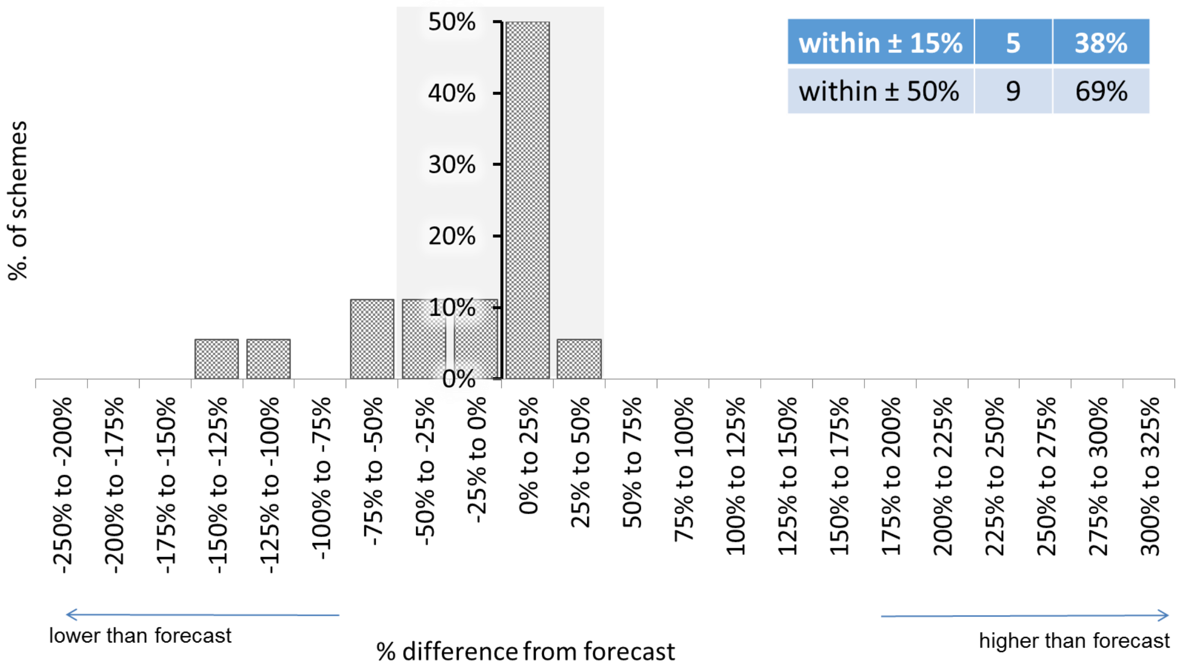
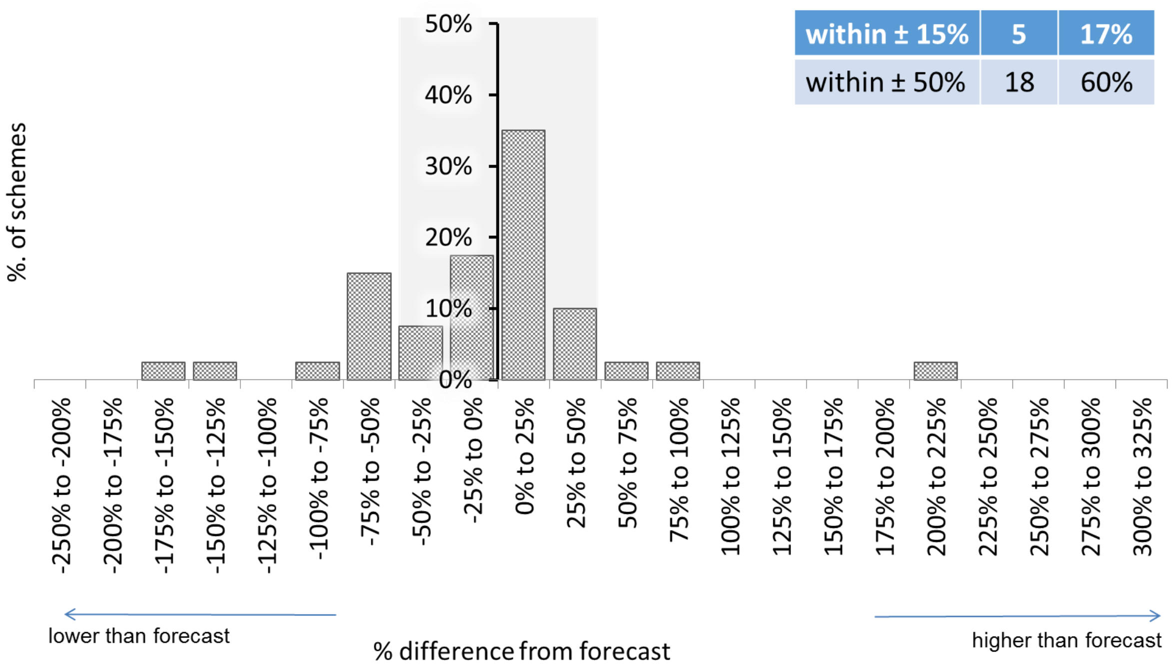


Figure 6-11 Accuracy of forecast indirect tax impacts



These plots of the accuracy of the other monetised benefits show:

- Vehicle Operating Cost and indirect tax impacts are mostly lower than forecast; and
- Over half of schemes have benefits within 50% of the forecast although this is a lower level of accuracy than noted for journey time savings in in Figure 6-8.

The accuracy of other monetised benefits is not considered here as their accuracies have not been evaluated within POPE or have been undertaken for only very few schemes.

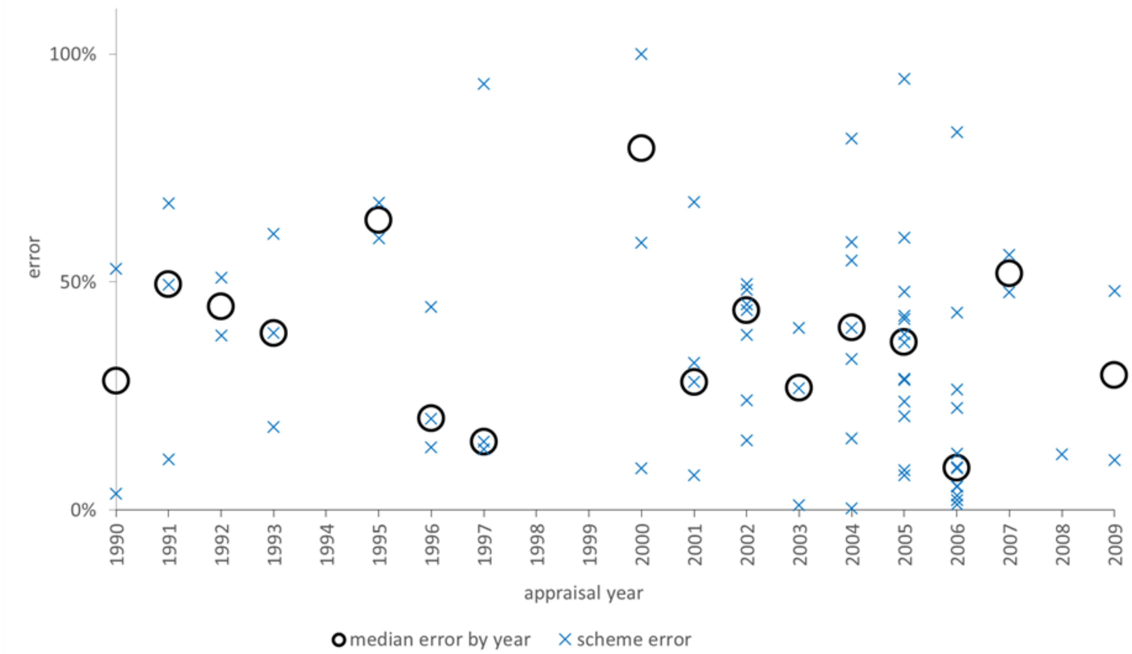
6.2.1 Breakdown of monetary benefits over time

The schemes in this meta-analysis have opening years between 2002 and 2012 and were appraised over a wider range of years from the early 1990s onwards.

The accuracy of the monetary forecasts of the benefits over time is illustrated in Figure 6-12 and Figure 6-13. Differences between the forecast and outturn benefits have been measured by the percentage difference between the forecast figures in the schemes' appraisals and the latest POPE outturn evaluations for each scheme. These include FYA results, where available, else OYA findings. This includes schemes with appraisal periods of both 30 and 60 years but, as the evaluation method is the same and the outturn benefits period matches the length of the appraisal, the same proportional difference is applicable. Appraisal years are grouped for the 1990s years and fore the most recent schemes in order to give a reasonable sample size.

Values per year for time period here are for all individual scheme results, excluding two outliers for each, and the averages (median) by year. Fewer schemes are included in the safety benefit accuracy sample due to the omission of those with no safety benefit prediction. There are however nine schemes in which, although a benefit was predicted, the outturn evaluation was zero hence a 100% margin of error.

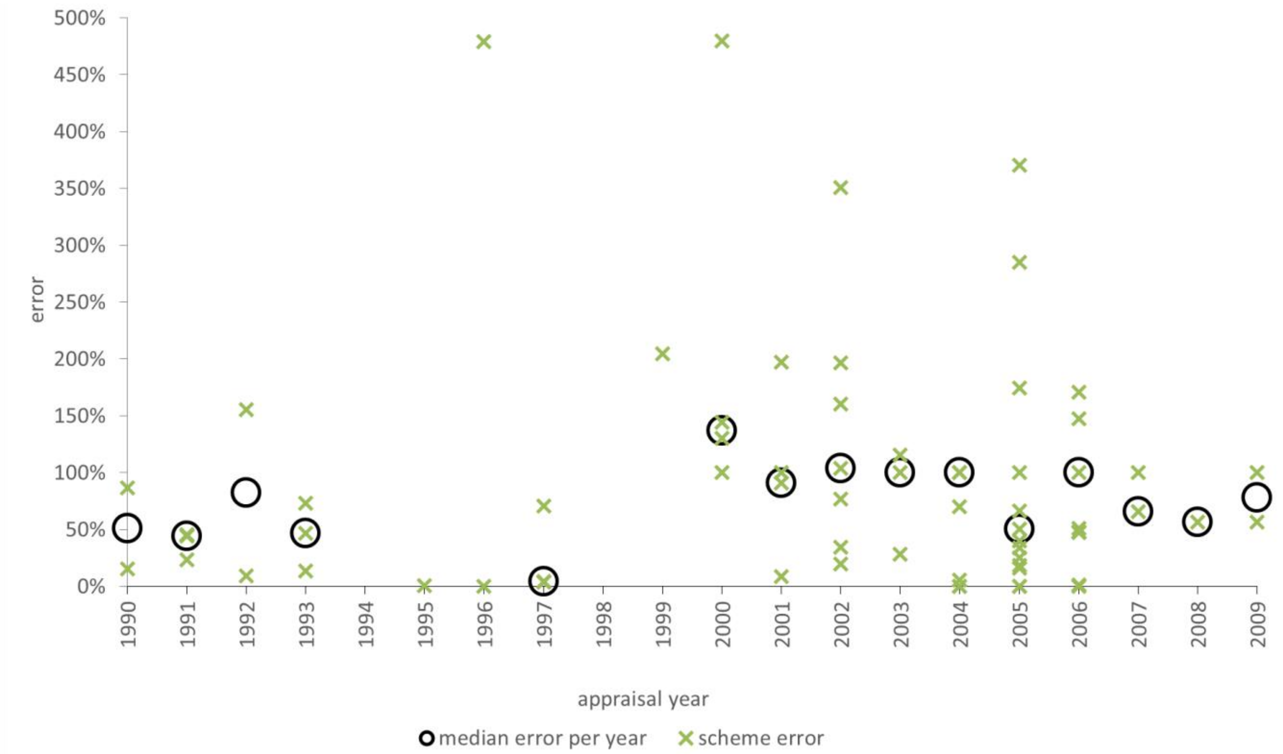
Figure 6-12 Journey time benefit forecasting accuracy over time



The plot of benefits forecasting accuracy grouped by appraisal year in Figure 6-12 shows:

- Journey time benefits are consistently more accurate than safety benefits, except for the very oldest appraisals (early 1990s).
- Journey time benefits show some evidence for an improvement in accuracy over time from 2000 to 2006, a period which covers two-thirds of the schemes here. The handful of 2007-2009 appraisals is too small to draw firm conclusions of a worsening.

Figure 6-13 Safety Benefit forecasting accuracy over time



The plot of safety benefit forecasting accuracy grouped by appraisal year in Figure 6-13 shows:

- Safety benefits, as shown earlier, have a much larger margin of error than journey time benefits; and
- There is some indication of an improvement in accuracy over time post 2000.

6.3 How accurate is the forecasting of Major Scheme costs?

Half of the Major Schemes had estimated costs in the business case within 15% of the outturn cost.

Since 2004, accuracy of cost estimating in scheme appraisal has been consistently improving.

For all of the Major Schemes evaluated within POPE, we have compared the outturn capital cost of the scheme at the time of the POPE study with estimated cost in the business case. As with the scheme monetary benefits, costs have been compared on a like-for-like basis through conversion to a common 2002 price base year. 73 schemes for which it was possible to present the costs in 2002 prices have been included in the assessment in this section.

POPE does not include detailed investigation of the reasons behind the inaccuracies of the cost predictions, but one of the main reasons has been found to be the length of the time period between the appraisal and the start of works. It is known, for example, that cost increases have occurred due to changes in the scheme following the economic appraisal such as additional flood prevention measures.

The sizes and hence costs of Major Schemes covers a wide range from £10m to over £400m, so here we focus on the size of the difference between the estimated and outturn costs, as shown in Figure 6-14.

Figure 6-14 Net margin of error in between estimated and outturn scheme capital costs (£m)

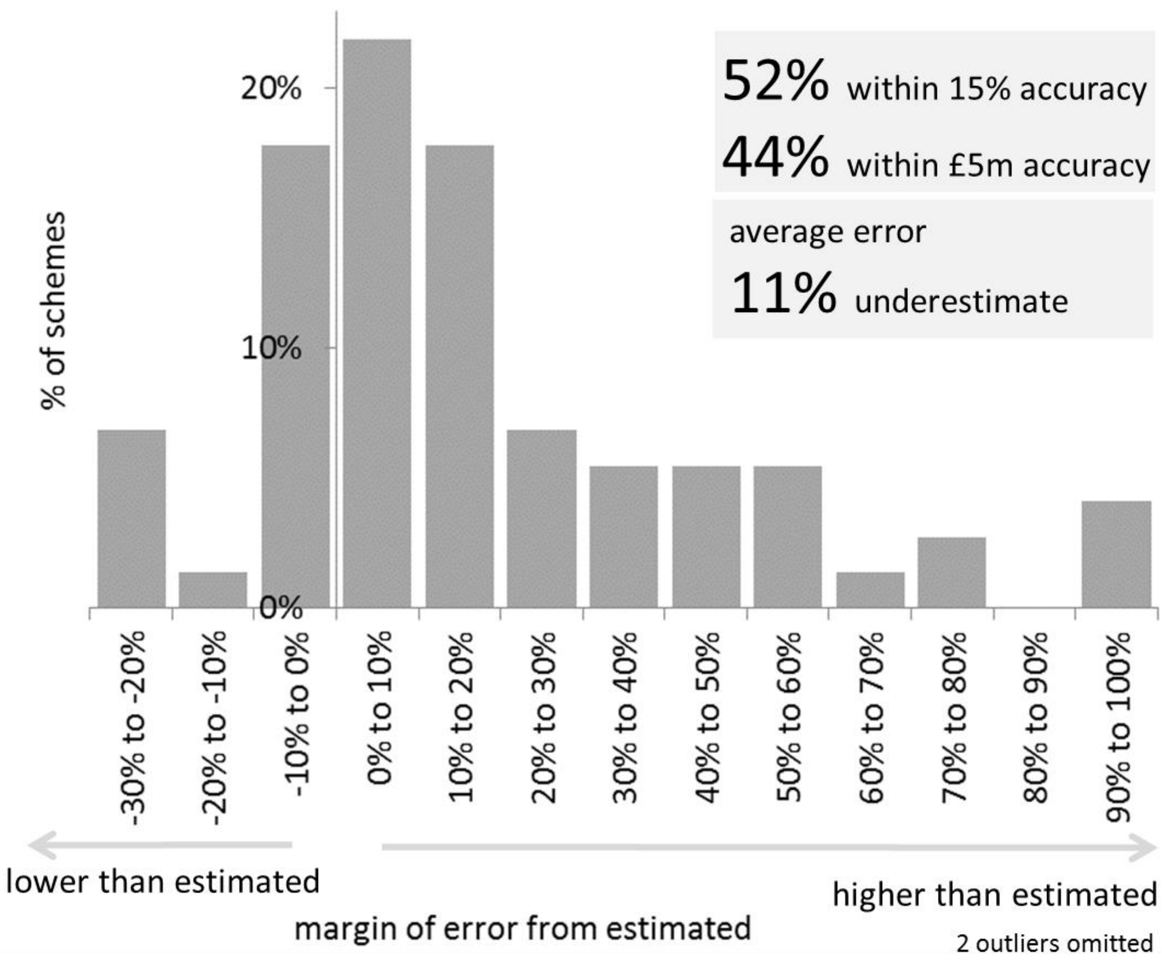
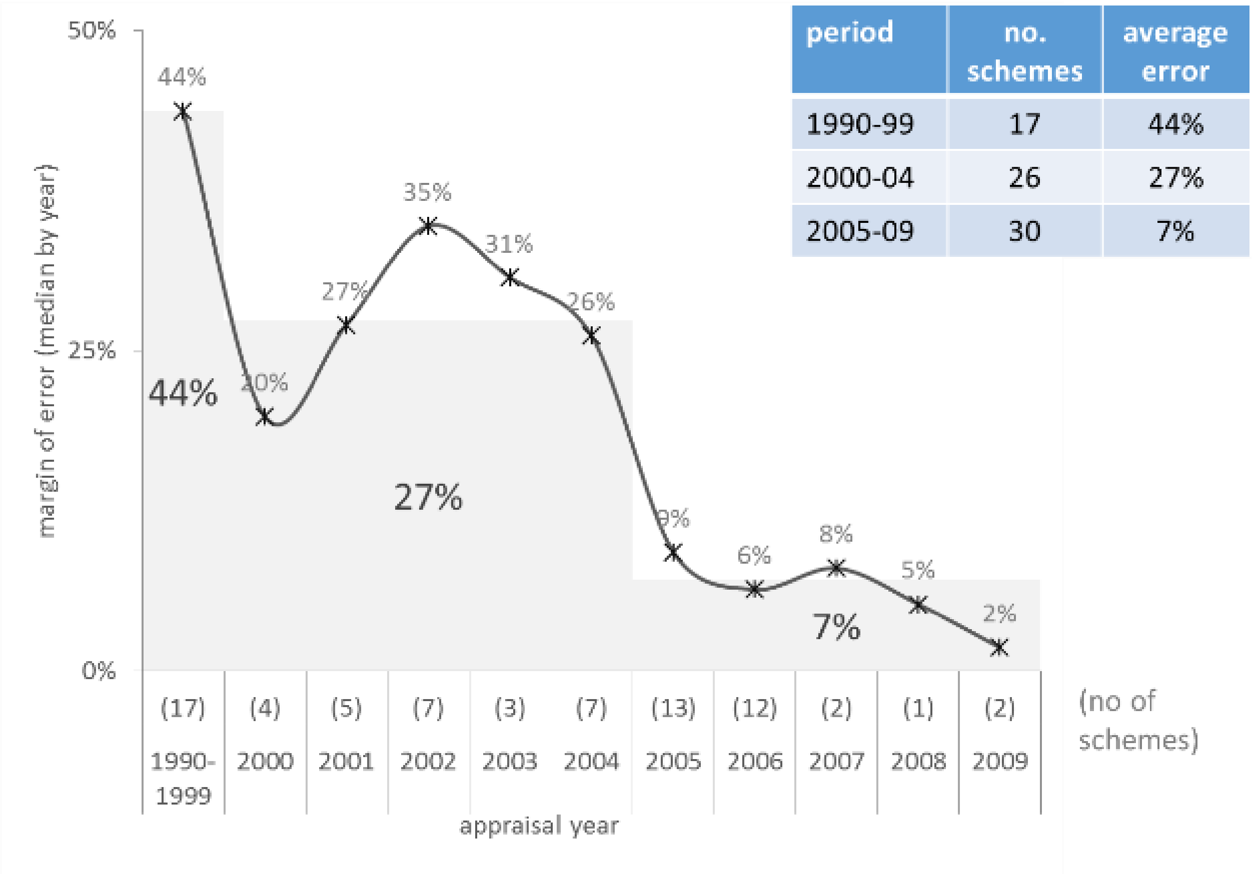


Figure 6-14 shows that the margin of error was most commonly between zero and 10%, although the average (median) error was an 11% underestimate. There was a handful of schemes with much higher levels of underestimation and, more rarely, overestimation.

Just over half (52%) were accurate within 15% of the original forecast costs set out in the business case.

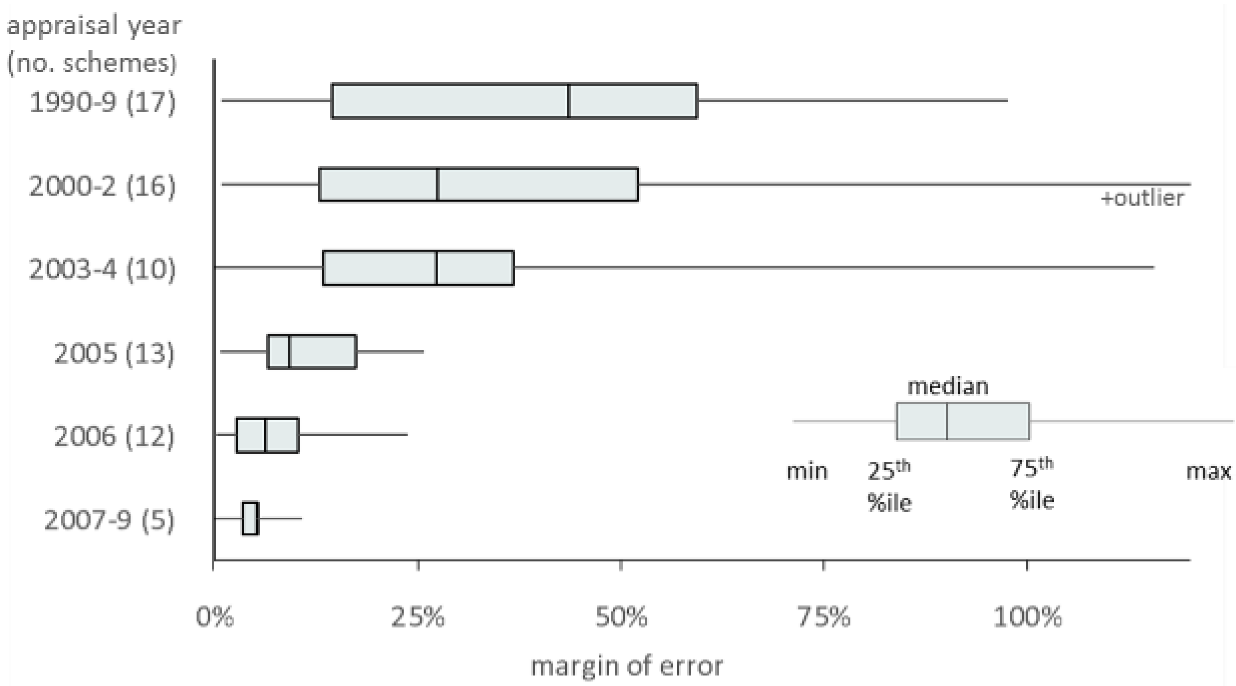
To evaluate whether cost estimating has got better over time, the size of the margin of error as a proportion of the outturn cost has been plotted against the year the scheme was appraised. Appraisal of the individual Major Schemes in this meta-analysis has often taken place over a number of years. During this time there may have been several updates to the estimated capital costs. Here we consider only the estimated cost in the business cases. Figure 6-15 shows the average (median) margin of error between the estimated and outturn costs over time and the range of error is shown by period in Figure 6-16.

Figure 6-15 Margin of error of capital cost estimates by appraisal period



period	no. schemes	average error
1990-99	17	44%
2000-04	26	27%
2005-09	30	7%

Figure 6-16 Range of Cost Margin error by appraisal period



The schemes included in this meta-analysis were appraised over a wide period. Highways England changed its cost forecasting methods in 2007 ('three point cost estimating'). Two schemes in the 2007-9 period used this method.

It is early at this stage to be confident that this has led to an improvement in cost accuracy but the data presented here gives a good indication of a trend for reduced margin of error in recent years.

Although in recent years, Major Schemes have generally been appraised at only a short period prior to construction; the same cannot be said for the oldest schemes included within the POPE studies which date back to the start of the TPI (Targeted Programme of Improvements) begun in the late 1990s, now known as the Major Schemes programme.

The main trends highlighted by Figure 6-15 and Figure 6-16 are:

- In the most recent years, from 2005 onwards, the average cost difference is only 7%;
- In the five years to 2004, there was a greater average margin of error and no trend in cost accuracy over time; and
- Most of the larger errors are from the schemes where the costs were estimated in the 1990s. The gap of a decade before these were built is likely to be the main reason for the errors of these schemes.

6.3.1 What is the average cost of a Major Scheme?

Major Schemes cost £39.5million in 2002 prices on average, and 60% of these schemes cost below £50million.

The sizes and hence costs of Major Schemes cover a wide range from £10m to over £400m. Here we give an overview of the average costs (Figure 6-17) and the range based on the types of schemes (Figure 6-18). These are based on 74 schemes and are given in 2002 prices.

Figure 6-17 Average outturn cost by scheme type

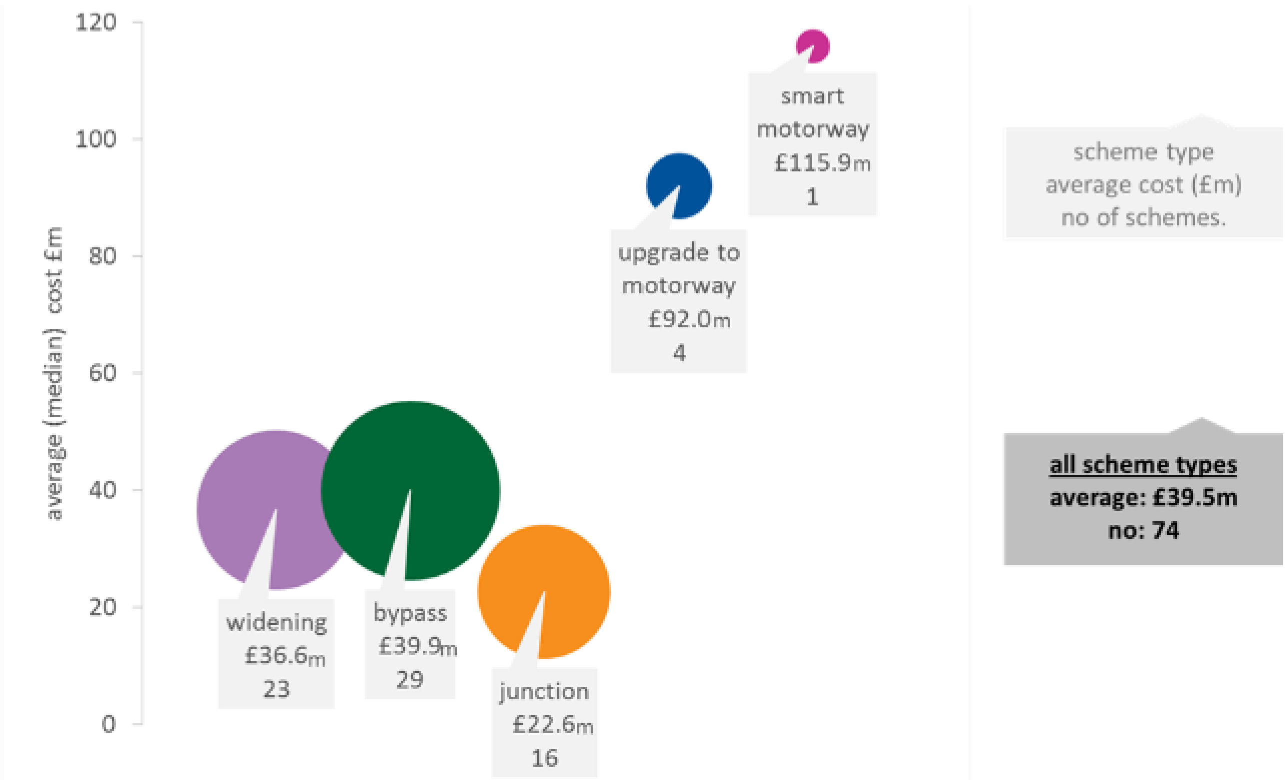
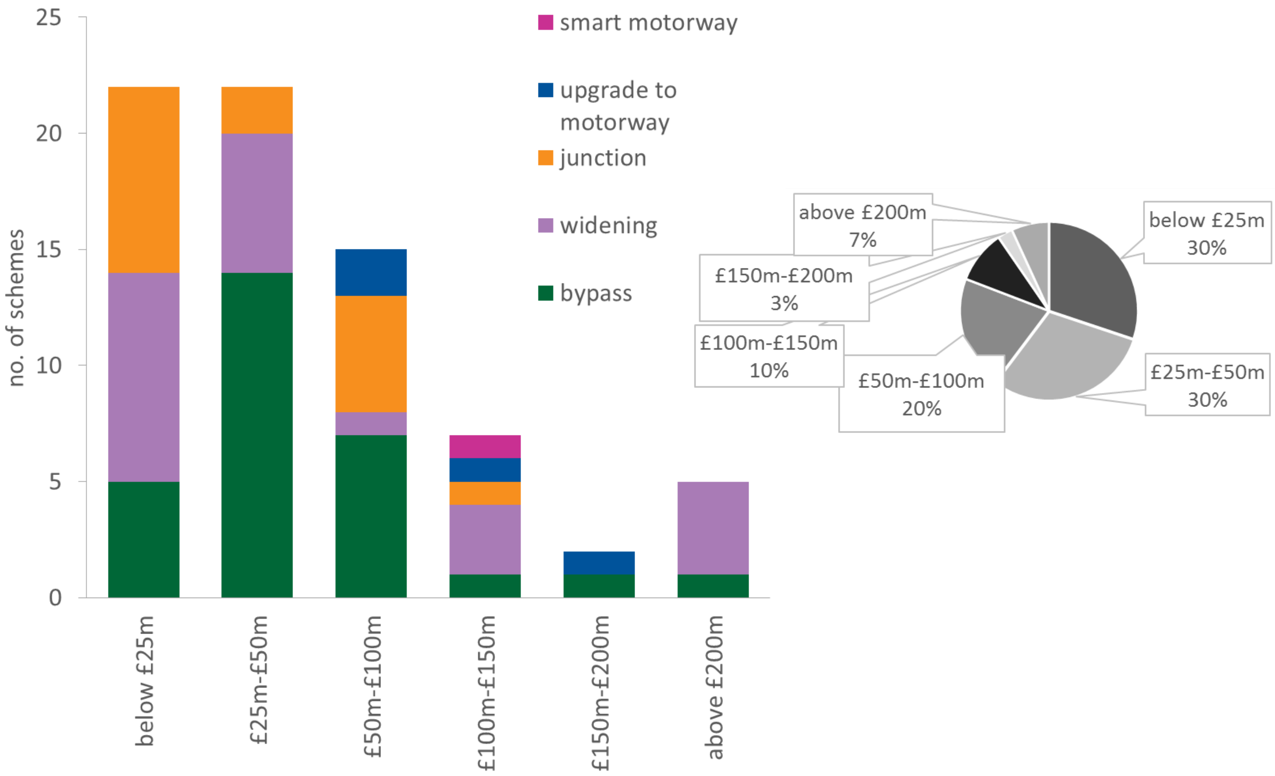


Figure 6-18 Outturn costs by scheme type



The range of scheme costs shows that:

- 60% of scheme costs less than £50m and the average cost overall was £39.5m;
- 20% of scheme costs were over £100m;
- Widening and bypass schemes included the lowest and highest costs reflecting the variation in the scope of these from motorway widening to smaller improvements in quieter parts of the SRN; and
- Upgrading to motorway schemes and the one smart motorway were all expensive, reflecting the greater scale of these types of schemes

6.4 Are Major Schemes offering value for money?

Post opening evaluation shows that the average Benefit Cost Ratio of major schemes is 2.7, which means that on average, for every £1 spent on the scheme, the return will be £2.70 in long term economic benefits.

73% of schemes achieved high value for money and 88% achieved medium or high value for money. A scheme is high value for money if the benefits are over double the cost.

Cost-benefit analysis is used to assess the value for money of Major Schemes. This involves the comparison between the cost of a scheme and its long term benefits.

In 2004, the DfT introduced a process which assigns an overall Value for Money (VfM) rating to a scheme. The VfM rating is an internal management measure used to inform decisions about a scheme. The VfM rating is also used to inform the ranking of schemes within a limited budget. The benefits to which WebTAG currently assigns market, or monetary, values, are the effects of the scheme on: the time and operating costs for consumers and business users; risk of fatality, injury or accident; physical fitness; carbon emissions; and noise. However, this would be to ignore other impacts which, while not being monetized, may have a significant effect on welfare. These impacts could be material to whether or not a scheme is worth implementing or its priority and are taken into account in the VfM process.

Submissions for the funding of a proposed Major Scheme must set out the VfM in accordance with DfT guidance. VfM is based on a number of indicators, key among which is the ratio between the costs and benefits, known as the Benefit Cost Ratio (BCR).

BCR is calculated by dividing the present value benefits by the present value costs. Expressing all costs and benefits in terms of present value means that values of money in the future (in particular the benefits which will extend for decades into the future) can be compared with costs which are spent earlier.

DfT guidance on Value for Money uses the following ranges of BCR used to categorise schemes as:

Benefits are less than costs (below £1 of benefits for every £1 spent):

- Poor value for money if BCR is less than 1;

Benefits are greater than costs (for every £1 spent, there will be more than £1 of benefits):

- Low value for money if BCR is between 1 and 1.5;
- Medium value for money if BCR is between 1.5 and 2;
- High value for money if BCR is between 2 and 4; and
- Very high value for money if BCR is over 4.

Non-monetised impacts are also considered and, if significant, can shift the VfM categorisation up or down from that derived by the BCR.

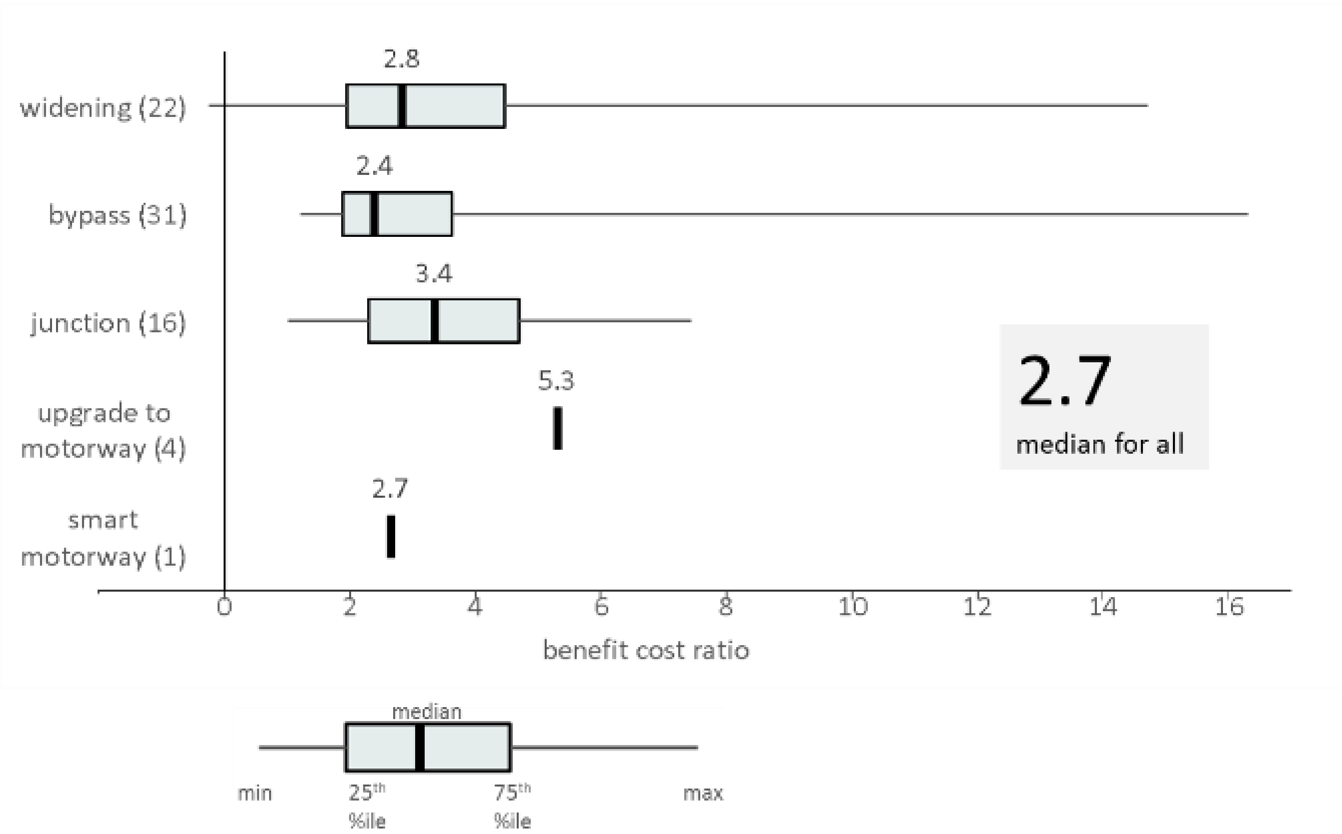
Using the outturn costs and the evaluations of the monetary benefits, Benefit Cost Ratios have been calculated for the evaluated schemes in POPE[23] and VfM categories determined. Non-monetised benefits are not considered here.

As noted in Table 6-1, in this meta-analysis the indirect tax impact is treated as part of the benefits rather than part of the costs, and this approach is in line with current guidance. Therefore it should be noted that the assessment of BCR likewise uses this approach and not that which was used in many of the schemes' original appraisals where indirect tax was included in a scheme's costs.

The averages and the range of the outturn Benefit Cost Ratios which have been achieved are shown by type of scheme in Figure 6-19.

[23] 73 schemes with costs and benefits expressed in 2002 prices and values for appraisal periods of 30 or 60 years

Figure 6-19 Outturn Benefit Cost Ratios by scheme type



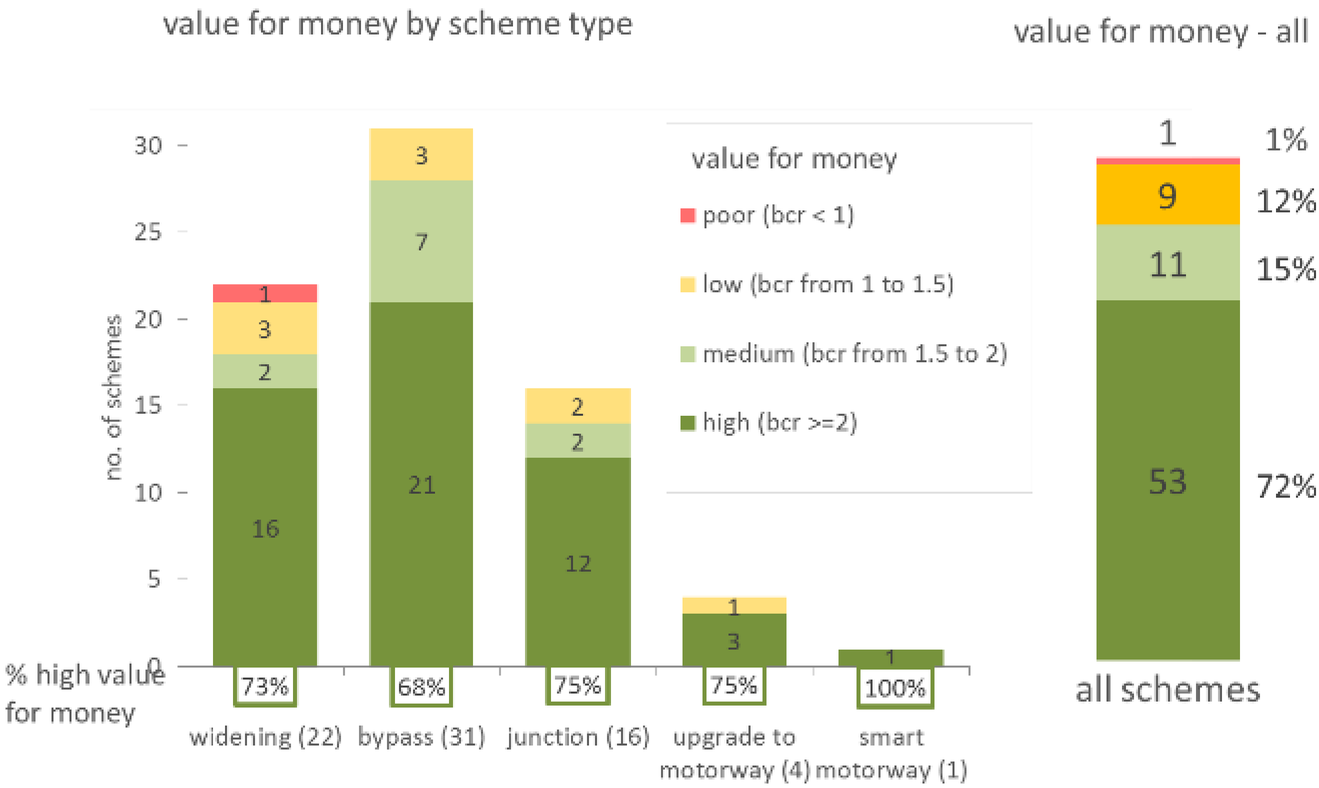
The range of BCRs in Figure 6-19 shows:

- All of the types of schemes have an average (median) BCR of 2.7, indicating that on average, the benefits will be more than double the cost;
- On average junction schemes had the highest average BCR of the types with a good sample size;
- All types of scheme show a wide range of BCRs, reflecting the variety of types of improvements undertaken within the categories presented here and their varying levels of success; and
- The majority of outturn evaluations of the benefit costs ratios are above two, meaning the benefits are more than double the costs.

Further analysis of value for money is the calculation of the ratio of the net present value to the cost (NPV/£). The average for all schemes is 1.7 (median) and 3.3 (mean).

The outturn BCRs have been used to categorise each scheme in the assessment of value for money according to the DfT criteria as set out above and the results are shown in Figure 6-20.

Figure 6-20 Outturn Value for Money Assessments of schemes



The key points regarding the value for money for the different scheme types are:

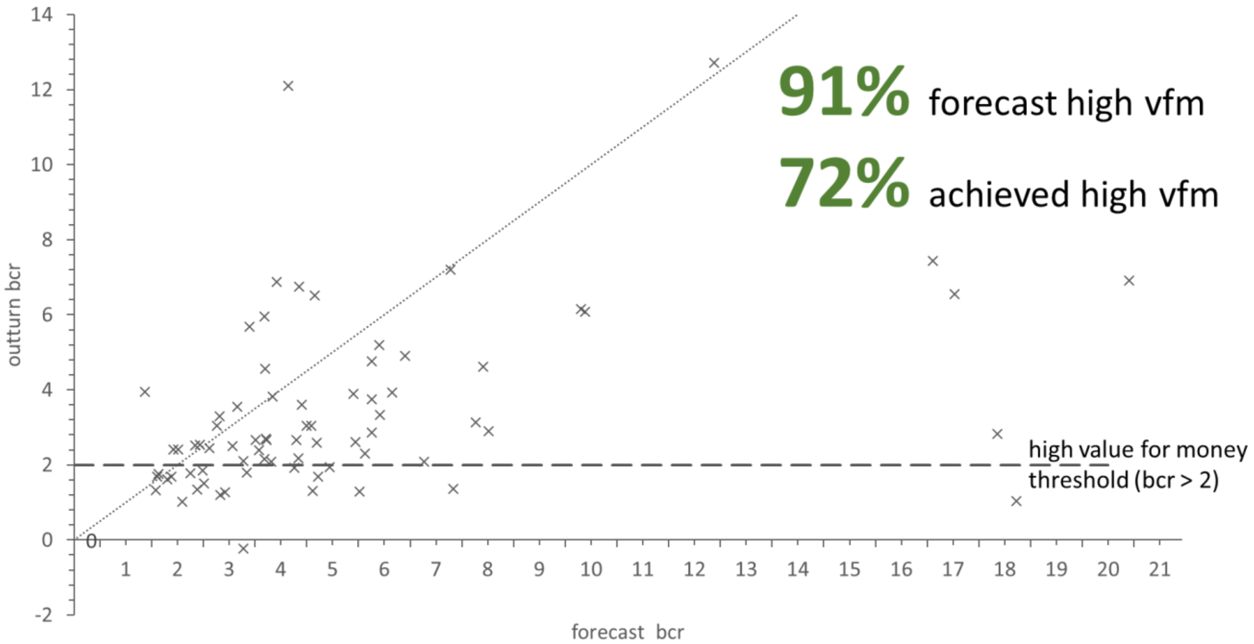
- The majority (72%) of all schemes show high value for money;
- 87% of schemes achieve medium or high value for money; and
- Schemes which fall into the lower value for money categories are most commonly bypasses. It is noted at the start of this report that this type of scheme was mainly completed in the earlier years of the period covered by this study (Figure 2-1) and this contributes to the change in VfM over time as discussed in Section 6.4.1.

It was noted earlier in section 5, that safety benefit evaluation methodology has been revised to more accurately reflect background trends in collision reduction. This means that the collision saving is lower than forecast, based on the assumption that without the scheme in place, there would have still been some collision reduction. This means that the monetised benefit of the safety improvement which is attributed to the scheme rather than other influences is lower and in some cases, may not be sufficiently large to be statistically significant, therefore reducing the overall monetary benefits and hence the BCR. Three schemes which were evaluated using the new approach have VfM categories which are lower than the 'high value for money' classification which had been expected, and this is partly due to the safety benefits being lower than forecast, although it should be noted that these three schemes are among the smallest of all the Major Schemes evaluated in POPE and are located on some of the least busy 'A' roads on Highways England's network.

Further to the examination of the outturn benefit cost ratios is the comparison against the original forecast ratios per scheme and expected value for money assessments.

Figure 6-21 presents the forecast and outturn benefits costs ratios.

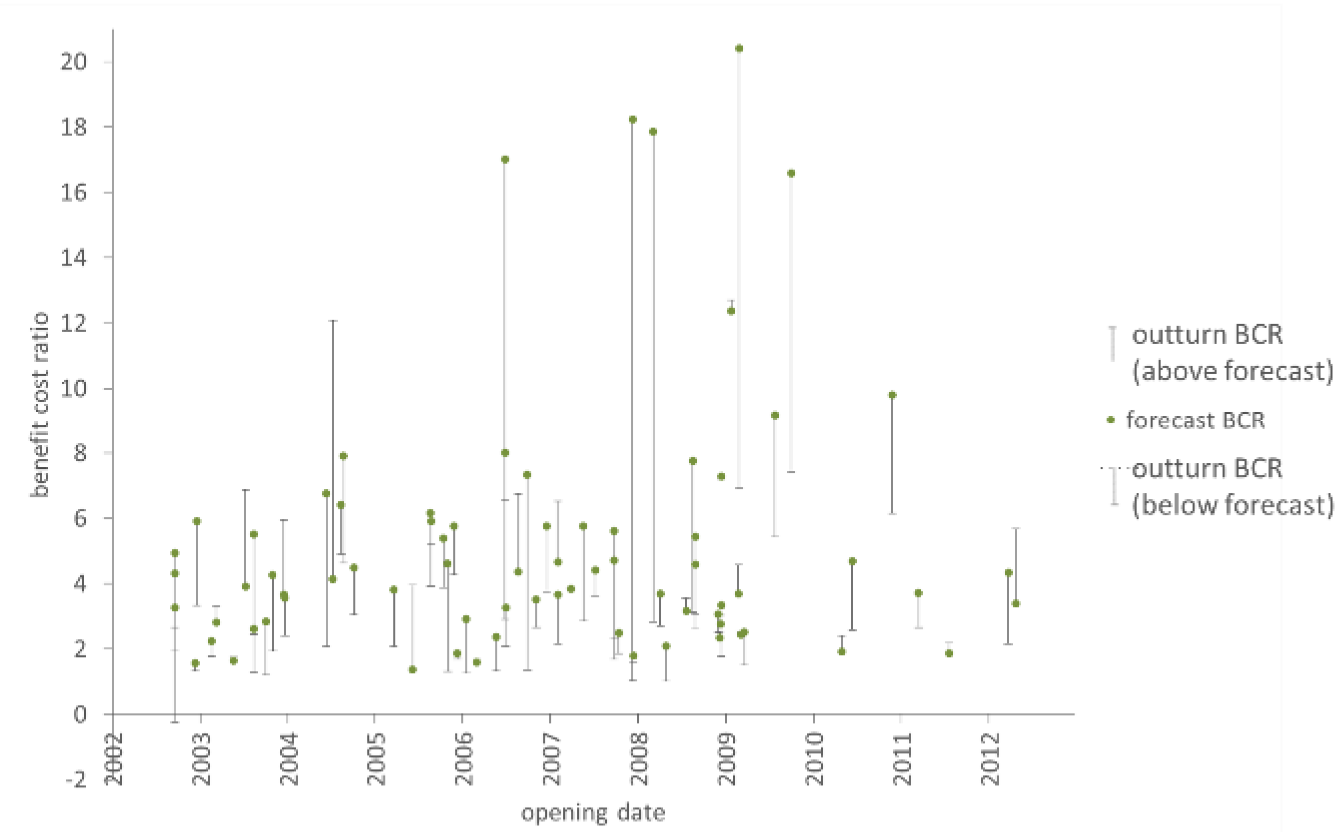
Figure 6-21 Comparison between forecast and outturn benefit cost ratios by scheme



This shows that although the majority of schemes are high value for money, the benefit costs ratios are mostly below forecast.

Figure 6-22 shows the trend over time in the margin of error showing all schemes.

Figure 6-22 Margin of error of benefit cost ratio forecasts over time



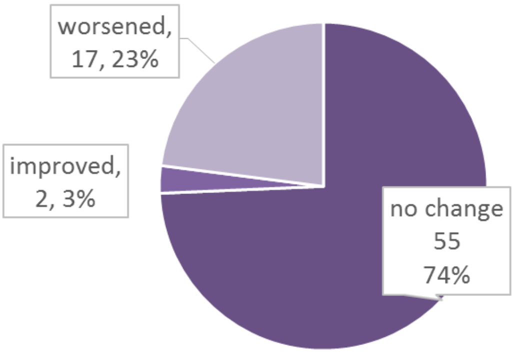
This graph presenting the individual margins of error shows:

- The accuracy of the forecast BCR varies widely. Only 18% were within 15% of that forecast

- There is no clear evidence of a trend over time.

Although this accuracy appears of concern, what is more important is the categorisation by value for money. This accuracy by scheme is summarised in Figure 6-23.

Figure 6-23 Difference between forecast and outturn value for money (VfM) assessments (based on monetised results only)



They important point illustrated here is that over three-quarters of schemes achieved the expected category of VfM or better.

As those schemes which have been evaluated to have a VfM assessment in a category lower than expected, further investigation has been undertaken of the reasons behind this which shows the following for the 17 which have an outturn VfM lower than forecast:

- 29% cost increase;
- 24% lower or no safety benefit;
- 29% lower journey time savings than predicted;
- 35% lower traffic volume using the scheme than predicted; and
- 18% predicted benefits in wider area could not be confidently identified.

The two schemes in which the VfM category was improved from that forecast achieved this through better than expected safety benefits.

It should be noted that the VfM analysis presented here excludes several impacts which are included in the VfM categories used by ministers when making decisions. This includes journey time variability (JTV) which, because it improves with reduced congestion, will tend to enhance a scheme's VfM category were it to be included.

6.4.1 Has value for money changed over time?

In recent years, from 2008 onwards, the proportion of schemes achieving high value for money has improved compared with that seen in the earlier part of the decade.

Evidence for a trend in value for money assessments over time for completed schemes has been investigated by plotting the numbers of schemes falling into each category, as assessed by the outturn BCR, grouped by the opening year. This is shown in Figure 6-24.

Figure 6-24 Outturn Value for Money assessment over time

This histogram shows:

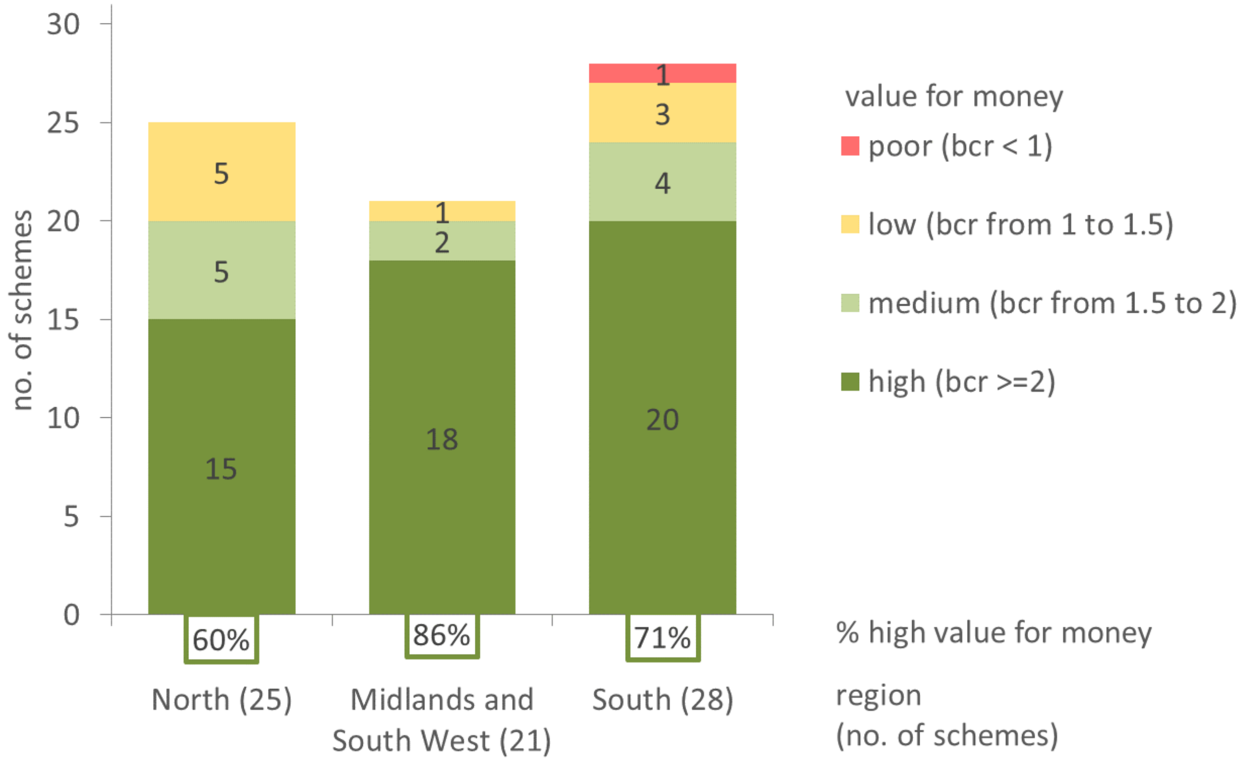
- Strong indication of a trend towards a greater proportion of schemes achieving a high value for money assessment over time; and
- Although few schemes are categorised as low or poor value for money there appears to be a trend for this to fall.

6.4.2 Do value for money assessments vary between Highways England's regions?

There is no evidence in the outturn value for money assessments of Major Schemes for differing trend between Highways England's regions.

The Major Schemes considered within this meta-analysis are spread throughout England, as illustrated in Figure 2-2, and within Highways England, these are managed within three different regions. The outturn value for money assessments for all the schemes have been grouped by region and this is shown in Figure 6-25.

Figure 6-25 Outturn Value for Money by Highways England's Major Projects regions



This shows that:

- The majority of the schemes in each region have achieved high value for money; and
- Schemes which are rated as lower value for money are spread across the regions showing that there is no evidence here of a problem in a particular region.

6.5 Are Major Schemes stimulating economic development?

There is anecdotal evidence to show that Major Schemes have assisted local and regional economic development through congestion reduction and improved journey time reliability which provides improved access to potential employment centres.

The government sees the strategic road network as being vital to British businesses and to the successful functioning of local and national economies[24]. The network not only provides England's main freight and logistics arteries, which connect international gateways, logistics interchanges and distribution centres, but also inter-urban connections, which can help put more people within reach of a wider range of jobs. The Road Investment Strategy (December 2014) states:

'There is strong evidence that transport investment, including in roads, can improve productivity and GDP. The SRN is a major facilitator of economic growth and having roads that meet the needs of all users, especially the freight and logistics sector, is vital for economic prosperity'

Many of the direct impacts of Highways England's Major Schemes such as changes in journey times and the numbers of collisions are monetised through the transport scheme appraisal process. However, there may be wider economic impacts, which can be either positive or negative, that are much more difficult to measure and quantify. WebTAG guidance now includes methods for estimating the wider economic and employment impacts of schemes, in detail. The appraisals for the majority of schemes included within this meta-analysis consisted of a basic qualitative assessment, or no assessment at all (in line with the guidance available at the time.

[24] Road Investment Strategy: Strategic Vision, Department for Transport (December 2014).

The POPE evaluation of wider impacts has been proportional depending on the forecast impact, and whether references were made to regeneration in the scheme-specific objectives. Due to the inherent difficulties in isolating impacts that are directly attributable to the scheme and not due to other factors (such as the economic downturn), POPE evaluations have typically focused on a qualitative ‘desktop’ analysis.

Figure 3-1 earlier in this report on page 19 showed that there were 22 schemes with a specific objective relating to ‘stimulating the economy’ and 21 achieved this objective, with 1 scheme with inconclusive evidence.

The remainder of this section provides case studies of schemes where the POPE process has been able to identify (albeit anecdotally) that the highway improvements have led to a beneficial economic impact.

Table 6-2 Case studies of schemes with wider economic impacts

Scheme	Evaluation of Wider Economic Impacts	
	Description	POPE evaluation (comparison to forecast)
A30 Bodmin to Indian Queens Improvement 	Upgrading of the A30 between Bodmin and Indian Queens to dual standard was expected to assist in reducing physical and perceived peripherality, thereby **assisting local and European Union regeneration objectives** of improving connectivity in Cornwall and the South West Region. Whilst it was not possible to quantify the wider economic benefits of the scheme, it was concluded that the scheme had been successful in supporting the local economy through enhanced connectivity.	Slight Beneficial (As expected)
M6 Junctions 8-10a Smart Motorway 	The M6 J8-10a Smart Motorway scheme was designed to tackle severe congestion on this section of motorway. The secondary objectives of the scheme related to the wider economic benefits that reduced congestion would deliver, including improved network resilience and agglomeration impacts for businesses. The appraisal of the scheme included welfare benefits as a result of the Smart Motorway implementation. The evaluation found that the increased capacity resulting from the scheme during certain hours of the day would drive wider economic benefits. The evaluation concluded that the scheme has **contributed to the growth aspirations of the West Midlands** region by providing additional capacity and improved journey times and reliability on the main strategic highway through the area.	Beneficial (As expected)
A3 Hindhead Improvement 	The improved transport connectivity achieved by dualling and tunnelling the A3 at Hindhead was forecast to have a wider economic impact on South Hampshire. In addition, by relieving Hindhead of through traffic, the blighted part of Hindhead was expected to experience an economic recovery. The scheme evaluation concluded that the improved journey times and reliability delivered by the scheme will have had economic benefits for South Hampshire given **better connectivity between Portsmouth and London**. The impact on Hindhead itself was also found to beneficial, with **evidence of new commercial activity** and house building following the scheme opening.	Moderate Beneficial (As expected)
A11 Attleborough Bypass 	The scheme was expected to deliver economic regeneration benefits at a regional strategic level, given the importance of the A11 to Cambridgeshire, Suffolk and Norfolk, linking their centres of population and employment as well as connecting ports and major areas of agricultural production. Although there was no quantifiable evidence to show the scheme had supported the economy in the area, the evaluation concluded that improvements to journey times and reliability will have **improved connectivity** and benefited the wider economy.	Slight Beneficial (As expected)
A595 Parton to Lillyhall Improvement 	The upgrading of the A595 to dual carriageway standard, as well as the bypassing of Distington was forecast to have a beneficial impact on the economy. This forecast was based on the fact that the A595 is the main north-south route in West Cumbria, with the scheme improving accessibility to employment and the potential for business markets to expand. This would support regional and European Union regeneration objectives. The evaluation concluded that the journey time improvements and increased road capacity delivered by the scheme were likely to have helped promote a more efficient transport system in the area, **improving north-south access to regional centres in West Cumbria** and aiding a large proportion of the population in terms of access to job opportunities and regional businesses.	Slight Beneficial (As expected)

The case studies presented in this section are intended to provide a snapshot of the typical economic impacts of Major Schemes for both nationally important schemes (such as the M6 J8-10a Smart Motorway) to local schemes (such as the A595 Parton to Lillyhall Improvement).

This section demonstrates that there are a number of examples of schemes which are likely to have led to wider economic impacts over and above the direct scheme impacts (such as changes in traffic flows, journey times and collisions).

7. Environment

Scheme Photo: A14 Haughley New Street to Stowmarket Improvement, Five Years After

7. Environment

7.1 How accurate are the forecasts for the Environmental sub-objectives?

An evaluation of the performance of each environment sub-objective against the forecast impact shows that overall:

- **70% of environmental sub-objectives are 'as expected'.**
- **16% of environmental sub-objectives are 'better than expected'.**
- **13% of environmental sub-objectives are 'worse than expected'.**

The environment objective consists of a number of sub-objectives which in simplistic terms are appraised and evaluated as per the methodologies outlined in Table 7-1.

Table 7-1 Summary of Appraisal and Evaluation Approaches for WebTAG sub-objectives

<table>
<tr><th>Environment Sub Objective</th><th>Appraisal Method</th><th>Evaluation Method</th></tr>
<tr><td>Noise</td><td>Consideration of changes in traffic flows, speed, composition (% HGVs) and road surface and definition of relevant mitigation measures.</td><td>Traffic volumes play a key role in determining noise impacts when comparing ES predicted figures with observed traffic flows and speeds. Noise measurements are not undertaken as part of POPE.</td></tr>
<tr><td>Local Air Quality</td><td>Consideration of changes in traffic flows, speed, composition (% HGVs) and identification of appropriate mitigation measures.</td><td>Traffic volumes and speeds play a key role in determining local air quality impacts. Where available, local air quality monitoring data is used.</td></tr>
<tr><td>Greenhouse Gases</td><td>Calculation of the fuel consumption changes (and associated greenhouse gas impact) arising from the scheme proposals.</td><td>Changes in carbon emissions measured against those predicted. Emissions are calculated based on traffic volumes, speeds and vehicle types.</td></tr>
<tr><td>Landscape</td><td>Examine the extent to which the road will be visible and definition of appropriate mitigation measures to integrate the road into the landscape.</td><td rowspan="2">The evaluation considers how the scheme has impacted on local landscape character, as well as its visual impact. Planting, earth mounding, screen fences and use of natural landforms (e.g. cuttings) are evaluated to ensure compliance to the commitments within the ES.</td></tr>
<tr><td>Townscape</td><td>Considers the impact of the scheme on the urban environment with emphasis on townscape features rather than the natural environment.</td></tr>
<tr><td>Biodiversity</td><td>Considers habitat loss, severance of habitats, effects of lighting, road spray, impacts during construction and definition of mitigation measures.</td><td>The evaluation is based on consultation with key stakeholders, review of ecological monitoring data and a site visit to confirm that mitigation measures are in place.</td></tr>
<tr><td>Heritage</td><td>Physical changes to archaeology through site activities leading to loss or damage of remains. Impacts on historic buildings through visual intrusion.</td><td>Relies on receiving Archaeological Evaluation Reports detailing the effects of the scheme and consultation feedback. Without these, only visual assessments of historic buildings and landscapes as noted in the appraisal are evaluated.</td></tr>
</table>

Environment Sub Objective	Appraisal Method	Evaluation Method
Water	Considers impact on quality of watercourse or groundwater from either routine highway drainage runoff or spillages. Definition of appropriate mitigation	The evaluation consists of site inspections to determine whether the mitigation measures are in place and performing as expected. Consultation with key stakeholders is also undertaken.
Physical Fitness	Examines how a scheme changes journey lengths, severance of routes for non-motorised users by considering changes to public rights of way.	The evaluation aims to confirm that changes to the public rights of way network, identified as being required as a result of the scheme, have been implemented during the site visit. Consultation with key stakeholders is also undertaken.
Journey Ambience	Examines impact of a scheme on traveller care (rest facilities), traveller views and driver stress (fear of accidents, frustration, route uncertainty).	Traveller stress - Improvements in journey times can be evaluated as having a positive effect on driver frustration. Traveller views - based on the views of the wider landscape available to the motorist and are determined by local landform and individual scheme earthworks features, and screen planting required for visual receptors and PROWs (public rights of way). Traveller care - Amenities available to the motorist; this includes rest stops and lay-bys introduced as a part of a scheme.

An analysis of the accuracy of environmental impact forecasts has been undertaken by comparing the AST and EST (Evaluation Summary Table) scores for each environmental sub-objective. The predicted impacts are assesed based on a seven point scale ranging from 'large beneficial' to 'large adverse'. This analysis makes a comparison between predicted and outturn impacts and identifies whether each sub-objective scored 'better than expected','as expected' or 'worse than expected' (based on a change of at least one point on the 7 point scale). The results are summarised in Table 7-2 followed by a brief commentary of the findings by sub-objective.

Table 7-2 Outturn Evaluation of Environment sub-objectives

Sub-objective	Outturn score				Comparison with prediction		
	Neutral	Adverse	Benefit	Not assessed	Better than Expected	As Expected	Worse than Expected
Noise	36%	18%	45%	1%	27%	59%	14%
Local Air Quality	25%	18%	56%	1%	28%	61%	11%
Greenhouse Gases	21%	62%	6%	11%	51%	13%	37%
Landscape	18%	76%	5%	1%	7%	73%	20%
Townscape	14%	7%	17%	61%	0%	96%	4%
Biodiversity	30%	61%	5%	4%	6%	78%	16%
Heritage	33%	54%	12%	1%	14%	81%	5%
Water	45%	33%	22%	1%	13%	79%	7%
Physical Fitness	47%	1%	39%	13%	2%	92%	6%
Journey Ambience	12%	0%	80%	8%	0%	94%	6%
All sub-objectives (excluding greenhouse gases)					**16%**	**70%**	**13%**

The key point to note from Table 7-2 is that the majority of the environmental sub-objectives were evaluated 'as expected' (70%), with 16% evaluated as 'better than expected' and 13% evaluated as 'worse than expected'. This shows that Highways England are mostly successful in delivering schemes with the expected impact occurring. However, the landscape and biodiversity sub-objectives scored 'worse than expected' with assessments of 20% and 16% respectively when compared with the Meta-analysis 2013 report which recorded 'worse than expected' assessments of 13% and 11% respectively. This is of further concern when scoring is compared against outturn scores which are 'adverse' in 76% and 61% of schemes respectively. All other sub-objectives assessed more schemes 'worse than expected' than in 2013.

A brief summary of the findings by sub-objective is below:

- **Noise** – 59% of schemes were 'as expected'. 27% of schemes were 'better than expected', which is primarily due to lower than forecast traffic volumes. The 14% of schemes which were 'worse than expected' are primarily due to higher than forecast traffic volumes.
- **Local Air Quality** – 61% of schemes were 'as expected'. 28% of schemes were 'better than expected', which is primarily due to lower than forecast traffic volumes. The 11% of schemes which were 'worse than expected' are primarily due to higher than forecast traffic volumes.
- **Greenhouse gases –** The results shown here indicate that most of the post opening impacts on greenhouse gases vary widely from the forecasts although the majority (51%) of schemes were 'better than expected'. 13% of schemes were 'as expected' and 37% of schemes were 'worse than expected'. Although heavily based on traffic volumes, the results differ from the noise and air quality results because of the importance of other factors such as speed and HGV numbers.
- **Landscape** – 73% of schemes were 'as expected'. 7% of schemes were 'better than expected' and 20% 'worse than expected'. A more detailed consideration of the performance of schemes against the landscape objective is contained in Section 7.4 on page 113.
- **Townscape** – Only a small proportion of schemes had a post opening evaluation against this objective as locations of many of the schemes are rural so the sub-objective is not applicable. Also, on many early AST's, townscape was often considered under the 'landscape' sub objective. The vast majority of schemes (96%) where townscape was considered were 'as expected' with only 4% being 'worse than expected'. Where a scheme includes a bypass, a significant reduction in traffic, particularly in HGVs along the old road has a positive impact on the local amenity and improves environmental conditions for villages and towns along the former route which had previously been subject to high traffic volumes. For some schemes, townscapes have been further enhanced by the provision of streetscape improvements often associated with de-trunking and this aspect is considered in more detail in Section 7.4.5 on page 129.
- **Biodiversity** – 78% of schemes were as expected and 6% were better than expected. However, 16% of schemes were 'worse than expected'. A more detailed consideration of biodiversity is contained in Section on page 101.
- **Heritage** – 5% of schemes were 'worse than expected' with the remaining being 'as expected' or 'better than expected'. This indicates that Highways England is successful in delivering the objectives for heritage as outlined in the individual scheme ES's.
- **Water** – 79% of schemes were 'as expected', 13% were 'better than expected' and 7% 'worse than expected'. POPE confirms that drainage facilities are in place and are being maintained as expected. Consultation responses received from the Environment Agency, Internal Drainage Boards and Councils are included where received. Schemes are generally found to be 'as expected' or 'better than expected' in most schemes. In instances where a 'worse than expected' assessment is made, maintenance issues are usually identified and include silting, blockage of outlets and general lack of maintenance within the confines of balancing pond sites.
- **Physical Fitness** – 92% of schemes were 'as expected' with only 6% being 'worse than expected'. Where schemes have been assessed as 'worse than expected', it is noted that issues include height clearances for bridleways which do not conform to DMRB standards, delays experienced through junctions and restricted access for users after scheme opening.
- **Journey Ambience** – 94% of schemes were evaluated 'as expected' with only 6% evaluated as 'worse than expected'. This is primarily due to higher than expected traffic volumes resulting in the worse than expected driver frustration levels.

7.2 What are the carbon impacts of Major Schemes?

The majority of Major Schemes result in increased carbon emissions in the opening year. However, in general the observed carbon impact is lower than forecast.

The Government's 'Road Investment Strategy' (December 2014) places particular emphasis on mitigating the local air quality and carbon emission impacts of Highways England's network. This section of the meta-analysis will focus on the evidence obtained through the POPE process relating to greenhouse gases where carbon dioxide is the most abundant of the greenhouses gases arising from road transport and it is measured in terms of the equivalent amount of CO2.

The tools used for predicting the greenhouse gas impacts of the Major Schemes considered in this sample typically involved one of the following approaches:

- The modelling tool COBA (**Co**st **B**enefit **A**nalysis);
- The modelling tool TUBA (**T**ransport **U**sers **B**enefits **A**ppraisal); or
- The DMRB (**D**esign **M**anual for **R**oads and **B**ridges) air quality spreadsheet.

The predictions of the carbon impact are published in the AST under the 'greenhouse gases' sub-objective and in the ES under Regional Air Quality. For some of the older Major Schemes with Environmental Statements dating back to the 1990s, it was not included on a consistent basis. For the schemes in this sample, the predictions of the net greenhouse gas emissions impact are normally for the scheme opening year.

The POPE process for evaluating carbon emissions is based on using the most appropriate methodology to assess the emissions on the key links. Normally this involves the use of the DMRB air quality spreadsheet approach. The focus is on the net emissions resulting from the scheme i.e. the difference with and without the scheme. The outturn evaluation uses observed traffic volumes, HGVs and average speeds.

There are two key elements to the POPE evaluation of Carbon:

- Firstly in order to enable the most informative like-for-like comparison of the outturn evaluation with the forecast, it is necessary to recreate a forecast based on:
  - Known set of links with predicted traffic data; and
  - Known methodology.
- Secondly the evaluation of the outturn net impacts for the same links in the road network and using the same methodology. This is based on observed data.

This analysis will focus on the POPE results that have been presented in the Scheme Evaluation Table (SET) which is published on Highways England's website and considers the results from one year after opening studies only.

Figure 7-1 summarises the observed impacts of Major Schemes on carbon emissions in the opening years.

Figure 7-1 Impact of Major Schemes on changes in carbon emissions in opening year[25]

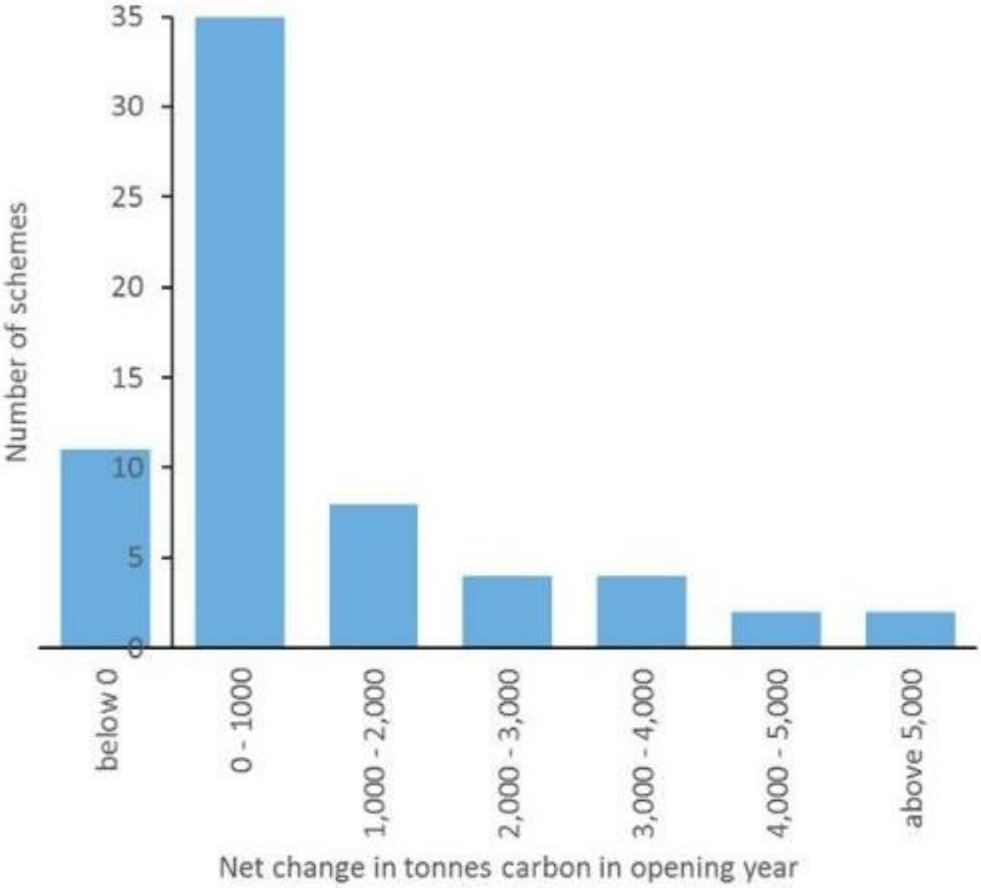


Figure 7-1 shows that the majority of Major Schemes result in an increase in carbon emissions in the opening year. This is typically due to one or a combination of a number of factors:

- Changes in traffic volumes – an increase in traffic using the scheme may result in increased carbon emissions.
- Changes in distance – the layout of the Major Scheme may result in vehicles having to travel further or shorter distances than before, which can have a corresponding impact on the emissions.
- Changes in vehicle composition - different types of vehicles emit different levels of greenhouse gases.
- Changes in speeds – some speeds are more efficient in terms of fuel consumption (and therefore greenhouse gas emissions) than others. As with the DMRB air quality assessment spreadsheet, the POPE approach to the evaluation of greenhouse gases is based on average speeds, which does not accurately consider the detail of the impact of peak period congestion's stop-start conditions which are typically more inefficient than average speeds.

The findings of increased emissions arising from the completion of most major schemes is unsurprising, as in most cases this was forecast. The accuracy levels are examined in Figure 7-2 which presents a comparison of the percentage difference between the forecast outturn carbon impacts in the opening year.

[25] Two outliers have been removed (from the +5,000 category).

Figure 7-2 Spread of schemes forecast vs. outturn opening year carbon impacts

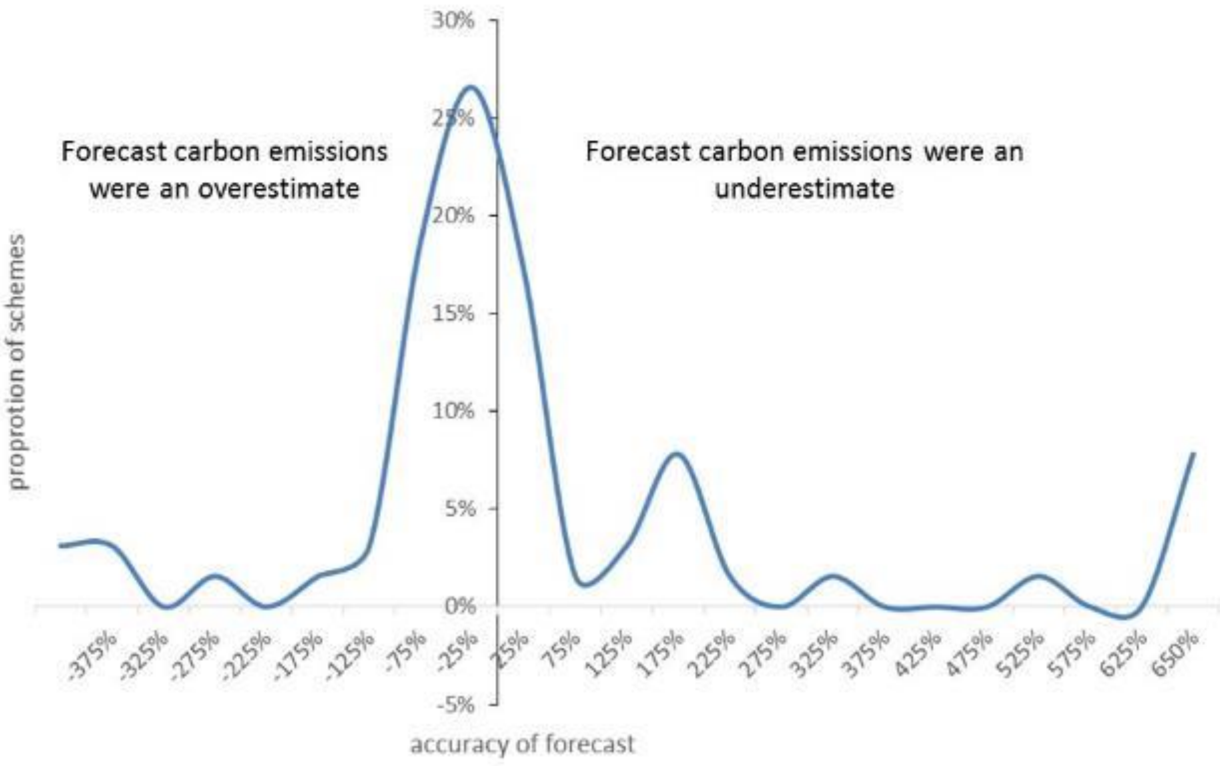


Figure 7-2 shows that:

- The majority of schemes (63%) had an outturn impact within +/-50% of the forecast impact
- Most of the schemes had forecasts which were overestimations of the actual impact. This is likely to be due to traffic forecasts having a tendency for to overestimate the actual level of traffic as shown in Figure 4–7 earlier in this report on page 30.

7.3 Is Highways England successfully maintaining biodiversity mitigation areas?

Biodiversity mitigation measures have generally been provided for all schemes considered in this meta-analysis. For 44% of schemes, certain elements of mitigation would appear not to have been provided, were deemed to be no longer required post Environmental Statement, had been slightly amended to suit site conditions, were underestimated or design issues were raised.

Monitoring was available for 57% of schemes

Based on the site visits for POPE and information provided within the landscape evaluations, it would appear that habitats such as grasslands, woodlands and hedgerows are establishing. These evaluations are based on visual confirmation during POPE site visits and, when available, ecological surveys/reports received. Maintenance and management is generally being undertaken appropriately.

For fauna, issues tend to be scheme-specific caused by vandalism/damage, poor maintenance/management, slow establishment or lack of clarity on responsibilities for the specific features.

This line of enquiry considers the following key questions:

- Have biodiversity features been installed as presented within the published ES?
- Is biodiversity monitoring available?
- Are biodiversity mitigation features being maintained as required within the CEMP, HEMP or equivalent document?

56% of schemes (44) including both OYA and FYA are set to achieve their mitigation targets.

57% of schemes (46) have biodiversity monitoring information available.

35% of schemes (28) identified biodiversity mitigation issues, including slow establishment of flora and maintenance.

7.3.1 Have biodiversity mitigation features been installed as outlined in the ES?

For 80 of the 81 schemes[26] considered for this meta-analysis, biodiversity mitigation measures have mostly been provided and are generally in line with those proposed. However some elements of these mitigation measures have not been provided in 36 schemes.

It is also evident that for some schemes, ecological mitigation has been implemented to a greater extent than indicated in the ES. This is usually as a result of later surveys indicating the presence of species and habitats not originally found and which would be affected by the scheme, or due to the requirements of the statutory consultees or changes in environmental legislation since the ES was prepared.

Thirty six (44%) schemes were identified by POPE where elements of mitigation have not been provided or have required amendment. Common themes are identified as follows (some schemes had multiple amendments), as a percentage of all schemes. Further details regarding individual schemes are shown in Table 7-3.

- Mitigation for fauna not provided **7%**
- Mitigation no longer required post ES following further surveys **6%**
- Mitigation changed **5%**
- Mitigation underestimated in ES **7%**
- Mitigation for habitat enhancement not taken forward **12%**
- Concerns raised regarding Drainage Design **9%**

Table 7-3 Summary of schemes where elements of biodiversity mitigation have not been provided

Theme	Scheme Name	OYA/ FYA	Comments
Mitigation for fauna not provide	**M40 J15 Longbridge Roundabout**	OYA	The local authority noted that measures for overwintering lapwing were not included in the ES and Lapwing are now lost to the area as a result of the scheme.

[26] For one new scheme (Birmingham Box Phase 2) specific species mitigation was not included in the ES as impacts were not expected and insufficient information has been made available at OYA for POPE to comment further i.e. to confirm whether mitigation was required or not.

Theme	Scheme Name	OYA/ FYA	Comments
	A66 Greta Bridge to Stephen Bank Improvement	OYA	No fencing provided to channel otters towards the safe crossing provided within the scheme. MAC identified that although a new culvert has mammal ledges, the old structure does not and the ledges only allow mammals to gain access to the central reserve but not beyond.
	A66 Stainburn and Great Clifton Bypass	FYA	No specimen trees to channel bats, log pile hibernacula or woodland edge works to stabilise retained woodland.
	A500 City Road Improvement	FYA	No installation of artificial bat roost cavities.
	A120 Stansted to Braintree Improvement	FYA	Bat boxes at two bridges not provided.
	A595 Parton to Lillyhall Improvement	FYA	No information relating to Amphibian tunnels has been made available to POPE and it is thought that these were not included within the final scheme.
Mitigation no longer required post ES following further survey prior to construction	**A419 Blunsdon Bypass**	OYA	Reptile hibernacula not required as pre-scheme surveys found no reptiles.
	M62 J6 Improvement	OYA	Mitigation for reptiles and water voles was not provided.
	A27 Polegate Bypass	FYA	Less badger fencing was required.
	M25 J16-23 Widening	OYA	New ponds not required as verification surveys found that water voles were absent from watercourses probably due to predation by mink. River corridor habitat was improved for water voles should they return,
	A595 Parton to Lillyhall Improvement	FYA	Red squirrel nest boxes not provided as these would encourage grey squirrels, which had recently moved into the area, to the detriment of the reds.
Mitigation changed	**M1 J25-28 Widening**	OYA	An otter ledge was not added to a culvert, as it was considered unlikely to flood.
	A421 Bedford to M1 J13 Improvement	OYA	The otter ledge was removed following agreement between Highways England and the Internal Drainage Board (IDB) on the basis that it could cause a restriction in flow in times of flood. It was considered that the route through the adjacent railway bridge would offer a suitable alternative route.
	A595 Parton to Lillyhall Improvement	FYA	To avoid the wide grassed central reserve becoming suitable foraging areas for barn owls and the possible increase in mortality due to exposure to traffic. Extra Heavy Standard Alder trees have been planted. Where low-maintenance grass remained in the central reserve it was likely that it would require cutting more frequently than envisaged, to ensure that it did not become colonised by small mammals.
	A500 City Road Stoke	OYA	At Fowlea Brook due to stability issues during construction grassed slope had to be changed to a solid concrete retaining wall, with potential impact on mammal passage in times of high flood.
Mitigation underestimate d in ES	**M6 Carlisle to Guardsmill Extension**	OYA	M6 and A6 - The number of reptiles/amphibians requiring to be translocated exceeded the numbers expected and required alternative receptor sites to be provided, including off-site habitat areas some distance from the schemes.
	A6 Alvaston Improvement	FYA	
	A500 Basford, Hough, Shavington Bypass	FYA	Mitigation included in the 1991 ES was not as extensive as was expected by the time of

Theme	Scheme Name	OYA/ FYA	Comments
			construction, at which time additional land for mitigation could not be acquired through the CPO process. This meant that mitigation measures had to be fitted into the space available and in some instances a compromise had to be accepted by the nature conservation agencies.
	A30/A382 Whiddon Down Junction	OYA	Dormice were found outside the original area covered by the licence at a remote location of the works and a new licence had to be applied for causing delays to the build.
	A66 Carkin Moor Improvement	FYA	Based on the increased incidence of wildlife fatalities it would appear that more ecological mitigation could have been included within the scheme design.
	A66 Greta Bridge Improvement	FYA	
Mitigation for habitat enhancement not taken forward	**A46 Newark Lincoln Improvement**	FYA	Wildflower seeding proposals not taken forward and replaced with open/amenity grassland. For the A1 Peterborough-Blyth junctions, it was expected that wildflower seeding would be undertaken as remedial measures by the Contractor. For Newark it was listed as a possible mitigation measure rather than a firm ES commitment. For Stannington it is understood that since the FYA site visit the MAC has undertaken some targeted wildflower plug planting on the cutting slopes around the junction where low fertility soils are suitable.
	A1 Peterborough Blyth Junctions	OYA	
	A1 Stannington Junction	FYA	
	A120 Stansted to Braintree Improvement	FYA	Translocation of turves not possible due to contract timetable, with nowhere for translocation at time of site clearance.
	A1033 Hedon Road Improvement	OYA	Opportunity lost to safeguard local habitat of interest at Hedon Road due to lack of survey. For Caxton Common, the ES did not specifically include mitigation for bluebells despite noting that they should be retained.
	A428 Caxton Common to Hardwick Improvement	OYA	
	A1 (M) Ferrybridge to Hook Moor	FYA	A1(M) Ferrybridge: an opportunity was lost with regard to stripping and storing woodland soils disturbed by the road works separately for re-use near to the original locations.
	A5 Nesscliffe Bypass	OYA	A5 ES requested that the material from the peat bodies disturbed during construction should be reused in the creation of wetland areas nearby. However, at the stage that the peat bodies were discovered, the inflexibility of the implementation process and inability to acquire more land resulted in the peat not being used.
	M25 J16-23 Widening	OYA	The ES proposed management to remove conifers and rhododendron from Denham Marsh Wood (between J16 and 17) as compensation for loss of ancient woodland. At OYA POPE is not aware whether this management has been undertaken.
	M25 J28 (A12 Brook Street)	FYA	Provision of reptile hibernacula and refugia were not undertaken; as the pre-scheme embankment had been replaced on a like-for-like basis; further enhancement for reptiles was not considered necessary.
Co nc er ns	**A30 Bodmin to Indian Queens Bypass**	OYA	Water run-off from construction activities led to siltation of local watercourses affecting biodiversity

Theme	Scheme Name	OYA/ FYA	Comments
	A69 Haydon Bridge Bypass	OYA	and requiring remedial measures to be agreed with EA during construction.
	A590 High & Low Newton Bypass	OYA	
	A46 Norton Lenchwick	10YA	EA raised ecological issues post opening over the design of watercourse crossings and diversions and noted that box culverts lacked mammal passes.
	A500 City Road Stoke	OYA	EA identified that river channel design incorrectly built on site and required remediation of the River Trent channel.
	A21 Lamberhurst Bypass	OYA	EA commented that the design provides suitable access under the bridge for wildlife to use during normal and high flows but not for otters or other mammals to use during severe flooding, when access under the bridge may be restricted.
	A27 Southerham to Beddingham Improvement	OYA	The new ponds (one created for drainage purposes, one for ecological benefit) could have been more wildlife friendly with less steep sides and variable depths.

7.3.2 Is biodiversity monitoring available?

It would appear from consideration of scheme evaluation reports for this meta-analysis that monitoring has generally been undertaken where protected species Defra licences have been required, and mitigation measures have been included in schemes. Mitigation licences are a legal requirement under The Conservation of Habitats and Species Regulations 2010 (as amended) which implements the EC Directive 92/43/EEC in the United Kingdom where European protected species are affected by development proposals.

Based on information provided, monitoring is in place or expected to be undertaken by FYA for 46 (**57%**) of the 81 schemes.

POPE is not aware whether monitoring post-opening is being carried out or not for 15 schemes (**19%**) because no information has been made available, however, 3 of those are at OYA and it may well be that by FYA information will be available (M6 Birmingham Box, A419 Blunsdon and M27 J3-4). At one FYA scheme it is understood that post opening monitoring was due to take place from year 6 onwards i.e. outside the reporting period for POPE. For mitigation measures such as mammal underpasses and fencing inspected as part of ongoing routine maintenance rather than a specific Mitigation Licence requirement, POPE does not always receive information confirming whether this monitoring has happened or not – it depends whether individual Scheme aftercare inspection reports are provided and also whether they include such detail.

For 20 schemes (**25%**) monitoring was not a scheme requirement and this includes some older schemes where monitoring was not always considered as part of the ES, together with others where the biodiversity impacts were minimal and therefore monitoring was not considered necessary. Table 7-4 highlights 32 (**40%**) schemes where issues have been identified based either on monitoring received or site visit information. For the remaining schemes no particular issues were noted or POPE cannot comment because although monitoring was understood to have been / or was being undertaken no data was provided to POPE.

Table 7-4 Summary of scheme specific biodiversity themes from monitoring data

Species	Scheme Name	OYA / FYA	Comments
Bats	**M1 J6A to 10 Widening**	OYA	

	M62 J6 Improvement	OYA	Lighting of underpasses has deterred expected use by bats, with suggestions for amending the level of lighting to make these routes more likely to be used by bats.
	A21 Lamberhurst Bypass	OYA	A programme of monitoring should be set up for bats to act as indicator species for successful operation of the land bridge for a minimum of 3 years or as requested by the Defra licence, but it would appear this did not happen.
	A419 Commonhead Junction	FYA	The HEMP notes that a misunderstanding on boundaries between the MAC and Contractor meant that supposed monitoring of bat and bird boxes did not happen.
	A47 Thorney Bypass	FYA	30 bat boxes were located on a golf course just to the north of the scheme, but there has been no monitoring since installation so it is not known if they are being used.
	A3 Hindhead Improvement	OYA	Scheme monitoring indicates that the bat boxes have not been successful as none were found to be used by bats - may be due to availability of other roosting opportunities within habitat surrounding the scheme.
	A590 High and Low Newton Bypass	FYA	Mixed results from bat monitoring, some mitigation less effective than was hoped for. The bat guidance structure was to be monitored in summer 2013. It was agreed with the Lake District National Park Authority that it would be removed if it was no longer being used by bats. POPE is not aware whether or not this monitoring took place.
	A428 Caxton Common to Hardwick Improvement	FYA	Monitoring of bat boxes confirmed that those surveyed had not been used.
	A595 Parton to Lillyhall Improvement	FYA	Monitoring indicated a decrease in bat activity through the culverts during periods of high flow of water. Monitoring of the bat guide bridge indicated that in 2011 numbers using the commuting route had not yet recovered to pre-construction levels.
Badgers	**A6 Clapham Bypass**	FYA	*Lack of use of badger mitigation:* A6: An artificial badger sett was provided but never used and removed after some months. M25: Monitoring to date has not recorded any use of an existing badger tunnel refurbished and extended at both ends following the works, possibly due to lack of vegetative cover. A34: Badgers were using the tunnels under the slip roads but the mainline tunnel was not generally used, possibly because the length was too great for the badgers to want to use and further work on maximum viable length of badger tunnels would be of value.
	M25 J16-23 Widening	OYA	
	A34 Chieveley to M4 J13 Improvement	FYA	
	A6 Alvaston Bypass	FYA	*Issues with badger fencing* (A6 and A43) Badger fencing not continuous or section missing. A46: Badger fencing implemented not in line with current standards. A5: A balancing pond was not enclosed by badger fencing and observations noted that the access gate had been left open allowing badgers to enter the site through the gate which gives access to the A5. A1: It was not expected in the ES that there would be badger fences provided as part of the scheme, however there have been some badger deaths and the Local Authority would like fences to be provided.
	A43 Whitfield Turn -Brackley Hatch Improvement	FYA	
	A46 Norton Lenchwick Improvement	10YA	
	A5 Nesscliffe Bypass	OYA	
	A1 Bramham-Wetherby Bypass	OYA	

	A34 Chieveley	FYA	A34: during the aftercare period two incidents of badger deaths possibly attributed to the construction of an environmental barrier preventing badgers from moving west across the A34 - this might be resolved by new badger fencing on the east side of the A34.
	A6 Great Glen Bypass	FYA	*Periodic flooding at tunnels.* (For A428 Caxton Common and A421 Great Barford at OYA but not noted at FYA potentially due to dry conditions). For A1(M) Ferrybridge at OYA but no information available at the FYA stage.
	A421 Great Barford Bypass	OYA / FYA	
	A6 Rushden and Higham Ferrers Bypass	FYA	
	A428 Caxton Common to Hardwick Improvement	OYA / FYA	
	A1(M) Ferrybridge to Hook Moor	OYA / FYA	
	M6 Toll	FYA	
	A30 Bodmin to Indian Queens Improvement	FYA	
	A14 Haughley New Street to Stowmarket Improvement	OYA	Badger tunnel exited into contractor's compound rather than into agricultural field as expected in ES due to compound being retained on site for a separate scheme in agreement with landowner.
	A43 M40-B4031 Dualling	FYA	The use of a combined mammal tunnel and drainage culvert may discourage badgers from using the culvert when it is holding water
	A63 Selby Bypass	FYA	Site visit observations indicated that the diameter of one of the mammal tunnels appeared to be less than the 600mm recommended in DMRB.
Otters	**A1 Willowburn to Denwick**	FYA	The local Wildlife Trust considered that 600mm diameter culverts were too small for otters in times of flood when they become impassable. In these conditions, otter are likely to cross the carriageway. However, there was no evidence that the otter population had been adversely affected by the A1 dualling.
Water voles	**A249 Iwade to Queenborough Improvement**	FYA	Initial water vole translocation was not successful, with Natural England suggesting that habitat creation would be a better solution than translocation, particularly for fast breeding species.
Barn Owls and raptors	**A64 Colton Lane GSJ**	FYA	Failure of larger sized trees reduced effectiveness of planting to deflect barn owls and raptors up and above traffic.
	A66 Temple Sowerby Bypass and Improvement	FYA	MAC undertook additional planting in response to the increased numbers of barn owl mortalities; aiming to increase the height of owl flight paths, consequently reducing the number of mortalities.
	A1 Stannington Junction	FYA	MAC records indicated 2 barn owl casualties in 2007 and one in 2009 noting slow establishment of the new landscape planting together with good foraging habitat in the vicinity of the scheme may have contributed to the barn owl fatalities post opening.
Birds	**A5117 Deeside Junction Improvements**	OYA	Bird boxes were not used in 2009 and the monitoring report recommended repositioning them higher up.

Great Crested Newts	**A6 Alvaston Improvement**	FYA	Initial failure of Great Crested Newt (GCN) ponds and translocation worse than expected. This was primarily due to an underestimation of the population size. Monitoring highlighted the failure of mitigation ponds and remediation works took approximately five years to be satisfactorily delivered. The GCN population was less than a tenth of the pre mitigation size at FYA.
	A27 Southerham to Beddingham Improvement	FYA	Monitoring did not identify any GCN It was concluded that the negative result does not necessarily imply that GCN are now absent from the water bodies, since only 1 survey was undertaken in order to comply with the DEFRA licence (4 surveys are more usually undertaken), that bottle traps are not a reliable search method, and that there was too much vegetation present, or the water too turgid, for torching to be effective.
	A595 Parton to Lillyhall Improvement	FYA	Stickleback were noted in one of the four ponds which were likely to be detrimental to the GCN population over time.
	A428 Caxton Common to Hardwick Improvement	FYA	Lower GCN numbers were recorded in 2011 - wildfowl using the pond may be the reason for the reduction in aquatic vegetation which is used by GCN as substrate for egg laying. 2011 also a significantly dry year and nationally reduced GCN counts were noted.
Reptiles	**A3 Hindhead Improvement**	OYA	Populations of adder, common lizard and slow worm were translocated from an area of habitat in Boundless Copse to a receptor site on National Trust land near Highcombe Edge. A population of grass snake was translocated from the same location in Boundless Copse to a receptor site on Forest Enterprise land at Hurthill Copse. No reptile monitoring surveys had been undertaken at OYA and the success or otherwise of the translocation cannot be determined.
	A30 Bodmin to Indian Queens Improvement	OYA	NE commented that with regard to relocating reptiles from the road area without ongoing monitoring it was not possible to confirm how successful the mitigation has been.
Butterflies	**A30 Bodmin to Indian Queens Improvement**	OYA/ FYA	Specific monitoring of the new Marsh Fritillary breeding habitat has not been undertaken as part of the scheme. This was identified as required in the English Nature/HE Butterfly Handbook where the A30 Bodmin scheme has been used as a case study for butterfly mitigation. By FYA, NE has monitored the site and has seen flying adults in June of 2011 and 2010 but no larval webs. NE notes that the Marsh Fritillary butterfly has declined markedly across the Goss Moor area during this time although there is no direct link to the scheme.
Dormice	**A3 Hindhead Improvement**	OYA	By 2012 many dormouse boxes (approx. 50%) could not be found and of those checked few were found to have evidence of use by dormice. No records were available to show whether dormice are using the dormouse bridges, and generally there is no data from any UK highways scheme of usage of dormouse bridges of similar design being used by dormice.
	A21 Lamberhurst Bypass	FYA	A programme of monitoring should have been set up for dormouse to act as indicator species for successful operation of the land bridge for a minimum of 3 years or as requested by the Defra licence, but it would appear this did not happen. Some dormouse monitoring did take place in adjacent woodland as part of a national programme.

	A30 Bodmin to Indian Queens Improvement	FYA	Monitoring results in 2012 confirmed that dormice are still present within Black Acre Farm and Innis Downs. Several nest tubes had been lost and several could not be accessed due to the dense vegetation. The dormouse-boxes were not checked as the boxes had degraded. No evidence of dormice was recorded from the hair-tubes along the dormouse access bridges.
Invertebrates	**A3 Hindhead Improvement**	OYA	Beetle monitoring indicated a likely significant effect on saproxylic (dead wood) invertebrate habitat through reduced dead wood resource and change of microclimate. Habitat improvements undertaken (additional planting and dead wood) with monitoring to be undertaken in 2014.
Issue	**Scheme Name**	**OYA / FYA**	**Comments**
Funding Issues	**A590 High and Low Newton Bypass**	FYA	There has been less extensive monitoring of bats than originally envisaged.
	A27 Southerham to Beddingham Improvement	OYA	The ES suggested extensive monitoring, however, only monitoring required as a condition of Defra Licences (bats and GCN) has been undertaken, along with monitoring of barn owls.
	A595 Parton to Lillyhall Improvement	FYA	The ES suggested 'best practice' ecological monitoring but where no formal commitment had been made or there was no obligation associated with wildlife legislation, it was not taken forward.

Conclusions

Monitoring information has been made available for 57% of schemes evaluated compared with 55% in 2013. Scheme monitoring provides evidence of the effectiveness of biodiversity mitigation measures and, of equal importance, also highlights where measures could be improved or are performing less well than anticipated. Issues with badger mitigation features are the more common which is not surprising given the widespread distribution of badger. It is also worth pointing out that of the 5 (4 OYA and 1 FYA) schemes being considered in this Meta-analysis for the first time, monitoring was available for 4 and may not have been a scheme requirement for the other. In addition, for the 2 schemes now at the FYA stage and where it was expected at OYA that monitoring data would become available – this has been the case, which could indicate that for more recent schemes monitoring reports are becoming more readily available to POPE.

The scheme survey/monitoring reports are not always made available to POPE for a variety of reasons including archiving of hard copy information, corruption of electronic files or lack of continuity of personnel leading to difficulties in tracing information. A requirement for all scheme survey and monitoring reports (pre, during and post construction) to be available digitally from a central data base or via the MACs and ASC's would help improve the availability of information and therefore the confidence in post-opening evaluation outcomes. Ensuring that all parties (including the MACs and ASCs) are made aware of the environmental commitments relevant to each scheme would also overcome any confusion relating to areas of responsibility for on-going biodiversity monitoring and maintenance.

Monitoring would appear to be undertaken when it is an ES or Defra licence requirement. More general monitoring, for example for the establishment of species-rich grassland or habitat areas, is generally not undertaken. It is not clear to POPE why monitoring appears limited as there are clearly requirements in the ES for targets to be achieved. It has been identified as a potential issue in this meta-analysis and could become an emerging trend for future evaluations.

7.3.3 Are biodiversity mitigation features being maintained as required in the HEMP or equivalent document?

Based on the site visits undertaken as part of the POPE process and information provided within the landscape evaluations, it would appear that habitats are generally being maintained and managed appropriately. There are however, examples where species rich/wildflower seeded areas or marginal aquatic planting associated with ponds were not establishing as expected, where translocated plants / hedges have not been managed/maintained and where noxious weeds were prevalent.

Specific issues relating to fauna mitigation have been identified in 28 (35%) schemes with details on individual schemes shown in Table 7-5. In addition many schemes identified issues with habitat creation areas, but have not been detailed individually here. Common themes for fauna are identified as;

- Lack of maintenance / management **22%**
- Vandalism **6%**
- Slow establishment **11%**
- Storm damage **1%**

Table 7-5 Summary of schemes with specific problems with mitigation measures for fauna

Theme	Scheme Name	OYA / FYA	Comments
Lack of Maintenance and/or Management	**Common issues affecting at least 10 schemes**		Problems with habitat creation areas due to lack of maintenance/management, including where location outside the highway boundary.
	A14 Haughley New Street to Stowmarket Improvement	OYA	A mammal ledge at Tot Hill culvert was broken (to be repaired).
	A43 Silverstone Bypass	FYA	Great Crested Newt (GCN) habitat not maintained, and the condition of dormouse nest box/tubes indicated they had not been maintained, and bat boxes would not be physically checked or moved for health and safety reasons.
	M5 J17-18 Improvement	FYA	Slight issue with GCN pond outside Highway Boundary and whether it would be subject to on-going maintenance – overgrown at FYA
	M1 J31-32 Widening	FYA	Although results of the GCN monitoring were positive there was no standing water in the pond located off site; pond not due to be managed in the future i.e. beyond the period discharged in the licence.
	A63 Melton Grade Separated Junction	FYA	Litter was a likely hindrance to badgers at one of the tunnels.
	A419 Commonhead Junction	FYA	Misunderstanding over boundaries resulted in bat and bird boxes not being maintained as expected in the HEMP.
	A34 Newbury Bypass	FYA	Management issues led to deterioration in the internationally recognised Desmoulin's whorl snail habitat.
	A5117/A550 Deeside Park Junctions Improvement	OYA	Badger fencing had been damaged at some locations (to be repaired).
	M60 J5-8 Widening	FYA	Pond not operating as expected and possibility that without continued management the effectiveness of wetland ditches may cease to perform their functions as habitats for smooth and palmate newts.
	M6 Toll	FYA	Many recommended remedial works e.g. repairs to otter and badger fencing remained outstanding.
	A428 Caxton Common to Hardwick Improvement	FYA	Badger fencing breached at base and required maintenance to avoid increases in animal mortality. May not have been installed to required specification. Water vole habitat mitigation considered sub-optimal and remedial works recommended.

<table>
<tr><th>Theme</th><th>Scheme Name</th><th>OYA / FYA</th><th>Comments</th></tr>
<tr><td rowspan="10"></td><td rowspan="2">A3 Hindhead Improvement</td><td>OYA</td><td>Nearly all dormouse boxes checked in 2012 were damp, or in need of repair. Those not found were presumed to have fallen from their tree. Recommended replacement to allow monitoring to continue and to improve their suitability for dormice</td></tr>
<tr><td>OYA</td><td>Only 80 bat boxes out of the 171 were found and most were in poor condition, wet inside and therefore unsuitable for roosting bats.</td></tr>
<tr><td rowspan="2">A30 Bodmin to Indian Queens</td><td>FYA</td><td>Positive use of dormouse nest tubes and barn owl boxes during monitoring but they required replacement and had degraded before the end of the five year maintenance period</td></tr>
<tr><td>FYA</td><td>Issues with litter and rubble at badger tunnel entrances and vegetation overgrowth</td></tr>
<tr><td>A595 Parton to Lillyhall</td><td>FYA</td><td>Emergence surveys of the bat hibernation chamber in 2008, 2009, 2010 and 2011 have revealed no bats emerging from the structure; nor have bats yet been recorded using the heated chamber which was noted to be damp due to water ingress.</td></tr>
<tr><td>A6 Rothwell Desborough</td><td>FYA</td><td>The integrity of the GCN exclusion fence had been compromised.</td></tr>
<tr><td>A10 Wadesmill</td><td>FYA</td><td>Some instances of gaps at the base of badger fencing and gates.</td></tr>
<tr><td>A421 Great Barford</td><td>FYA</td><td>Whilst the GCN permanent fencing has been maintained in place, it is noted that the vegetation has not been strimmed away from the fence which would allow newts to climb over.</td></tr>
<tr><td>A21 Lamberhurst Bypass</td><td>FYA</td><td>Wetland habitat mitigation could have been further enhanced by removing the amphibian fencing allowing amphibians using the toad tunnel to access the ponds.
Temporary plastic sheeting may be preventing amphibian movement into/out of the adjacent woodland unnecessarily.</td></tr>
<tr><td rowspan="5">Vandalism</td><td>M1 J25-28 Widening</td><td>OYA</td><td>Some bat boxes vandalised and required to be moved and others exhibited damage by squirrels and the weather.</td></tr>
<tr><td>A6 Alvaston Bypass</td><td>FYA</td><td>Vandalism and lack of maintenance of badger fencing.</td></tr>
<tr><td>A10 Wadesmill Bypass</td><td>FYA</td><td>Vandalised bat cave and a pedestrian gate at pond allowing a complete break in deer and badger fencing.</td></tr>
<tr><td>A1(M) Ferrybridge to Hook Moor</td><td>FYA</td><td>Vandalised deer gate and short section of badger fencing missing.</td></tr>
<tr><td>A595 Parton to Lillyhall</td><td>FYA</td><td>3m section of otter ledge vandalised and unlikely that otters would be able to use ledge in the current condition.</td></tr>
<tr><td rowspan="2">Slow establishment</td><td>M62 J6 Improvement</td><td>OYA</td><td>Great Crested Newt habitat not establishing as well as expected.</td></tr>
<tr><td>A66 Temple Sowerby Bypass</td><td>OYA / FYA</td><td>‘Green bridge’ planting not establishing as well as expected to act as a guide for foraging bats and badger connectivity.
At FYA, although planting not thriving, it is slowly establishing and bats have been observed foraging</td></tr>
</table>

Theme	Scheme Name	OYA / FYA	Comments
			along the road embankments and utilising the structure to cross the road.
	M6 Toll	FYA	The 2008/2009 GCN surveys found that further mitigation measures needed to meet the requirements of the great crested newt licence.
	A64 Colton Lane	FYA	Failure of larger sized trees reduced effectiveness of planting to deflect barn owls and raptors up and above traffic.
	A66 Temple Sowerby	FYA	MAC undertook additional planting to raise owl flight paths in response to the increased numbers of barn owl mortalities.
	A3 Hindhead Improvement	OYA	Acid grassland seeding on the old A3 has been moderately successful, however it would appear that the heather restoration of the old A3 has not been successful.
	A66 Long Newton	FYA	The failure and poor performance of significant elements of the landscape proposals are likely to have impacted on habitat diversity and resulted in localised ecological effects that are worse than expected.
	A30/A382 Whiddon Down Junction	FYA	Although reptiles still inhabit the monitoring area, albeit in low numbers, there is little evidence to suggest that the regeneration of habitat has achieved favourable conditions.
	M25 J28 (A12 Brook Street)	FYA	Heavy grazing by deer has resulted in a break in continuous vegetation - potentially disruptive to bat movements and could give rise to altered foraging behaviours leading to roost/ foraging habitat severance.
Storm Damage	**A27 Southerham to Beddingham Improvement**	OYA	Barn owl box and tree destroyed by storm damage. (NB successful breeding had occurred at 2nd box, and attempted but failed breeding at the 3rd box).

Conclusions

Maintenance and management of habitats varies across schemes. For fauna, issues tend to be scheme-specific caused by vandalism/damage, poor management or lack of clarity on responsibilities for the specific features. For some of the issues either Highways England or the MAC/ASC were already aware of the problem and remedial measures were programmed to be carried out e.g. A14 Haughley and A5117 Deeside.

Possible reasons for lack of maintenance/management could be down to the timing of aftercare activities, potential funding issues playing a part in the level of maintenance and management, or lack of clear environmental commitments at the time of the ES, although further study would be required to be able to draw any firm conclusions.

7.4 How successful is Highways England in mitigating the landscape and townscape impacts of Major Schemes?

Overall 80% of schemes assessed show that overall landscape objectives set in the ES are set to be achieved. It is noted that when compared with the Meta-analysis 2013 (84%) and Meta-analysis 2010 (93%), a reduction in target achievement is evident.

This evaluation identifies deterioration in landscape scheme target achievements when compared with ES predictions of impacts. It also serves to highlight issues within individual schemes that impact upon growth target achievements.

Performance of schemes against targets set in their ES is as follows:

- **7% of schemes had landscape impacts which were 'better than expected';**
- **73% of schemes had landscape impacts which were 'as expected'; and**
- **20% of schemes had landscape impacts which were 'worse than expected'.**

Additionally, this section confirms that the use of locally appropriate materials within schemes where traditional resources identify location and history makes a positive contribution to scheme design and is generally welcomed by local councils and residents.

Assessment of the impact of schemes on designated sites confirms that 45 (56% of 81 schemes) schemes assessed for this Meta-analysis are located within or adjacent to designated landscapes which have included national designations such as National Parks or Areas of Outstanding Natural Beauty (AONB), greenbelt, historic parks and gardens or historic landscapes, as well as areas designated at a local level such as Areas of Great Landscape Value.

Finally, this section confirms that townscape/streetscape initiatives undertaken particularly during de-trunking and as included in the ES design are generally well received when returning a previously congested urban space to a more locally appropriate village/town.

This line of enquiry considers the following key questions:

- What are the landscape impacts of Major Schemes?
- Is landscape mitigation in place at the One Year After stage set to achieve its target at the five year after opening stage?
- How does Highways England use locally appropriate materials in its schemes?
- How accurately are impacts forecast for designated landscapes?
- How often do suggested townscape/streetscape improvements identified in the ES get provided?

Landscape definition with relevance to this report:

The term landscape commonly refers to the view or appearance of the land. However, the landscape is a combination of both cultural and physical characteristics or components, which give rise to patterns that are distinctive to particular localities and help to define a 'sense of place'. The landscape is not therefore simply a visual phenomenon but relies upon other influences including topography, land use and management, ecology and historical and cultural associations[27].

Landscape is not only a rural phenomenon as it encompasses the whole external environment, including cities, towns and small settlements. The character of the urban environment can be defined as townscape. Townscape is the interaction of both the physical and social characteristics of the urban environment and the way in which they are perceived. Physical characteristics include urban structure and grain and the spaces between buildings which together combine to create the layout of the urban environment. Other physical characteristics include the height and mass or scale of buildings and their appearance in terms of both construction materials and detailing or decoration. The social characteristics of a townscape are determined by how these physical characteristics are used and it is the interrelationship of these characteristics that give a place its character and distinctive identity.

Landscape & Visual impact Assessment for Highway Schemes

Within the ES / EAR for each scheme, a Landscape and Visual Impact Assessment is undertaken which identifies:

- The baseline conditions of the existing landscape and the impact that a scheme will have on it; and
- Mitigation measures, including landscaping to mitigate the visual intrusion of the scheme on the wider landscape.

POPE landscape reports refer to the requirements identified within the ES and determine whether the impacts as identified within the ES are as expected based on mitigation measures installed, planting conditions during construction and aftercare maintenance undertaken to ensure growth targets are to be met. This Meta-analysis picks up on these expectations to identify possible trends linked to overall mitigation success or failure, growth target attainment and the effects of reduced aftercare.

Common aims of landscape works include[28]:

- Mitigation of the loss of landscape features such as hedgerows, mature vegetation and field ponds;
- Minimising the visual impact of the proposals on properties and public areas and where possible improve on the existing situation;
- Compliance with and support of local landscape management and restoration strategies;
- Generally enhance the landscape within the road corridor, both for local amenity and the benefit of road users;
- Consider various landscape, cultural heritage and ecological designations; and
- Wherever possible, the planting and seeding works should aim to provide value for wildlife

7.4.1 What are the landscape impacts of Major Schemes?

Earlier in this report in the summary of the environmental impacts of Major Schemes (Table 7-2 on page 97) it was noted that the majority of schemes (**76**%) had some adverse effect on the landscape sub-objective and in **73%** of cases this was in line with the forecasts. To examine this further the landscape evaluation results by different type of scheme are presented in Table 7-6.

[27] Definitions taken from the A3 Hindhead ES Volume 1 Chapter 13.
[28] Some examples taken from A5117 Deeside HEMP.

Table 7-6 Summary of Landscape evaluation results by scheme type

Scheme type	Number of scheme evaluations				Comparison with prediction		
	Neutral	Adverse	Benefit	Not assessed	Impact Better than Expected	Impact As Expected	Impact Worse than Expected
All Schemes	18%	76%	5%	1%	7%	73%	20%
Bypass	6%	84%	9%	0%	9%	75%	16%
Junction	29%	67%	0%	5%	10%	65%	25%
Widening	16%	80%	4%	0%	4%	72%	24%
Upgrade to Motorway	50%	50%	0%	0%	0%	100%	0%
Smart Motorway	100%	0%	0%	0%	0%	100%	0%

Table 7-6 above demonstrates that the predicted impact on the landscape as a whole is most affected for **Bypass** and **Online Widening** schemes due to the immediate impact on surrounding residents and landscape character. After scheme opening POPE assessments show that **20%** of schemes are **'worse than predicted'** which is concerning when compared with the mostly adverse impacts predicted in the ES.

When assessing the impact of schemes on the landscape, it is noted that **73%** of schemes are assessed as 'As Expected', with **7%** as 'better than expected' and **20%** 'worse than expected. When compared with the 2013 Meta-analysis and 2010 Meta-analysis (see Table 7-7) a trend towards a worsening impact on the landscape sub-objective overall is noted. It is noted that the majority of schemes assessed in the 2010 Meta-analysis were OYA schemes which attract a higher percentage 'as expected' assessments due to their early stage in target achievement. This may skew the overall statistics comparison. It is suggested that a further comparison be undertaken in the 2017 Meta-analysis to confirm whether the worsening effect on landscape is a trend for investigation especially targeting planting conditions during construction and aftercare maintenance regimes.

Table 7-7 Landscape evaluation changes over time

Year of Meta-analysis	POPE Evaluation		
	Better than expected	As expected	Worse than expected
2010	4%	89%	7%
2013	8%	76%	16%
2015	7%	73%	20%

7.4.2 Is landscape mitigation in place at the One Year After stage set to achieve its target at the five years after opening stage?

ES predictions for landscape mitigation planting measures are based on the 'design year' which is fifteen years after scheme opening, by which time it is expected that planting will have met its objectives for screening and integration into the wider landscape. Mitigation planting is evaluated for POPE at the one year after scheme opening stage where it is often noted that it is too early in the establishment phase to judge the likelihood of growth target achievement, but determines the expected success based on planting in accordance with the ES. Where schemes have reached or exceeded their five year after scheme opening stage, OYA targets are compared with FYA achievements to determine whether continued growth and required maintenance has resulted in a higher likelihood of target achievement. POPE evaluations are only undertaken up to five years after opening. Planting is evaluated to be 'as expected' if plant establishment is in line with average growth rates for the location and species, together with any scheme-specific targets at the stage (year) of development.

Key Findings

Overall planting in place at OYA was set to reach its growth targets as required in the ES within most schemes, with isolated planting plots showing slow growth which could in part be due to exposed locations, poor or compacted soils or lack of maintenance including noxious weed control. Overall this interrogation shows that:

- For schemes currently at the OYA only stage of assessment, landscape mitigation is set to achieve its targets for **90%** of schemes.
- Considering all schemes assessed for this Meta-analysis (excluding those schemes where an assessment at OYA was not undertaken), OYA landscape mitigation targets are set to be achieved for **64%** of schemes with OYA and FYA landscape mitigation targets set to be achieved for **73%** of schemes.
- Overall **17%** of schemes identified landscape mitigation issues at OYA.
- **22%** of schemes were assessed where the aftercare period was noted to be between two and three years. Of these schemes, **12%** showed no effects of a reduced aftercare period.

Analysis of landscape mitigation impacts with particular relevance to growth target achievement and aftercare maintenance

In order to analyse the assessment made by POPE for the Landscape sub-objective, this Meta-analysis has considered how successful ES identified landscape and visual impacts and proposed mitigation measures have been through the interrogation of growth targets set and aftercare maintenance required to ensure landscape and visual impacts of schemes do not exceed those identified in the ES.

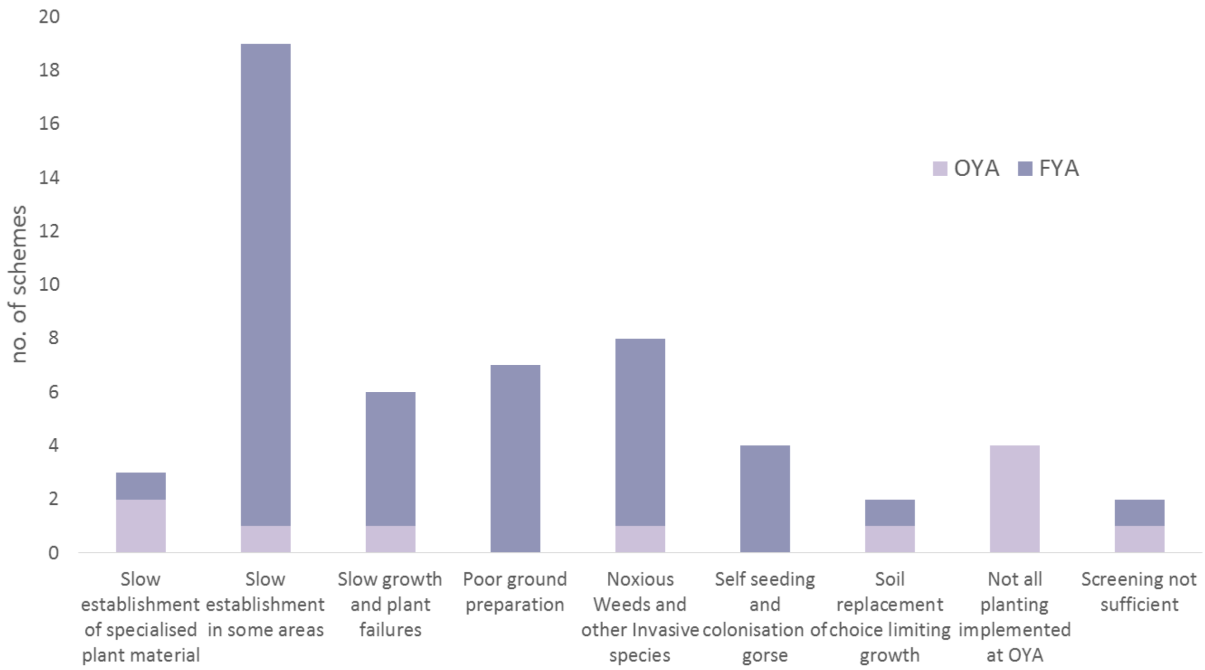
Are landscape growth targets being met for major schemes?

This line of enquiry considers growth target achievement and factors impacting upon this achievement and success of aftercare maintenance. Table 7-6 on page 115 demonstrates that the majority of schemes fulfil their overall commitments required in the Environmental Statement (ES). However, an increasing number of schemes as shown in Table 7-7 on page 115 are showing a deterioration in reaching or exceeding their ES targets for landscape.

When considering whether schemes have fulfilled their ES commitments, common aims of each individual scheme have to be considered to determine whether this has indeed been achieved. An important part of the success of landscape planting is to provide visual screening, landscape integration and compensation for the loss of existing planting including habitats. Growth target assessments considered in each POPE report forms an important part of this examination.

Whilst the statistics overall for the achievement of targets set for landscape mitigation are generally positive, 55 issues identifying individual or multiple issues within 36 (45%) schemes were noted. Nineteen of these issues are for slow establishment of landscape planting. This is of particular concern where ground preparation issues are identified as a contributory factor as ground preparation in line with DMRB requirements is required to ensure good plant growth. All 19 schemes identified with slow establishment have ground preparation issues. Additionally, slow growth with high failure rates is recorded for eight schemes with a high incidence of noxious weeds and other invasive species recorded in eight further schemes. Figure 7-3 details common themes and concerns of these 55 issues. Detail regarding which schemes make up each category is shown in Appendix A.

Figure 7-3 Landscape mitigation – common themes identified during POPE evaluations



Where schemes require particular vegetative species mitigation to fulfil the commitments in the ES, it is especially important that aftercare maintenance ensures that this mitigation performs as required. Three schemes have been identified that appear to not meet the requirements for particular growth success, although this is at the OYA stage and therefore planting has time to develop before the FYA assessment:

- The **A3 Hindhead** scheme (OYA stage) report notes that the establishment of **heather** along the restored alignment of the old A3 through the Devil's Punch Bowl has not been successful as yet. The vegetation monitoring undertaken as part of the aftercare has not found any evidence of heather establishment to date, although a general herb layer has established. The report notes that this is not unusual with trials and extensive research on similar sites by others has shown that heather establishment is very fickle – being heavily affected by the fertility of seeds in any one year, slow growth rates and extent of disturbance. The report concludes that the maintenance strategy should ensure that invasive weeds or aggressive species such as Gorse are kept under control during the Aftercare Period in an effort to aid colonisation / establishment.
- The **A1 Braham – Wetherby** scheme (OYA stage) report notes that the **cowslip plug planting** within the verge in some locations does not appear to have been successful. As this scheme assessment is at the OYA stage it is assumed that any replanting of the cowslip will be noted in the FYA report, including the success or failure of those plants noted as successful at OYA.
- The **A30 Bodmin – Indian Queens** Improvement scheme (FYA stage) notes that the **Devil's Bit Scabious** (required for the success of the **Marsh Fritillary butterfly**) was recorded as unsuccessful as germination had not proven successful. The report notes that the designers suggested that plug planting should be used to ensure successful establishment but this was rejected due to the additional cost.

Are landscape growth targets being affected by aftercare length reductions?

In addition to the analysis of landscape mitigation targets, aftercare periods have been analysed to determine the effect that the length of the aftercare period has on landscape targets being met. An aftercare period of five years is the accepted period in which landscape maintenance is required to ensure growth targets (of scheme vegetation are met. Although varying between each scheme, aftercare maintenance generally includes:

- Grass cutting regimes outside of MAC maintained areas;
- Watering to all standard, heavy and extra heavy standard trees to ensure establishment and survival in times of drought;

- Maintenance of stakes and individual tree / shrub guards;
- Maintenance of weed free circles to a radius of 500mm around each plant station in all tree and shrub plots;
- Physical or chemical control of noxious and other identified undesirable vegetation;
- Regular weeding of ornamental planting areas;
- Annual inspections to identify defective / failed planting stock to be replaced and any defective / failing grass sward to be re-seeded as necessary; and
- Diversity of species establishment maintenance to areas of habitat creation.

Aftercare period identification

Forty three (53%) schemes recorded an aftercare period of five years or more. The aftercare period was not recorded in POPE reports in 22 (27%) schemes. Sixteen (20%) schemes were assessed where the aftercare period was noted to be between two and three years.

- Of the 43 schemes with a known aftercare period of five years or more, **93**% were set to achieve their targets.
- Of the 22 schemes where an aftercare period has not been confirmed by POPE, **86%** were set to achieve their targets.
- Of the 16 schemes assessed with a reduced aftercare period of two or three years, **73%** of schemes were set to achieve their targets. However individual issues have been identified within these sixteen schemes that may impact on their design year targets if not actioned

Of these 16 schemes, common themes are identified as follows, and scheme-specific information is included in Appendix A.2:

- Handover issues (10) **63%**
- Gorse establishment with potential to outcompete planting plots (4) **25%**
- Impact on growth targets (2) **13%**
- A reduction in aftercare had no effect on growth target achievements (2) **13%**

It should be noted that the above totals include where more than one issue was identified per scheme (A590 High and Low Newton Bypass, A64 Colton Lane GSJ, A34 Newbury Bypass and M27 J11-J12 Climbing Lanes).

Does the contract type have any impact landscape mitigation targets?

Contract types making up the 81 schemes assessed for this Meta-analysis included:
- Early Contractor Involvement (with orders)
- Early Contractor Involvement (without orders)
- Design and Build (with orders)
- Design and Build (without orders)
- Design, Build, Finance and Operate
- Managed Motorways Framework

No significant trends were identified for landscape mitigation targets when assessed by contract type.

Conclusions

This assessment highlights the need for ensuring correct planting conditions for planting plot types at construction stage and the continued stipulated aftercare maintenance requirements during the establishment stage (as highlighted in DMRB[29] volumes 10 and 11) to ensure the commitments made in the ES are fulfilled. When referenced together with the summary of the environmental impacts of major schemes (Table 7-2) it is clear that landscape and visual impacts of schemes have increased over the last five years at least. However, 86% of schemes assessed for this Meta-analysis, are set to achieve their growth target predictions. These targets are applicable to visual screening, landscape integration and compensation for the loss of existing planting including habitats. Additionally, success of visual

[29] Design Manual for Roads and Bridges.

screening is critical to protect sense of place for the built heritage and integration of road corridors into sensitive landscapes and habitats.

7.4.3 How does Highways England use locally appropriate materials in its schemes?

This section considers how Highways England uses locally appropriate materials and introduces vernacular style into its road schemes, including those which have incorporated sculptural elements, focal planting, 'gateway' features and landmark bridges as these all help provide a sense of place[30] within the local landscape. The analysis is based on examples of schemes where the use of locally appropriate materials and vernacular detailing has been discussed within the reports.

Vernacular Design Detailing – the incorporation of vernacular style using locally appropriate materials has been used to achieve a sense of place as part of scheme design to integrate schemes into the landscape and reflect local character; including stone walling, Cornish hedges, use of stone facing at structures and locally characteristic timber fencing.

One example, to illustration this aspect of scheme design, is the A590 High and Low Newton Bypass scheme located at the edge of the Lake District National Park (LDNP). The evaluation notes that local landscape elements have been incorporated into the scheme to good effect; the great attention to detail has also helped the scheme sit well within the landscape at the edge of the LDNP. Structures including the underpass wing walls and culvert head walls have been faced with locally sourced stone in keeping with the local vernacular style. Approximately 8.4km of new dry-stone walls, 1.4m high, have been used along the highway boundary incorporating gate posts from existing walls into new field accesses. They link with existing walls and help integrate the scheme into the local landscape. Figure 7-4, Figure 7-5 and Figure 7-6 illustrate vernacular elements of the scheme design.

Figure 7-4 New dry stone walls replicate local boundary patterns, reuse field gateposts and tie into existing walls

[30] Sense of place. Either the intrinsic character of a place, or the meaning people give to it, but, more often, a mixture of both.

Figure 7-5 Locally sourced stone used to face the bridge wing walls

Figure 7-6 Stone faced headwalls at new culvert/mammal tunnel below the A590 High and Low Newton Bypass

Gateway Features – 'Gateway' features can also engender a sense of place by using local materials or by incorporating landscape features with local significance e.g. sculpture, landmark bridges or focal planting and several are included in Table 7-8. For balance, examples are also included where evaluations considered that the highway design could have been more focussed in providing local distinctiveness.

Table 7-8 Examples of schemes incorporating landscape features

Theme	Scheme	POPE Observation
Sculptural feature	A1(M) Ferrybridge to Hook Moor upgrade to motorway 	One landscape feature has been provided instead of the three proposed in the ES. Ideas came via a design competition and the winning design reflects the local cultural heritage of the area representing burial mounds. The conical limestone sculptures, located adjacent to the Ferrybridge Power Station and near the Holmfield Interchange, were required to be of sufficient size to make an impact for drivers; visual interest being a key objective.
	A421 Great Barford Bypass 	Before the bypass construction started, a metal Black Cat was located on the roundabout which gave a sense of place to this busy junction with the A1. It has subsequently been reinstated and the Black Cat roundabout balancing ponds have been designed as a feature with grass seeded sculptural banks.

	A5117 Deeside Park Junctions improvement 	Near to the border of England and Wales on the A5117 scheme lion and dragon emblems have been created using stone chippings on embankments at the Woodbank Junction. Grass and weed species are beginning to establish within the areas of stone chippings and unless maintained these gateway features will lose their definition and visual appeal.
Focal planting	A1Willowburn to Denwick Widening 	The A1 widening scheme is on low embankment where it passes though the historic Alnwick Castle parkland and is clearly visible. It would appear that the landowner has planted an avenue of trees in traditional park style tree guards alongside the A1 to provide a formal landscape framework to the road corridor, in keeping with the adjacent parkland. Although there are some intermittent groups of trees on the highway embankments, more formal planting by Highways England might have been more appropriate in this particular location.
	A1033 Hedon Road Widening 	The roundabouts are an important feature of the route provided at major junctions, however, a lack of maintenance by FYA meant that the strong designs no longer 'read' well. The ES stated that the roundabouts would provide potential locations for public art. However, apart from the timber sculpture at Alexandra Dock no other sculptures have been located along the route. Although the idea was mentioned in the ES the actual provision of sculptures was not part of the scheme. If it had been then this would have provided a series of focal points along the route and an opportunity to create a distinctive and high quality gateway to Hull. New railings had been installed at various locations along the route to resist impact from traffic but they also add to the sense of place and provide continuity of design.
Landmark bridges	A63 Selby Bypass 	The A63 crosses over the River Ouse which is navigable and to allow movement of river traffic, the new bridge over the river was designed and constructed to swing through ninety degrees. The new bridge is a distinctive feature along the bypass.

	A21 Lamberhurst Bypass 	Along the A21 a 'Land bridge' has been incorporated into the scheme to maintain access to Scotney Castle National Trust property and estate along its original line. The NT considers 'the type of bridge with the new bush and tree growth means that it is not as distracting as a typical bridge would be, and therefore softens the impact and blends into the surrounding landscape'. The Countryside Agency considered the land bridge to be 'excellent'. The POPE evaluation noted that the land bridge vegetation had established well and provides a landscape framework to the Scotney Castle access drive as well as visually linking the retained existing woodland on either side of the bypass cutting.
	A249 Iwade to Queenborough Improvement 	English Heritage stated that the new bridge is a striking addition to the landscape, visible from a few more places than anticipated and also offering a panoramic view of the surrounding area from it. The POPE report notes that the design of the long shallow curve of the Sheppey Crossing deck helps to unify the disparate elements of the industrial landscape and reduce the impacts of the other elements such as the Kingsferry Bridge, pylons, the refinery and Ridham docks. When viewed from the Queenborough junction the Sheppey Crossing is another vertical element in a flat and open landscape dominated by vertical industrial infrastructure.
	A2 Bean Cobham Phase 2 Widening 	The local authority stated that ideally it would have been desirable to have a more elegant design for the footbridges along the scheme, but through negotiation it was agreed that they would be widened and the hare motif added to the parapet to make them distinctive. The hare design was inspired by a Roman brooch found by HS1 works at Ebbsfleet.

Use of Locally Appropriate Materials - During the POPE consultation process a number of standard and scheme relevant question are posed to consultees. One of these questions is ‘in your opinion has the use of materials and finishes to structures been appropriate’. Specific responses to this question are not always provided but, where responses have been received and also based on POPE site visit observations, 20 schemes are noted to have had positive feedback on use of materials. For 8 of these 20 schemes consultees considered the general use of materials and finishes have been appropriate. Further details are shown in Table 7-9 for the remaining 12 schemes where a specific use of particular materials or applications was mentioned in the evaluations.

Table 7-9 Schemes where specific materials/applications were considered appropriate

Theme	Scheme	Consultation Comment / POPE Observation
Dry Stone Walls	A1 Bramham Wetherby upgrade to motorway	Consultee: where dry stone walls have been built these are of good quality.
	A66 Temple Sowerby Bypass	Observation: Considerable lengths of locally characteristic dry stone walls have been constructed and restored.
	A590 High and Low Newton Bypass	Consultee: The use of materials is seen to be in keeping with the local landscape and better than expected for the use of dry stone walling.
	A69 Haydon Bridge Bypass	Consultee: Considered the new dry stone walls to be particularly good
Retaining Walls	M25 J28 Brook St Junction	Consultee: The use of materials and finishes on new retaining walls is very appropriate.
	A650 Bingley Bypass	Observation: Landscape planting is establishing, providing a good framework to the road and a balance to the stone faced retaining walls which reflect local character.
	M25 J12 -15 Widening	Observation: Retaining walls have been used to widen existing embankments within the highway boundary, using exposed aggregate pre-cast panels designed to ‘blend’ into the local landscape.
Structures	A1 Stannington Junction Improvement	Observation: The use of traditional materials, particularly for the visible structures of the underpass was expected in the ES and the bridge abutment walls have been faced with stone.
	M1 J25 to 28 Widening	Observation: The widened bridge has been clad in grey brick and the appearance and finish of this structure is considered an improvement on those existing along the scheme corridor.
	A1(M) Ferrybridge to Hook Moor upgrade to motorway.	Observation: Materials and finishes to structures were chosen to be sympathetic to their setting. The design of the reinforced concrete piers at the Holmfield Interchange was agreed with the Commission for Architecture and the Built Environment and they are shaped to imitate the cooling towers of the Ferrybridge Power Station. The bright yellow footbridge provides a link for Holmfield Lane but is visually prominent.
	M60 J5-8 Widening	Observation: As expected in the ES where pedestrians have access to structures, e.g. along the tow path of the Bridgewater Canal, main concrete faces have been clad in brick

Urban walls and railings	A1033 Hedon Road Improvement	Consultee: considered that the visual/landscape design aspects of the scheme were particularly good and had significantly enhanced a previously run-down part of the city – important as it is the gateway to the city and region for visitors from abroad. Particularly impressed by the quality of the design and construction of the walling and wrought iron fencing at the western end (see below) 

Use of Materials with Differing Responses - In addition to the positive feedback received / observed, 3 schemes received differing views on the use of materials, both positive and negative, from consultees commenting on the same scheme – evidence that to a certain extent this is a subjective area of design. An evaluation overview is also included in Table 7-10 for context, the specific consultee comments have not been responded to with no specific reference to materials and finishes.

Table 7-10 Schemes where differing views have been received

Scheme	Consultation Comments	Evaluation Observations
A5 Weeford Fazeley Bypass	At OYA the District Council commented that 'generally the finishes and materials are considered appropriate / acceptable. However it is considered that the materials of the central reservation could have been improved and there is a visual/litter issue that needs to be addressed through maintenance.'	Finishes and materials were not specifically commented on; litter was noted along some boundaries and in drainage ditches.
	At FYA the County Council considered that the appropriate use of materials and finishes was worse than expected. "The bridges are of a standard design with concrete finish, which tends to detract from the overall visual quality of the road and more appropriate finishes could have been utilised".	
A419 Blunsdon Bypass	At OYA the Parish Council considered material finishes to be visually appropriate.	Mitigation generally implemented as expected but too soon to evaluate the success of the new landscape planting in screening traffic and integration of the scheme into the local landscape – materials not specifically mentioned.
	Also at OYA the Borough Council commented that there did not appear to have been any real effort to reduce the visual impact of the structures, though they are as expected. They noted that the structures are slightly unusual in that they use weathering steel and consequently will always look rusty and as if they need re-painting.	
A14 Rookery Crossroads Grade Separated Junction	At OYA the District Council considered the use of materials and finishes to structures reasonable as the structures are not particularly intrusive or have a major landscape impact.	The realignment of the A14 has had little impact on the landscape character and views from properties or public areas as expected. Materials not specifically mentioned.
	Also at OYA the County Council considered the bridge finish to be bland and the signs very intrusive.	

Materials Considered Inappropriate - Analysis of the data has also identified that scheme materials are not always well received by consultees and for 10 schemes material choices have been considered unsuitable by consultees and these are identified in Table 7-11. For another two schemes the evaluation reports noted that some of the vernacular boundary treatments proposed in the ES were not taken forward into the final design/construction phase:

- A595 Parton to Lillyhall Bypass - Stone walling was included in the ES design as it is a characteristic boundary treatment in the local area and to replace stone walls lost to the scheme. At the southern end of the scheme it has been replaced by timber post and rail fencing; and

A30 Whiddon Down Junction Improvement: The proposed Devon hedge bank was planted as an ordinary hedge on the earthworks to the over-bridge.

These two examples are relatively small changes but do illustrate that traditional detailing can be lost between ES proposals and the final design.

Table 7-11 Locally vernacular style or materials considered unsuitable/not appropriate

Scheme	Consultation Comment	POPE Observation
A1 Peterborough to Blyth Grade Separated Junctions **Carpenters Lodge junction**	The local authority considered the bridge had no sense of locality – so not appropriate but as expected because local character is not embedded very far in road schemes. New planting will shortly hide views of the Burghley estate stone wall a feature of local significance, with resultant loss to the local character of the road.	The opportunity to include some local distinctiveness into the scheme has been lost through choice of bridge materials, and the locally significant stone boundary wall will be screened by new planting; the scheme seems to have failed to create a sense of place, one of the landscape objectives.as it links it to failure of a scheme objective
M6 Toll **Motorway**	The turquoise colour of the toll booth canopies was felt to stand out too much by the County Council, who considered that a darker green colour would have blended into the landscape more effectively and that further offsite planting could be undertaken in mitigation.	The evaluation does not specifically address the impact of the toll booths. Colour is a subjective issue but it should be noted that one of the ES objectives was to blend the road into the existing landscape as far as possible.
A120 Stanstead to Braintree **Bypass**	The District Council considered that the new road layout detracts from the setting of the listed gatehouse at High Wood which has 'lost its sense of place'. The satellite roundabout adjacent to the gatehouse has been 'landscaped' with artificial turf which is considered entirely inappropriate in this context. The County Council stated that generally the materials and finishes to structures are considered to be appropriate with the exception of the 'engineering' facing brick applied to the abutments of the over bridge at the GSJ which is insensitive to the character of the area. A more elegant engineering solution may well have been warranted given the proximity to the historic town of Great Dunmow. The limited opportunities for planting in this location does not help in ameliorating the visual impact of this structure.	The evaluation did not specifically mention the impacts on the listed gatehouse. With regard to the bridge at the Dunmow South junction the evaluation site visit found the bridge at the Dunmow South junction looked satisfactory and reflected the style of the bridges in the vicinity of Panners Interchange.
A2 Bean Cobham Phase 2 **Widening**	The Borough Council considers with regard to the use of materials and finishes to structures that the design and materials are "standard" – and do not match those of HS1[31].	The evaluation does not specifically mention materials and finishes, it notes that the new transport corridor with associated lighting and sign gantries located close to the HS1 line has adversely impacted on the local landscape character and although new

[31] HS1= High Speed 1

Scheme	Consultation Comment	POPE Observation
		landscape planting is in place it will take time to mitigate the effects.
M40 J15 (Longbridge) **Junction**	Parish Council commented on materials that “the final appearance of the concrete structures is raw and brutal with no attempt made to dampen down this inappropriate end result in a rural area”. 	The evaluation notes that the green wall helps to soften the appearance of the bypass flyover, but the structure and its embankments introduce a strong vertical element to the landscape that is visible from receptors to the north, east and west of the scheme. The concrete finish of the flyover and other structures implemented across the scheme are as expected in the ES.
A38 Dobwalls Bypass	With regard to finishes the local authority considered that: ‘Generally landscape detailing and finishing is poor’. 	The lack of greening on the slopes along the length of the bypass due to the use of low nutrient ‘shillet[32]’ makes the route feel somewhat barren, drawing the eye to the hard engineering, several areas of which appear to have been poorly finished, as opposed to showcasing the more vernacular features within the design such as the Cornish Hedges – see adjacent illustration.
A63 Melton Grade Separated Junction	Parish Council considers the design of the footbridge to be ‘poor’ and a blot on the landscape. 	It was expected that the most significant landscape impacts would be as a result of the visual intrusion of the large prominent junction and the footbridge at Gibson Lane.
A421 Improvements M1 J13 to Bedford – Bypass	The District Council commented with regard to use of materials in the construction of the new bridges – ‘brick making is a historic feature of the area and use of this material for the new bridges would have been more in keeping with the local character of the area’. It also noted that ‘the central safety barrier has introduced a bright "spine" which is very dominant feature visually and one which had not been anticipated’. The Regeneration Trust said that ‘the bridleway over-bridge structure is particularly visually intrusive owing to the metal construction and paint colouring. Whilst appreciative of the engineering considerations, it would have been much more compatible with the environmental regeneration vision for the area if a timber or	New overbridges will remain visible in the landscape until the planting scheme surrounding it matures As mentioned in the consultation received from the district council, the use of a concrete central median barrier is highly visible to the surrounding areas and will remain so until planting matures and the initial brightness of the barrier fades.

[32] Shillet - Coarse soil with pieces of slate – a locally available quarry by product in Cornwall.

Scheme	Consultation Comment	POPE Observation
	combined steel/timber unit had been used instead.	
M4 J18 Widening	The Council commented that the small plant building alongside the roundabout at Junction 18 was not detailed in the manner they would have expected for a new building in the AONB.	The POPE report noted that this building did not form part of this scheme design and was constructed as part of a communications infrastructure upgrade.
A500 City Road and Stoke Junction	The City Council's Urban Design and Conservation Team are of the opinion that an opportunity has been missed to visually improve the environment of people using the A500 because of the utilitarian design of the highway structures. The materials and design details do not create a sense of "local distinctiveness". The whole project looks to be of a much lower standard than that of the nearby A50 with its acres of red and cream brickwork, distinctive bridges and metalwork. 	The POPE evaluation says -the concrete retaining walls adjacent to the A500 below Glebe Street have been enhanced with a terracotta render and the use of a silver ribbon mural as proposed in the ES. This enhancement was not proposed for either the Stoke Road or City Road junctions. It has improved the appearance of the underpass for both pedestrians and vehicle travellers and is as expected in the ES.

It would appear that adverse comments tend to be scheme-specific and do not necessarily represent a particular trend. They do, however, demonstrate that the opportunity to include some local distinctiveness into schemes can be lost through choice of materials and that these issues are important locally. The evaluations do not always respond to specific issues raised by consultee with regard to materials and do not necessarily agree with the consultation opinions expressed (A120, A500 and M4 J18).

Conclusions

Based on the considerations of schemes for this Meta-analysis where specific references are included regarding materials there are more schemes where materials are considered to have been locally appropriate by consultees or site visit observations than not, and it is evident that the use of appropriate materials makes a positive contribution to scheme design and is generally welcomed by consultees. It is however, a subjective area of design and opinions do differ on the detail.

Vernacular design incorporating locally appropriate materials compliments existing features whilst providing distinctive and high quality elements to the overall design, often using traditional construction detailing which helps to integrate schemes into the landscape and reflect local character The inclusion of 'gateway' features also creates a 'sense of place' often with local significance.

7.4.4 How accurately are impacts forecast for designated landscapes?

Forty five (**56%** of 81 schemes) schemes assessed for this Meta-analysis are located within or adjacent to designated landscapes[33] which have included national designations such as National Parks or Areas of Outstanding Natural Beauty (AONB), greenbelt, historic parks and gardens or historic landscapes, as well as areas designated at a local level such as Areas of Great Landscape Value. This is compared

[33] Some schemes have more than one designated landscape.

with the 2010 Meta-analysis[34] report where 33 (**56%** of 59 schemes) schemes were listed as being located within or near designated landscapes.

POPE revisited the OYA assessed schemes from the 2010 Meta-analysis and found original predictions to still be relevant and as such have not influenced the 2010 assessment of designated landscapes identified at that stage.

As can be seen from Table 7-12 below, most impacts on designated landscapes have been considered to be 'as expected'. However, this assumes that the landscape planting will continue to establish satisfactorily to screen and integrate the scheme into the local landscape.

Table 7-12 Predicted vs. Outturn Impacts in Relation to Designated Landscapes

POPE evaluation result	AONB	National Parks	Local Authority Designation	Greenbelt	Historic Park or Landscape
Better than expected	0	1 (1%)	1 (1%)	0	0
As expected	8 (10%)	1 (1%)	20 (25%)	9 (11%)	7 (9%)
Worse than expected	5 (6%)	1 (1%)	3 (4%)	2 (3%)	2 (3%)

Two schemes were considered better than expected; A590 High and Low Newton due to the care and attention to detail in the design as well as close working with the National Park authority to deliver the agreed scheme and M25 Brook Street although the local authority did not expand on its reasons.

Schemes were considered worse than expected for a variety of reasons including:

Meta-analysis 2010 findings (and still considered relevant for 2015 Meta-analysis)

- AONBs - adverse effect on the natural beauty and character of the AONBs, including the pattern of the landscape and loss of tranquillity (A34 Newbury, A27 Southerham to Beddingham Improvement), scheme intrusive in the AONB and impact underestimated (A41 Aston Clinton). sign gantry being more visible and a plant building not being detailed in the manner expected in the AONB (M4 junction 18);
- National Park – landscape impact on newly designated National Park greater than expected particularly the raising of the road on embankment (A27 Southerham to Beddingham Improvement);
- Local designations -planting had not matured as quickly as expected (A428 Caxton Common to Hardwick Improvement), impact underestimated in AST due to full lighting and over-bridges (Newark);
- Greenbelt – worse than expected at OYA although may improve as planting establishes (A428 Caxton Common to Hardwick Improvement); and
- Historic Parks and Landscapes - Significant changes made to the landscape character of a historic landscape (A10 Wadesmill to Colliers End Bypass) and the scheme not respecting open views to an ancient field system as expected in the ES (A30 Bodmin to Indian Queens Improvement).

Meta-analysis 2015 (OYA schemes not assessed for the 2010 Meta-analysis)

- AONBs - the widening being online had a slight negative impact, particularly the erosion of a narrow corridor of trees (A2 Bean-Cobham, phase 2 Pepperhill – Cobham)
- Local Designations - impact of the scheme on local landscape character was worse than expected in the vicinity of the grade separated junction (A14 Haughley New Street – Stowmarket Improvement); and

[34] This question was not included as part of the 2013 Meta-analysis.

- Greenbelt - the scheme had not given due regard to designations including conservation areas, SLAs or Green Belt had ruined the open, rural feel of the landscape and that many of the local landscape features of individual and grouped trees, mature hedgerows, meadowland and part of the riverine tree belt had been destroyed (M40 junction 15)

7.4.5 How often do suggested townscape/streetscape improvements identified in the ES get provided?

From the AST and EST entries, the removal of traffic is seen as the main benefit for bypassed settlements and specific streetscape improvements are not often considered to be necessary, particularly where the fabric of the townscape would not be adversely affected by the proposed works. However, improvements are welcomed by local communities who see the removal of trunk road paraphernalia as an important aspect of reclaiming their local townscape environment.

This question has been answered with reference to townscape/streetscape improvements highlighted in POPE scheme reports – original source documents have not been revisited. Townscape /streetscape deliverables are not always detailed in the ES and might only be highlighted in evaluations if commented on by consultees.

Of the 9 schemes where specific reference has been made to streetscape improvements in the ES, 7 of these (5 Bypass, 1 upgrade to Motorway and 1 Junction) would appear to have generally provided the enhancements as expected, although for 3 of these, certain elements have not been taken forward.

For two schemes the enhancements were not taken forward, further details are shown below;

- **A69 Haydon Bridge Bypass** – The AST specifically referred to the planting of 6 trees along the de-trunked section of road would bring benefits and ES mitigation plans also indicated that six heavy standard trees would be planted at key town centre locations for traffic calming and townscape enhancements. At OYA these had not been provided; and
- **M40 A404 Handy Cross Junction** - The ES noted that the junction improvements would provide the opportunity to create a sense of arrival at Handy Cross that might help restore a sense of local distinctiveness. The scheme included a location for a possible sign/sculpture on the verge in between Marlow Road and Marlow Hill. This was identified as 'non-essential' in the ES and was not taken forward which is seen as an opportunity lost.

The 7 schemes where townscape/streetscape proposals formed part of the ES scheme design are summarised below.

A3 Hindhead Improvement – Bypass: The ES expected that streetscape improvements would be implemented along the closed section of London Road (formerly the A3) following the completion of the main scheme. These have been provided including reduction in width and resurfacing of London Road between the Hindhead Crossroads and the National Trust Car Park, installation of a traffic calming raised table and turning head at the National Trust Gateway, widened footways, parking bays, seating street furniture and landscaping. The former traffic signals at the crossroads were replaced with a double mini-roundabout incorporating signalised pedestrian crossings which appears to be causing some localised confusion.

A590 High and Low Newton Bypass: Townscape along the old A590 has become less urban in character. The removal of significant volumes of traffic from the villages has improved the visual amenity and in turn local landscape character with measures undertaken to 'downgrade' the road including widened verges to reduce carriageway width in High Newton (see Figure 7-7). This caused more issues regarding maintenance than had been expected by the local community and by FYA some of the verges had been adopted by households via a stopping up order and others were maintained by a working party of volunteers.

Figure 7-7 Widened verges along old A590 at High Newton reduce the visual appearance of the old carriageway in keeping with the village setting

A1(M) Ferrybridge to Hook Moor upgrade to motorway: The POPE evaluation considered that the ES commitments to downgrade the existing A1 from Brotherton to Selby Fork had been delivered, with additional features provided by the DBFO Co and Fairburn Parish Council.

It confirmed that along the 'old' A1 through Fairburn, the more formal landscape treatment creates a sense of place on entering the village as expected. New semi-mature tree planting has been undertaken, stone walls retained / repaired and a small community garden has been planted by the DBFO Company (as an additional facility not part of the ES design). The removal of the old A1 overbridge has enabled a small skateboard park to be provided; this was designed and built at the instigation of Fairburn Parish Council with grant aid (Figure 7-8).

Figure 7-8 Avenue street tree planting and widened verge area within Fairburn which the ES expected would provide open areas similar to a village green with the aim to reconnect the two sides of the village (left). Fairburn Community Garden at OYA (right)

A38 Dobwalls Bypass: The scheme included proposals to amend the geometry of the approaches to Dobwalls to increase footpath widths (Figure 7-9). Following opening, the former A38 through Dobwalls has been de-trunked and a number of improvements were made by the local authority to the old road (although partly funded by Highways England which was included in the predicted cost of the scheme). Improvements included narrowing the road with lining, introducing double mini roundabouts at the crossroads in Dobwalls and the removal of the signalised pedestrian crossing outside the pub in the village. These elements have combined to improve visual amenity and create a road more suited to village character.

Figure 7-9 Example of changes to townscape delivered by A38 Dobwalls Bypass

A500 City Road and Stoke Junction Improvement: POPE found that in general the improvements and mitigation had been carried out as proposed in the ES with the exception of the raised-bed planting within St Peter's Churchyard Conservation Area and the landscaping aspects of Fowlea Brook (re-grading and softening of banks) due to EA access requirements. The canal side wall elevations at all junctions have been clad with brick to integrate with the retaining walls on the opposite side of the canal in keeping with the character of the Trent and Mersey Canal Conservation Area. The new environmental barrier at the Cornwallis Street/Maclagan Street area is a concrete wall with a blue wave pattern façade. Figure 7-10 shows that the concrete retaining wall adjacent to the A500 below Glebe Street has been enhanced with a terracotta render and the use of a silver ribbon as proposed in the ES. It has improved the appearance of the underpass for both pedestrians and vehicle travellers.

Figure 7-10 Concrete retaining wall cladding

A6 Alvaston Bypass: Two areas of environmental enhancement were identified in the ES as an Archaeological Interpretation Area/nature area intended to deliver a 'travel through time' educational experience as a resource for local primary schools and a wetland/wildflower area. The site visit confirmed they had been implemented and were well used for informal recreation; there was no interpretative information or evidence that were used as an educational resource (Figure 7-12). There was however, evidence of anti-social activities including vandalism, fly-tipping and littering (Figure 7-11) partly due to the areas being somewhat secluded and screened by planting from adjacent properties.

Figure 7-11 Fly-tipping and littering at the Archaeology Interpretation Site and Nature Area

Figure 7-12 Entrance and sculptural features within the Archaeology Interpretation Site and Nature Area. In the absence of any on site interpretative material, it was considered difficult for an uninformed visitor to appreciate the original intentions.

A1033 Hedon Road Improvement – widening: The ES included comprehensive landscape and streetscape proposals which have generally been provided including extensive areas of planting and mounding, feature walling, new railings at various locations along the route to resist impact from traffic and add to the sense of place and provide continuity of design (Figure 7-13 left), provision of a community amenity area to allow relocation of the Marfleet Memorial – although there were some issues relating to maintenance of planting (Figure 7-13 right) and retention of the existing York stone paving and mature street trees in the area in front of H.M prison and Hedon Road Cemetery.

Some features have either been amended since the ES, not taken forward or retro-fitted;

- The Newtown Court to Ferries Street proposals changed as a result of a post Public Inquiry decision. The pocket park is not a semi-enclosed predominantly soft landscape area as originally envisaged;
- Streetscape improvements outside the shops at Marfleet Avenue were not as extensive as in the ES; underground services limited the number of new trees planted. Paving in front of the shops did not form part of the Scheme, however, if it had been possible to extend the new paving right up to the building façades this would have helped the overall streetscape appearance;
- Although the idea of sites for possible public art along the route was mentioned in the ES the actual provision of sculptures was not part of the scheme. If it had been then this would have provided a series of focal points along the route and an opportunity to create a distinctive and high quality gateway to Hull.

Despite a paved 'splash strip' along the road edge being indicated on mitigation figures included in the ES they were not initially installed. They were eventually retrofitted along most of the route to overcome the problem of spray damage of verges and planted areas (Figure 7-14).

Figure 7-13 Feature railings (right) and boundary treatment and poor planting maintenance at the Marfleet community amenity area (left)

Figure 7-14 Examples where a splash strip was or was not provided at edge of kerb

Conclusions

Based on the examples considered for this Meta-analysis, and as would be expected, townscape/streetscape improvements include a mix of hard and soft design and are very much scheme-specific depending upon the scale of the road proposals and individual locations. Designs have generally been successful in reflecting local character and helping to restore a sense of place, although scheme-specific issues are sometimes raised by consultees or site observations. It is, however, important that enhancements are fully embedded in the ES design as commitments, to ensure that they are delivered as part of the final scheme.

It is also important that the full extent of any additional responsibilities falling to local communities as a result of downgrading or de-trunking roads is fully explored with the communities concerned.

Schemes where the local authority has implemented enhancements

In addition to streetscape improvements included within schemes, there are schemes where de-trunking has allowed the local authority to provide enhancements (10 schemes). The removal of traffic from the ‘old route’ provides an opportunity to introduce minor local improvements such as traffic calming and greater priority for pedestrians and cyclists (noted in 4 schemes).

Six schemes where more extensive streetscape improvements have been provided as part of the de-trunking process are included in **Table 7-13**.

Table 7-13 Examples of streetscape improvements undertaken as part of the de-trunking process.

Scheme	Enhancement
A10 Wadesmill Bypass	The removal of traffic from the villages enabled the local authority to undertake improvements including reducing the carriageway width, gateway features (village signs-illustrated), replacement street lighting and traffic calming which has enhanced the local street scene with a style more sympathetic to a village environment. 
A21 Lamberhurst Bypass	As a result of the bypass construction it was possible for the local authority to implement traffic calming measures together with other streetscape enhancements which have benefitted the amenity of the village including improvements at the village green and replacement of locally distinctive white picket garden boundary fence. Properties in close proximity to the old A21 have benefitted by significant reduction in through traffic, widening footpaths and providing more generous pedestrian areas adjacent to buildings. 
A1 Stannington Grade Separated Junction	The C364 through the village has undergone some environmental improvements carried out by the County Council in agreement with the Parish Council including a paved central reserve and occasional planters which reduces the dominance of the carriageway and provides a village feel to the main through route. 

A63 Selby Bypass	The bypass has enabled the local authorities to implement a programme of improvements to the town centre as part of an Urban Renaissance Programme which have improved the setting of Selby Abbey and the character and amenity of the Conservation Area. This has included repaving the area in front of the Abbey and the introduction of new street furniture, reducing the width of the carriageway on Gowthorpe and introducing speed reduction measures.   
A650 Bingley Relief Road	The town centre has benefited with traffic, particularly heavy goods vehicles, being transferred to the north of the town, which has also allowed the local authority to undertake various improvements to streetscape e.g. provision of a new town square next to the historic Butter Cross which provides an attractive focal point off Main Street, carriageway narrowing to allow on-street parking, pedestrian crossing points, introduction of a 20mph zone and provision of new street furniture and lighting columns.  

A66 Temple Sowerby Bypass & Improvements at Winderwath	De-trunking measures on the existing A66, including reducing the width of the road by extending the grass verges, removing the red central surface treatment and reducing the speed limit to 30mph, have reduced the impact of the road on the townscape and on the setting of the conservation area and listed buildings as expected. 

Conclusions

Based on the examples considered for this Meta-analysis, for schemes where no environmental enhancements were proposed in the ES, some form of townscape/streetscape improvement has been provided by others, usually by the local authority as part of de-trunking works (9 bypasses and 1 junction), The downgrading of former trunk roads by Highways England has therefore facilitated these improvements improving visual amenity and creating a road more suited to local town or village character.

It is worth pointing out, however, that it has been suggested by consultees for bypass schemes that small scale improvements along the former trunk road should, as a matter of course, be included in Highways England scheme design e.g. the removal of street furniture, signs and lighting which is no longer appropriate would help restore a more local town/village character and remove visual clutter from the street scene.

Overall, where townscape/streetscape initiatives were included in the ES design they have generally been implemented as expected and are well received locally.

7.5 Is Highways England improving document provision to support POPE studies?

The POPE environmental evaluations are predominantly based on the information that is made available. No new environmental surveys are undertaken for the purposes of POPE and hence the validity/depth of conclusions made about the likely effectiveness of scheme mitigation is strongly dependent on the information provided.

Collection and Scrutiny of Baseline Data

As a baseline for each scheme, environmental evaluations use the scheme's Environmental Statement (ES) or latest Scheme Assessment Report (SAR) and Appraisal Summary Table (AST). Scheme-specific background data is requested from the Highways England scheme Project Manager which is based on a standard list of information which has evolved over time. Post construction information such as 'As Built' scheme drawings for the environmental design and monitoring of landscape and biodiversity features are critical in allowing an accurate assessment of the impacts of schemes against those predicted in the ES.

Information relating to ongoing maintenance and monitoring, lately in the form of a Handover Environmental Management Plan (HEMP), greatly improves the quality of the evaluation process. Further information such as archaeological reports (popular and academic) and post opening non-motorised user (NMU) audits when received allow for greater clarity on scheme performance against ES environment objectives.

How does data availability affect the ability to evaluate the schemes?

Document and data availability has an impact on environmental aspects of evaluation as it determines the degree of certainty over which conclusions can be made. As no new environmental surveys are carried out for the specific purposes of POPE, confirming that scheme proposals have been provided as expected and ascertaining the effectiveness of some mitigation measures relies on scheme post opening information being available to POPE. Generally it has been possible to evaluate (at least to a limited extent) the majority of sub-objectives from data available. However, the robustness of reporting is greatly influenced by the quality and content of information received.

Non- availability of some documentation does not necessarily represent a non-compliance as not all documents listed will necessarily be a requirement of the individual scheme contracts and it this analysis does not take account of this.

To what extent has Highways England been able to provide the standard documentation requested?

The most commonly requested information for POPE evaluations is included in this evaluation. Data provided to support POPE evaluations for the **81** schemes being considered in this Meta-analysis has been variable between schemes for a variety of reasons. Where data was not provided this was typically due to:

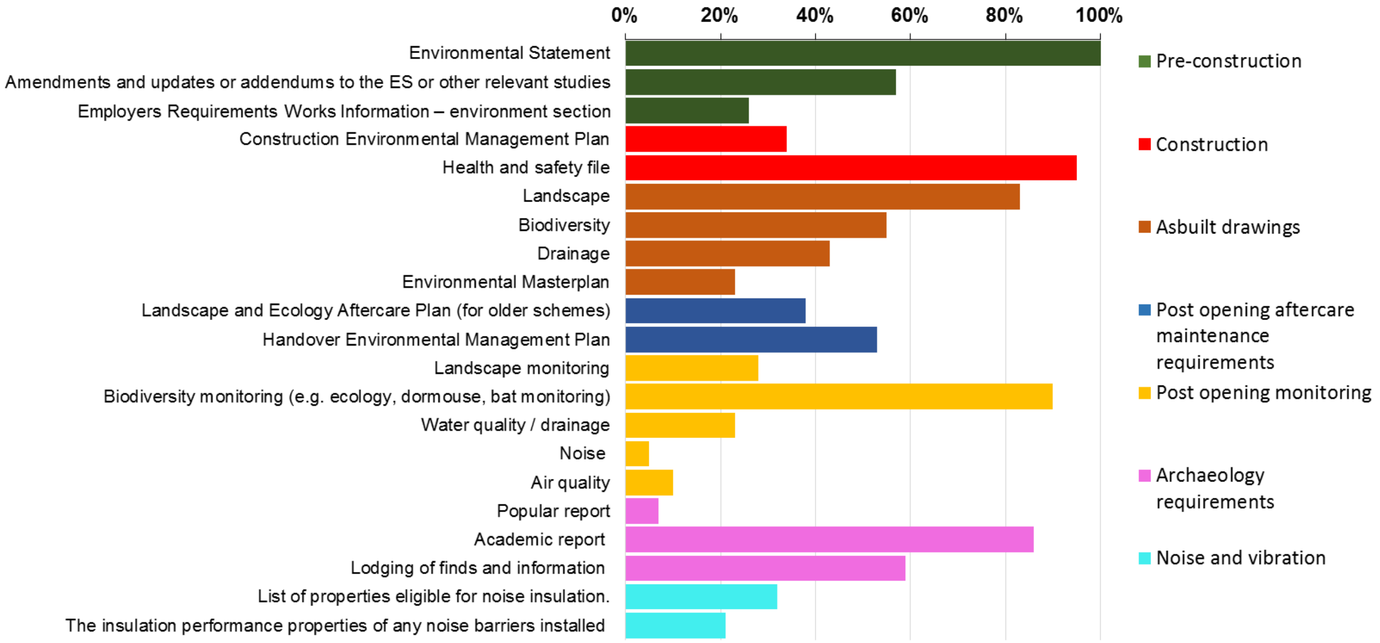
- Difficulties in retrieving requested documentation from Highways England's file archiving systems;
- Staff changes following scheme opening;
- Post construction surveys or monitoring not undertaken; and
- Data unavailable at time of request due to timing of evaluations compared with expected timescales for publishing key documents.

Due to changes in scheme appraisal and environmental requirements over time, in some instances it would not be expected that all documentation requested as part of POPE would be available. This aside the following trends have been identified with respect to data collection:

- Overall **33%** of information requested was received,
- Seventy two (**89%**) scheme reports received less than 50% of information requested.

It is noted that this Meta-analysis includes all schemes assessed within POPE, including 24 FYA schemes assessed in 2010. At this time, although there was a mostly comparable POPE document request list, items such as the Health and Safety file and the Employers Requirements (works information) were not included in this list. However, a comparison excluding 2010 data collection figures undertaken demonstrates that overall trends remain similar with only a slight improvement noted post 2010.

Figure 7-15 Breakdown of the overall reports and drawings received for the purposes of POPE



8. Further Analysis

Scheme Photo: A1 Bramham to Wetherby Improvement, One Year After

8. Further Analysis

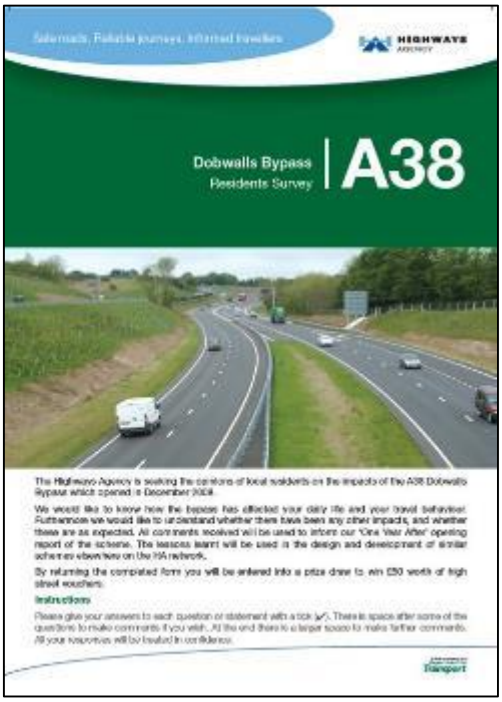
This section considers the remaining line of inquiry included in this Meta-analysis, many of which do not easily sit within a specific DfT objective for transport.

8.1 Are local communities satisfied with Major Schemes?

Local communities are generally satisfied with Major Schemes with 65% of questionnaire respondents (across 15 schemes) either agreeing or strongly agreeing that the scheme had made their community a better place to live.

Resident surveys' have been undertaken for 15 schemes to collate the opinion of those people directly impacted by each scheme. Whilst based on a relatively small number of schemes, these surveys have been undertaken as part of the POPE process in recognition that Major Schemes often have impacts on the community that cannot easily be evaluated fully through use of appraisal methods prescribed at the time of a scheme's appraisal. It should be noted therefore, that this section represents findings from a small number of schemes only and in no way aims to represent trends regarding all Major Schemes at a national level.

Residents Survey Example: A38 Dobwalls Bypass



Each survey asked respondents how much they agreed with the statement that the scheme consulted on had made their community a better place to live[35]. Results of this, split by scheme, are presented in Figure 8-1.

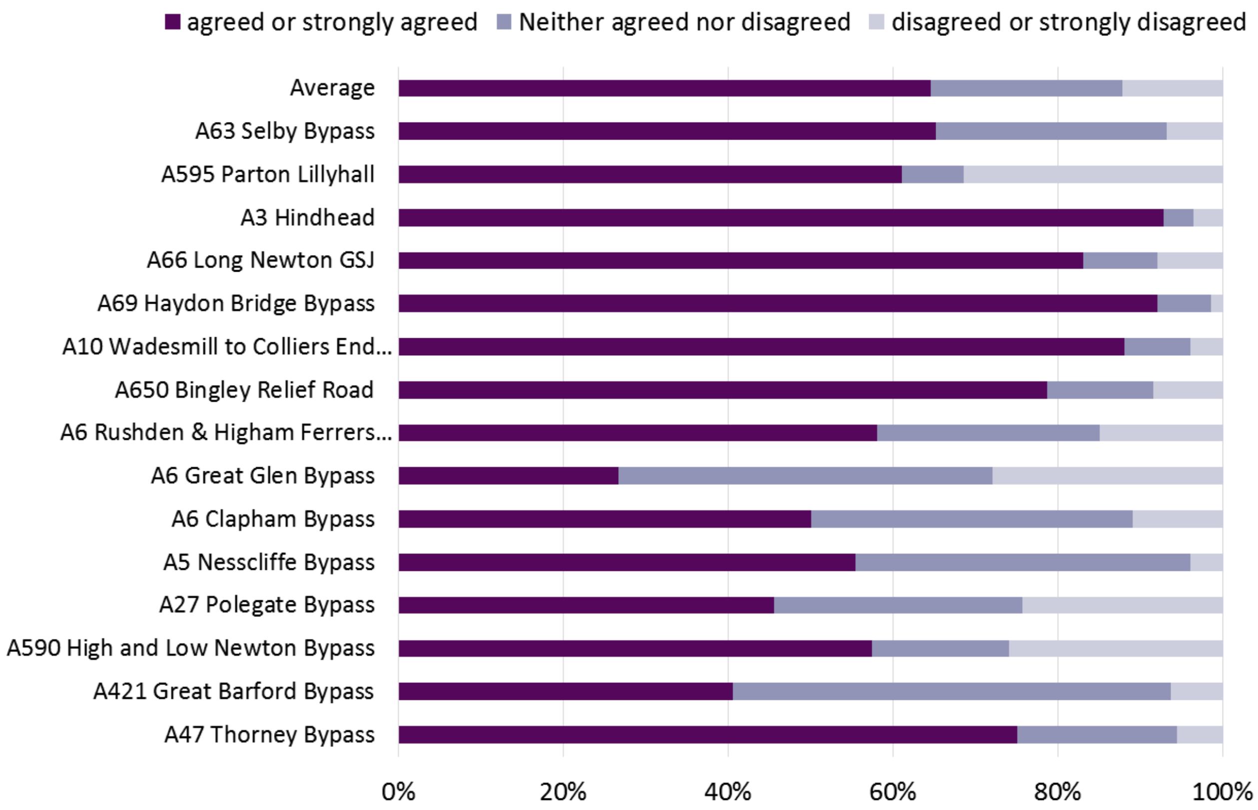
Across the 15 schemes, a significant majority (65%) of respondents either agreed or strongly agreed with the statement that the scheme consulted on had made their community a better place to live, as a reflection of satisfaction with scheme. This level of agreement ranged from 27% for the A6 Great Glen Bypass to 92% for the A3 Hindhead and A69 Haydon Bridge Bypass schemes.

Across the 15 schemes, 7% of respondents either disagreed or strongly disagreed that that the scheme consulted on had made their community a better place to live. For four of the schemes, levels of dissatisfaction exceeded a quarter of respondents (A590 High and Low Newton Bypass, A27 Polegate Bypass, A6 Great Glen Bypass and A595 Parton Lillyhall).

Whilst the sample is biased towards bypass schemes, in many instances lessons learnt from these surveys will be of value to any appraiser of a trunk road project with anticipated traffic reduction effects on built up areas and also prompt Highways England thinking about the wider community implications of its proposed schemes.

[35] For the A3 Hindhead and A595 Parton Lillyhall schemes, residents were instead asked how satisfied with the scheme they were.

Figure 8-1 Satisfaction levels in local communities based on residents' survey findings*



*Based on questions worded 'has it made … a better place to live' or 'how satisfied are you with …'

8.2 How long does Highways England Major Scheme appraisal take?

The average duration of Highways England Major Scheme appraisal is just over four years (for schemes with a construction start date between 2004 and 2009), although there is a wide variety between individual schemes.

There has been little change in the duration of scheme appraisal between 2004 and 2009.

Broadly speaking, transport scheme appraisal is the process Highways England undertakes (using the DfT's WebTAG guidance) to:

- Identify the problem to be solved;
- Identify a scheme;
- Develop the business case to ensure that the scheme is value for money and adequately mitigates any adverse impacts against the DfT's objectives for transport; and
- Secure the necessary funding approval for the scheme to allow construction works to commence.

Scheme appraisal can take differing lengths of time depending on many factors including the complexity of the scheme, size of the scheme, and whether a Public Inquiry is required. To determine how long scheme appraisal takes, this analysis assumes the following:

- Start of appraisal – Date of scheme entry into Highways England's Programme of Major Schemes.
- End of appraisal – Date of start of construction works on site.

The results of this analysis for schemes with a start of construction from 2004 onwards is shown in Figure 8-2. The older schemes have been omitted from this analysis because many schemes were already being appraised before they entered the Major Schemes Programme. It would therefore be inaccurate to include these schemes in the analysis.

Figure 8-2 Duration of Highways England's Major Scheme appraisal for schemes constructed from 2004 onwards

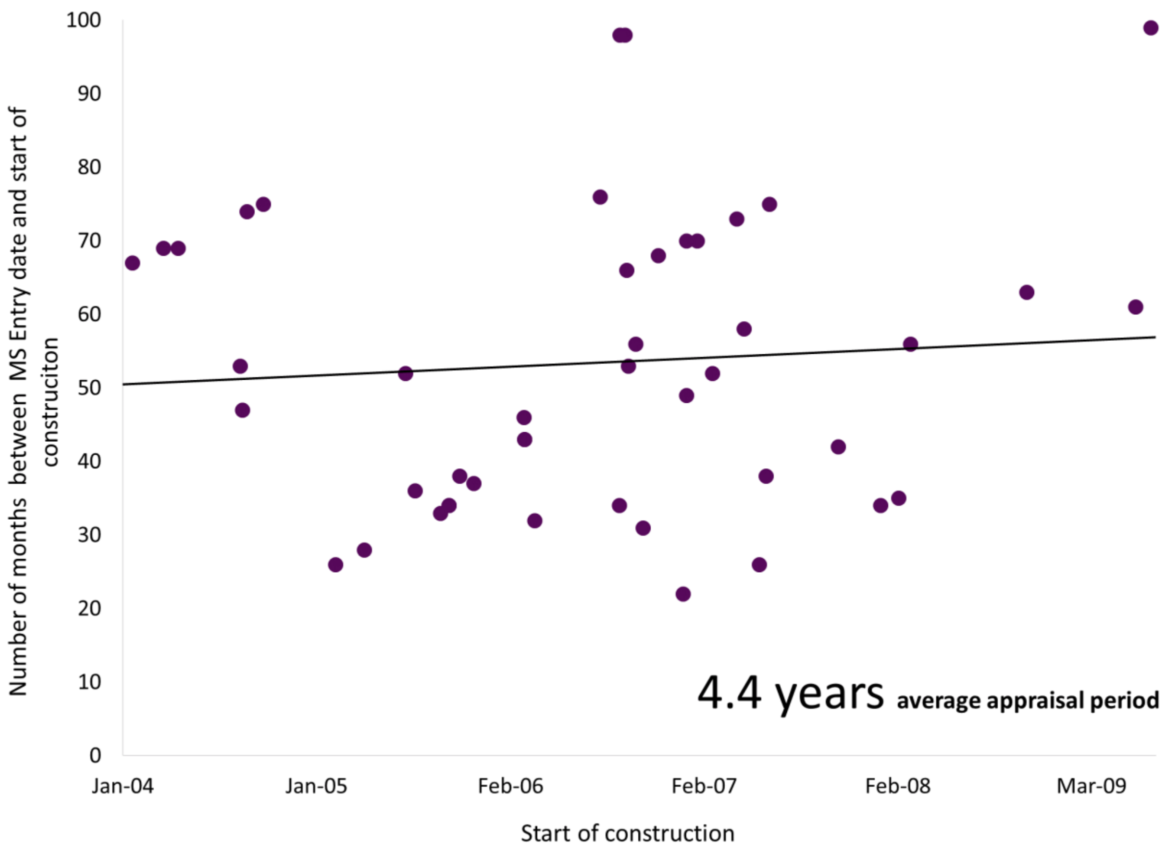


Figure 8-2 shows:

- There has been little change in the length of Highways England Major Scheme appraisal for schemes which commenced constriction between 2004 and 2009.
- There is a wide variation in the length of appraisal for individual schemes, with the range from approximately 20 months to 100 months. This is likely to be because Major Schemes can vary significantly in size and complexity, with many schemes subject to a Public Inquiry which also adds time to the process.
- The average appraisal period is just over four years.

8.3 How accurate are the forecasts for the accessibility objective?

Accessibility is concerned with increasing the ability with which people in different locations and with differing availability of transport can reach different types of amenities such as places of education, worship, leisure, healthcare and employment.

90% of schemes were evaluated 'as expected' for accessibility.

A5 Nesscliffe Bypass:
New Footbridge over A5

Accessibility was previously one of the five government objectives for transport which the majority of the schemes within this Meta-analysis were appraised against. In general terms, the DfT accessibility objectives (now called the 'Social' objective) is concerned with increasing the ability with which people in different locations, and with differing availability of transport, can reach different types of facility such as schools, places of worship, leisure facilities, hospitals and employment. The three sub-objectives with the accessibility objective are as follows:

- **Option Values** – The value that an individual places on having the option to use a new form of infrastructure, irrespective of whether they use it or now.
- **Severance** – The level of hindrance to pedestrians, equestrians, and cyclist movements caused by a specific barrier e.g. a dangerous road. Degree of severance is usually a function of suitable crossing facilities for different user groups.
- **Access to the transport system** – Relates to the proportion of non-car households within 250m of an hourly bus service.

An analysis of the accuracy of accessibility impact forecasts has been undertaken by comparing the AST and EST (Evaluation Summary Table) scores for each environmental sub-objective. The predicted impacts are assesed based on a seven point scale ranging from 'large beneficial' to 'large adverse'. This analysis makes a comparison between predicted and outturn impacts and identifies whether each sub-objective scored 'better than expected','as expected' or 'worse than expected' (based on a change of at least one point on the 7 point scale). The results are summarised in Table 8-1 which shows that the outturn impact of Major Schemes are predominantly 'as expected'.

Table 8-1 Outturn Evaluation of Accessibility sub-objectives

	Outturn score				Comparison with prediction		
Sub-objective	Neutral	Adverse	Benefit	Not assessed	Impact Better than Expected	As Expected	Impact Worse than Expected
Option Values	49%	0%	11%	40%	8%	92%	0%
Severance	30%	4%	63%	4%	5%	86%	9%
Access to the Transport System	55%	1%	17%	27%	6%	94%	0%
All sub-objectives					6%	90%	4%

Other key points from Table 8-1 are as follows:

- The forecasts for option values and access to the transport system are mainly 'as expected'. For option values, the schemes which are 'better than expected' are due to the appraisal not forecasting a benefit from improved walking and cycling facilities being implemented as part of schemes.
- For the small number of schemes where severance impacts were worse than expected, this was primarily due to low numbers of users of NMU facilities being observed (based mainly on site visit observations). The assessment contained in the scheme appraisal may have assumed a greater number of users, so the impact observed after opening is deemed to have been less or 'worse than expected', because fewer people have been affected.

8.4 How accurate are the forecasts for the integration objective?

Integration is concerned with ensuring that all decisions are taken in the context of the Government's transport policy at the time of the scheme appraisal.

89% of schemes were evaluated 'as expected' for integration.

M40 Junction 15 Longbridge:
Improved bus facilities on the A46 southbound

Integration was previously one of the five government objectives for transport which the majority of the schemes within this Meta-analysis were appraised against. The purpose of this objective was to ensure that transport intervention decision making is made within the context of national, regional and local policies. More specifically, this means:

- Integration within and between different types of transport, so that each contributes its full potential and that people can easily move between them.
- Integration with the environment, so that transport choices available support a better environment;
- Integration with land-use planning, at national regional and local level, so that transport and planning work together to support more sustainable travel choices and reduce the need for travel.
- Integration with policies for education, health and wealth creation, so that transport helps make a fairer, more inclusive society.

The integration objective had three sub-objectives:

- **Transport Interchange** – Consists of an assessment of the proposed intervention's impact upon freight and/or passenger interchange facilities.
- **Land Use Policy** – Relates to the extent to which the scheme is integrated with; and supported by land use policies and with proposals and policies concerning transport (all modes).
- **Other Government Policy** – This involves a review to identify whether the strategy or plan as a whole either (a) contributes to and is consistent with, (b) has no overall contribution or (c) is inconsistent with other Government policies beyond transport.

An analysis of the accuracy of integration impact forecasts has been undertaken by comparing the AST and EST (Evaluation Summary Table) scores for each environmental sub-objective. The predicted impacts are assesed based on a seven point scale ranging from 'large beneficial' to 'large adverse'. This analysis makes a comparison between predicted and outturn impacts and identifies whether each sub-objective scored 'better than expected','as expected' or 'worse than expected' (based on a change of at least one point on the 7 point scale). The results are summarised in Table 8-2.

Table 8-2 Outturn Evaluation of Integration sub-objectives

	Outturn score				Comparison with prediction		
Sub-objective	Neutral	Adverse	Benefit	Not assessed	Impact Better than Expected	As Expected	Impact Worse than Expected
Transport Interchange	57%	1%	12%	30%	5%	95%	0%
Land Use Policy	31%	4%	47%	18%	5%	83%	12%
Other Government Policy	31%	2%	36%	30%	4%	90%	6%
All sub-objectives					**5%**	**89%**	**7%**

As demonstrated in the previous analysis of forecast and outturn accessibility impacts, the majority of schemes were evaluated as ‘as expected’, as shown in Table 8-2. A number of the schemes were not assessed. This is because they were not considered in the appraisal (usually in line with the guidance available at the time).

9. Appendices

Scheme Photo: A66 Long Newton Grade Separated Junction Five Years After

Appendix A. Environmental issues

A.1. Landscape mitigation issues - schemes by Issue Category

Theme	Scheme	Evaluation Stage (OYA/FYA)
Slow establishment of specialised plant material (Species Rich Grassland, plug planting and heather)	A3 Hindhead Improvement	OYA
	A1 Bramham - Wetherby (Including Wetherby BP)	OYA
	A30 Bodmin Indian Queens Improvement	FYA
Establishment within the scheme, in some areas is less than expected	A2 Bean - Cobham Phase 2 Pepperhill - Cobham	OYA
	A428 Caxton Common to Hardwick Improvement	FYA
	A590 High and Low Newton Bypass	FYA
	A1 Stannington Junction	FYA
	A1(M) Ferrybridge - Hook Moor	FYA
	A11 Roudham Heath -Attleborough Improvement	FYA
	A120 Stansted to Braintree Improvement	FYA
	A27 Polegate Bypass	FYA
	A34 Chieveley-M4 Jct 13 Improvement	FYA
	A47 Thorney Bypass	FYA
	A595 Parton - Lillyhall Improvement	FYA
	A6 Alvaston Improvement	FYA
	A6 Great Glen Bypass	FYA
	A64 Colton Lane GSJ	FYA
	A650 Bingley Relief Road	FYA
	M60 J5-8 Widening	FYA
	A46 Norton Lenchwick Bypass (10 years after)	FYA
	A34 Newbury Bypass	FYA
	M6 Toll	FYA
Slow growth and high percentage failures	A1 Peterborough to Blyth	OYA
	M25 Junction 28-A12 Brook Street Junction Improvement	FYA
	M27 J11-J12 Climbing Lanes	FYA
	A1033 Hedon Road Improvement	FYA
	A11 Attleborough Bypass	FYA
	A500 Basford, Hough, Shavington Bypass	FYA
Screening through planting not sufficient resulting in areas being more exposed / visible	A1 Peterborough to Blyth	OYA
	A30 Bodmin Indian Queens Improvement	FYA

Theme	Scheme	Evaluation Stage (OYA/FYA)
Poor ground preparation	A428 Caxton Common to Hardwick Improvement	FYA
	A590 High and Low Newton Bypass	FYA
	A1 Stannington Junction	FYA
	A34 Chieveley-M4 Jct 13 Improvement	FYA
	A47 Thorney Bypass	FYA
	A6 Great Glen Bypass	FYA
	A34 Newbury Bypass	FYA
High incidence of noxious weeds and other invasive species	A69 Haydon Bridge Bypass	OYA
	A30 Bodmin Indian Queens Improvement	FYA
	A66 Greta Bridge to Stephen Bank Improvement	FYA
	M27 J11-J12 Climbing Lanes	FYA
	A47 Thorney Bypass	FYA
	A6 Rushden & Higham Ferrers Bypass	FYA
	A64 Colton Lane GSJ	FYA
	M60 J5-8 Widening	FYA
Self seeding and colonisation of Gorse	M27 J11-J12 Climbing Lanes	FYA
	A14 Rookery Crossroads GSJ	FYA
	A64 Colton Lane GSJ	FYA
	A34 Newbury Bypass	FYA
Introduced soil replacement mediums (colliery spoil / shillet) resulting in a large reduction in expected plant growth.	A38 Dobwalls Bypass	OYA
	A64 Colton Lane GSJ	FYA
Not all planting implemented by OYA review	A419 Blunsdon Bypass	OYA
	A421 Bedford to M1 Junction 13	OYA
	A69 Haydon Bridge Bypass	OYA
	M27 J3 to J4 Widening	OYA

A.2. Schemes with reduced establishment aftercare maintenance period

Theme	Scheme	Issue	Assessed to reach growth targets by Design Year	Aftercare period (years)	OYA / FYA
Handover Issues	A5117-A550 Deeside Park Junctions Improvement	Decrease of aftercare period by Highways England. Maintenance establishment handed to MAC – unclear whether MAC undertook maintenance in line with ES requirements for growth achievements	Too early to confirm.	Three	OYA
	A590 High and Low Newton Bypass	No evidence of weed-free circles around planting stations and some rank weed growth was visible within plots and balancing pond areas.	Yes	Three	FYA
	A66 Carkin Moor to Scotch Corner Improvement	Plant shelters remain in place throughout planted areas and along hedgerows, and although not adversely affecting the planting so far, are specified in the HEMP to be removed at the end of the three-year Aftercare Period. The MAC is of the opinion that they should have been removed as part of the original contract and that the MAC should not be expected to remove them (Handover issue).	Yes	Three	FYA
	A66 Greta Bridge to Stephen Bank Improvement		Yes	Three	FYA
	A66 Long Newton Junction	The HEMP outlined the need for continued management to maintain planted areas free of weeds until such time as the canopy had closed over completely, and to maintain areas of grassland to an acceptable and safe height as appropriate. Lack of replacement planting appeared to be a continuing issue.	Yes	Three	FYA
	A27 Polegate Bypass	Some of the new tree planting may not be establishing as well as others and it would be expected that this issue would be addressed as part of the ongoing landscape aftercare operations	Environment not assessed at OYA. FYA not set to reach targets.	Three	FYA
	M27 J11-J12 Climbing Lanes	Some areas subject to planting have a high mortality rate and it is clear that no active maintenance is in place. The landscape strategy for trees and shrubs in the Handover Management Plan notes that control of scrub is required to 'ensure that vigorous species such as gorse and bramble do not become dominant'.	At OYA it was determined that planting was acceptable (i.e. plants in place). At FYA planting was not set to reach targets	Two	FYA

Theme	Scheme	Issue	Assessed to reach growth targets by Design Year	Aftercare period (years)	OYA / FYA
Gorse establishment with potential to outcompete planting plots	A14 Rookery Crossroads GSJ	The use of common gorse was identified as a concern at OYA as this species tends to spread easily and can become invasive if not managed, to the detriment of other species within the planting mix. The HEMP quite clearly states that invasive species such as Gorse should be controlled and that plots should be monitored every two years for scrub control requirements. There appears to be no allowance for this in the early handover to the MAC.	At FYA, gorse has reached heights of 2 metres and there is a danger that it will overwhelm other plants, it being twice as high in many instances.	Three	FYA
	A64 Colton Lane GSJ	In some locations gorse has self-seeded and begun to establish. Without rigorous control through ongoing management it is likely that given time it will out-compete other more desirable species.	At OYA significant numbers of plants had died. At FYA planting was not set to reach targets	Three	FYA
	A34 Newbury Bypass	Gorse would appear to be colonising many plots at the southern end of the scheme at the expense of the designated plot species	At FYA planting was not set to reach targets	Three	FYA
	M27 J11-J12 Climbing Lanes	Colonisation of gorse is visible in one of the plots which further indicates a lack of required maintenance.	At OYA it was determined that planting was acceptable. At FYA planting was not set to reach targets	Two	FYA
No effect of reduced aftercare	A21 Lamberhurst Bypass	No growth related issues identified.	Yes	Three	FYA
	A66 Stainburn & Great Clifton Bypass		Environment not assessed. FYA set to reach targets	Three	FYA
Impact on growth targets	A500 Basford, Hough, Shavington Bypass	In the first year of the aftercare period, the number of plants lost was approximately 60%. Agreement was reached to use water retention polymer granules within the pit preparation due to free draining sandy soils. Landscape planting is slow to establish in some areas. Slow establishment could affect the long term objectives for landscape screening and integration without ongoing management.	Environment not assessed at OYA. FYA not set to reach targets	Three	FYA

Theme	Scheme	Issue	Assessed to reach growth targets by Design Year	Aftercare period (years)	OYA / FYA
	M60 J5-8 Widening	Expected shrub and tree planting in some locations were struggling to establish, and some failures had occurred, which could be in connection with the ground conditions (topsoil depth and quality and permeability of sub layers).A high presence of weed growth was noted during the FYA visit, this could be an indication that establishment maintenance has not been effective.	At OYA, planting failures and poor establishment were reported in some locations. At FYA planting in some areas was still struggling to reach its growth targets.	Three	FYA
	M27 J3 To J4 Widening	Growth of weeds and lack of topsoil in offsite planting areas may impact on growth targets	Yes (OYA only)	Two	OYA

Appendix B. Glossary

Term	Abbreviation	Description where appropriate
Average Annual Daily Traffic	**AADT**	This traffic flow is derived by averaging a traffic flow 24 hours a day, 365 days a year.
Appraisal Summary Table	**AST**	This records the impacts of the scheme according to the Government's five key objects for transport, as defined in **DfT** guidance contained on its Transport Analysis Guidance web pages, **WebTAG**
Automatic Traffic Count	**ATC**	A machine which measures traffic flow at a point in the road.
Benefit Cost Ratio	**BCR**	This is the ratio of the benefits expressed in terms of present value (**PVB)** divided by the costs also expressed in terms of present value (**PVC)**.
Cost Benefit Analysis	**COBA**	**CO**st **B**enefit **A**nalysis – a computer program which compares the costs of providing road schemes with the benefits derived by road users (in terms of time, vehicle operating costs and accidents), and expresses the results in terms of a monetary valuation. The **COBA** model uses the fixed trip matrix unless it is being used in Accident-only mode.
-	**COBALT**	**Cost and Benefit to Accidents – Light Touch**) is a computer programme developed by the DfT to undertake the analysis of the impact on collisions as part of the economic appraisal for a road and supersedes the COBA programme
-	**D3M, D4M**	**Dual 3 lane Motorway** and **Dual 4 lane Motorway**
Design Built Finance and Operate	**DBFO**	The private sector assumes responsibility for the operation and maintenance of a length of existing road (where appropriate) and for building specified improvement schemes for the life of the contract.
Design Year	**-**	A set period after the opening of a scheme for which the scheme is designed to be fit for purpose. This is usually 15 years after the planned opening year.
Department for Transport	**DfT**	A Government department whose objective is to oversee the delivery of a reliable, safe and secure transport system that responds efficiently to the needs of individuals and business whilst safeguarding our environment.
Design Manual for Roads and Bridges	**DMRB**	A comprehensive manual system which sets out current standards, Advice Notes and other published documents relating to Trunk Road works.
Design and Build	**D&B**	A project delivery system used in the construction industry. It is a method to deliver a project in which the design and construction services are contracted by a single entity.
Do-Minimum	**-**	In scheme modelling, this is the scenario which comprises the existing road network plus any other improvement schemes that have already been committed.
Do-Something	**-**	In scheme modelling, this is the scenario detailing the planned scheme.
Early Contractor Involvement	**ECI**	This is a model for contract procurement that is currently being used by various government agencies to deliver major road projects.
Environment Agency	**EA**	Public body for protecting and improving the environment in England and Wales.
Economic Assessment Report	**EAR**	A report presenting the economic appraisal of a scheme.

Term	Abbreviation	Description where appropriate
Elastic Assignment Modelling		An elastic assignment model uses an elasticity function to approximate some demand responses, in addition to the change in route response modelled by an assignment. It is assumed that the demand for travel between an origin and destination is purely a function of the change in costs for that mode between the two points.
Environmental Statement	**ES**	A document produced in accordance with the EIA Directive as transposed into UK law by EIA Regulations.
Evaluation Summary Table	**EST**	In **POPE** studies, this is a summary of the evaluations of the Government objectives for transport using a similar format to the forecasts in the **AST**.
Five Years After	**FYA**	Relating to five years after a scheme opened.
Fixed Demand Modelling		The assignment of traffic in a model using a fixed trip matrix with no induction or suppression of trips (also referred to as 'fixed trip matrix assignment').
Grade Separated Junction	**GSJ**	A GSJ is a junction at more than one level to enable through traffic on the main route to pass through unimpeded.
Great Crested Newt	**GCN**	
Highways Agency	**HA**	Formerly an Executive Agency of the Department for Transport. The HA has now become Highways England.
Highways England		A Government-owned Strategic Highways Company responsible for the strategic highway network in England.
Handover Environment Management Plan	**HEMP**	Provides a framework for Highways England to fulfil the environmental commitments made with regard to long-term management associated with schemes.
Incident Cost Benefit Analysis	**INCA**	A modelling programme used to estimate the monetised benefits of measures affecting journey time variability covering incidents on motorways and dual carriageways.
Journey Time Database	**JTDB**	Holds information on journey times and traffic flows for links of the strategic network.
Landscape and Ecology Aftercare Plan	**LEAP**	LEAP aims to provide details of the protection, management, monitoring and maintenance of existing and new planting, seeding and habitat creation areas undertaken by the contractor for five years following the construction and practical completion of the landscape and ecological works. The LEAP may be used to inform or be superseded by, the **HEMP**.
Landscape Management Plan	**LMP**	The LMP provides details of the maintenance requirements for planting undertaken within a scheme.
Local Model Validation Report	**LMVR**	A mandatory key element in reporting model reliability. Its purpose is to demonstrate the model reproduces an existing situation; summarise the accuracy of the base from which the forecasts are derived; to present validation procedures, and details of adjustments made during calibration.
Major Schemes programme	**-**	Highways England and formerly the Highways Agency's programme of investment in improvements to the Trunk road and Motorway road network comprised of a number of Major Schemes each costing more than £10million (formerly £5million).
Managing Agent Contractor	**MAC**	A MAC is the supplier responsible for the design and delivery of road maintenance in a particular area of England for a fixed period of years
Meta-analysis	**-**	A quantitative method of combining the results of independent studies and synthesizing summaries and conclusions from which new and improved processes can be developed.
Managed Motorway	**MM**	See smart motorway

Term	Abbreviation	Description where appropriate
Motorway Incident Detection and Signalling system	**MIDAS**	Inductive loops installed in the carriageway monitoring speeds, vehicle types and flows. The prime aim of **MIDAS** is to protect the back of queues, which have formed or are about to form, by automatically setting suitable signals to warn approaching traffic.
National Trust	**-**	A charity completely independent of Government which works to preserve and protect the buildings, countryside and coastline of England, Wales and Northern Ireland, in a range of ways, through practical conservation, learning and discovery.
Natural England	**NE**	The Government's advisor on the natural environment, whose remit is to ensure sustainable stewardship of the land and sea so that people and nature can thrive.
Non-Motorised Users	**NMU**	A generic term covering pedestrians, cyclists and equestrians
National Road Traffic Forecasts	**NRTF**	This document defines the latest forecasts produced by the **DfT** of the growth in the volume of motor traffic. The most recent one is **NRTF11** and the one previous was **NRTF09**.
Net Present Value	**NPV**	Net Present Value is the value of the benefit of a scheme and is calculated by subtracting the discounted sum of all future costs from the discounted sum of all future benefits i.e. NPV = PVB - PVC
Net Present Value / Cost Ratio	**NPV/£**	NPV/£ is a measure of best value for public accounts expenditure, defined as the ratio NPV / PVC. It is an alternative measure of value to the BCR.
One Year After	**OYA**	Relating to one year after a scheme opened.
Post Opening Project Evaluation	**POPE**	Before and after monitoring of all major highway schemes in England.
Personal Injury Collision	**PIC**	A road traffic collision reported to the police and in which at least one person required medical treatment.
Present Value Benefits	**PVB**	Value of a stream of monetary benefits accruing over the appraisal period of a scheme expressed in the value of a single 'present' year to give a present value based on the concept of discounting. Discounting is a technique used to compare costs and benefits that occur in different time periods. It is based on the principle known as time preference that people prefer goods and services now rather than later. This preference for goods and services now rather than later applies to both individuals and society.
Present Value Costs	**PVC**	As for **PVB** but for a stream of costs
Public Right of Way	**PROW**	These are roads, paths or tracks which can run through towns, countryside or private property and are open to everyone to walk on. Some PROWs are also open to horse-riders, cyclists and motorists.
Sites of Specific Scientific Interest	**SSSI**	The country's very best wildlife and geographical sites. There are over 4,000 **SSSI**s in England, covering around 7% of the country's land area.
Smart Motorway	**SM**	Smart Motorways (previously called Managed Motorways) help relieve congestion by using technology to control traffic flows, making best use of the existing road space by utilising the hard shoulder, assist in the management of incidents and providing information to road users. They also allow the hard shoulder to be used as a running lane at peak times to create additional capacity.
-	**STATS19**	A database of injury accident statistics recorded by police officers attending accidents.

Term	Abbreviation	Description where appropriate
Sustainable Drainage Systems	**SUDS**	Water management practices and facilities designed to drain surface water in a manner that will provide a more sustainable approach than what has previously been the conventional practice of routing run-off through a pipe to a watercourse
Trip End Model Program	**TEMPRO**	A program which provides access to the **DfT'**s national Trip End Model projections of growth in travel demand, and the underlying car ownership and planning data projections.
Traffic Forecasting Report	**TFR**	The TFR details the forecasting approach, in terms of future network and matrix development, as well as assignment methodology and use of VDM. The report shows the impact of the scheme on traffic flows and journey times.
Traffic Data System	**TRADs**	The Traffic Data System which holds information on traffic flows at sites on Highways England's network.
Transport Users Benefit Analysis	**TUBA**	A computer system issued and maintained by the DfT. The program calculates the costs and benefits that would accrue to users of a transport system, companies, national and local government as a result of making improvements to a transport network.
Variable Demand Modelling	**VDM**	VDM predicts and quantifies the change in demand due to a change in transport conditions for a number of demand responses including mode choice, trip frequency, trip distribution and time of day choice.
Vehicle Operating Costs	**VOC**	The use of the road system by private cars and lorries gives rise to operating costs for the user. These include costs of fuel, oil and tyres, and an element of vehicle maintenance.
Value for Money	**VfM**	In this study, VfM refers to the DfT guidance on interpretation of BCR ranges for use in the Business Case of a scheme.
WebTAG	**-**	**DfT**'s website for guidance on the conduct of transport studies.

Appendix C. List of Tables and Figures

List of Tables

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