A66 Northern Trans-Pennine Project
TR010062

3.8 Combined Modelling and Appraisal Report

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3.8 COMBINED MODELLING AND APPRAISAL REPORT

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Executive Summary

The Combined Modelling Appraisal (ComMA) Report discusses the transport modelling, traffic forecasts and economic appraisal work undertaken for the A66 Northern Trans-Pennine Project. The ComMA report is an 'end of stage' document and contains key findings of the appraisal work on the social, environmental and economic impacts. The following technical reports underpin the content included in the ComMA and are listed as appendices to this report:

- Transport Data Package (Appendix B) outlines datasets and sources used for the development of the A66 Transport Model (A66TM).
- Transport Model Package (Appendix C) describes the methods used to build the A66TM, the calibration of the model to reflect real world traffic conditions during the base year and results from the validation of the model.
- Transport Forecasting Package (Appendix D) provides information for the forecast traffic models both Do Minimum (DM) and Do Something (DS).
- Economic Appraisal Package (Appendix E) describes the methods used to assess the impacts of the Project and present the range of economic, environmental and social impacts of the Project.

The Project includes upgrading the existing single lane sections of the A66 to dual two-lane all-purpose roads with a speed limit of 70 miles per hour (mph), except for a section of the A66 from the M6 junction 40 through Kemplay Bank which will have a speed limit of 50mph. The Project also includes amendments to existing junctions and accesses within these sections.

Traffic demand and network performance on the A66 between M6 Junction 40 and A1(M) Scotch Corner and the local network surrounding the corridor have several specific characteristics:

- Key national and regional strategic transport corridor with no direct rail alternatives for passenger or freight movements. Despite the strategic importance of the A66, the route between the M6 at Penrith and the A1(M) at Scotch Corner is only intermittently dualled and has six separate sections of single carriageway.
- High levels of long-distance freight traffic along the A66 corridor. Heavy Goods Vehicle (HGV) proportions currently exceed 20% on most scheme sections except for J40 and Kemplay Bank where if falls just below 20%.
- Variable road standards, together with the lack of available diversionary routes when incidents occur, affects road safety, reliability, resilience and attractiveness of the route.
- Important route for tourism and connectivity for nearby communities.
- The A66 carries local slow moving agricultural vehicles and other traffic making short journeys, which can have an impact on other users, especially on the single carriageway sections.

The A66TM has been used to support the Development Consent Order (DCO) application for the Project. The model uses SATURN software and has been developed using the Northern Regional Transport model (NRTM) which provides a starting point for the development of detailed scheme specific models such as the A66 Project. Initial model development undertaken in the earlier stages of this study, namely PCF (Project Control Framework[1]) Stages 1 and 2, was based upon the North Regional Traffic Model (NRTM). During the preliminary design stage (PCF Stage 3), the A66TM has been refined such that it is suitable to inform the DCO application following the work undertaken previously at options development stage (PCF Stage 2). The A66TM is a strategic model which extends across England, Scotland and Wales with an ‘Area of Detailed Modelling’ (AoDM) covering the north of England.

The base year for the A66TM has been updated from the options development stage from 2015 to 2019 and has been calibrated to represent an average weekday in March (Monday to Friday) based on observed data, in line with the NRTM. The process to collect data and to use this within the model has been undertaken in line with the Department for Transport’s (DfT) Transport Analysis Guidance (TAG) and agreed with National Highways’ Transport Planning Group, and through consultation with Stakeholders. The impact of Covid-19 on the ability to collect data is discussed in this report which also outlines why the latest data used within the model comes from 2019.

Separate models were developed to represent a morning peak hour (08:00-09:00), average interpeak hour (10:00-16:00) and average evening peak hour (16:00-18:00). All models were calibrated and validated using DfT guidance provided in TAG unit M3-1.

The A66TM is a variable demand model. This means that the model predicts how the travel patterns in the area would change once the Project is built and provides additional road capacity along the Trans-Pennine route. These responses include changes to the frequency of making trips, the time of day at which those trips are made, the transport mode used and the destination of trips. The model then estimates the route they use, which provides information on how many vehicles are using each part of the road network and how long it takes to complete a journey.

The primary purpose of the A66TM is to assess the traffic impacts of the A66 Project and to provide inputs into the economic and environmental appraisals, as well as inform the buildability (construction and traffic management) of the Project.

In addition to the strategic modelling work, operational micro-simulation models were developed using VISSIM[2] for the terminal junctions (J40/Kemplay Bank and

[1] The Project Control Framework (PCF) is the framework that was launched by the then Highways Agency (now National Highways) and Department for Transport on 1st April 2008 to ensure that major improvement projects are delivered which meet customers' aspirations in a cost efficient and timely manner. The project lifecycle contains 8 stages, inclusive of stage 0. A project team typically has to go through these stages to successfully deliver the project. PCF stage 1 focuses on Options Identification, PCF2 on Option Selection, and PCF3 on Preliminary Design.
[2] https://www.ptvgroup.com/en/solutions/products/ptv-vissim/

the A1(M) at Scotch Corner) at either end of the A66 Project corridor. This enabled a more detailed assessment to help understand the implications of the proposed Project including necessary infrastructure improvements at each junction.

Several separate junction models were also developed with TRL Junctions 9 software using both ARCADY[3] and PICADY[4] programs to assess key junctions. These junctions are either on the A66 or local road network close to the A66 and could be impacted by changes in traffic flows due to the Project.

Future year models were developed using DfT guidance provided in TAG Unit 4 – Forecasting and Uncertainty. Traffic forecasts were prepared assuming a 2029 opening year, 2044 design year and future 2051 forecast year. The level of traffic growth for cars in the future is taken from the DfT's National Trip End Model (NTEM). These forecasts, known as the TEMPro 7.2 forecasts, are available at the census Lower Super Output Area (LSOA) geography. Freight growth for goods vehicles is based on Road Traffic Forecasts (RTF) 2018 Scenario 1 which uses central projections of Gross Domestic Project (GDP), fuel price, and population.

A review of planned local developments, including highway infrastructure improvements in areas surrounding the A66 Project was undertaken by contacting local authorities. Where these developments were either under construction, with planning permission or had a submitted planning application (defined in TAG Unit M4 as 'near certain' or 'more than likely'), they were added into the model to provide greater spatial detail as to where the future growth is most likely to occur. The level of traffic growth nearby is then adjusted so that the overall level of future traffic in the local area matches the growth predicted in the TEMPro 7.2 forecasts.

A set of models Do Minimum (DM) and Do Something (DS) were built. Differences between the model predictions of flows, journey times and travelled distances were obtained from the models and then monetised in the economic appraisal. Flows from both the DM and DS models also formed the basis for environmental appraisals and safety assessments.

The models demonstrated that the Project would provide a reduction in journey times in each modelled period. The impact produced a DS travel time which is 11 to 13 minutes less than DM in 2044, which increases to a reduction of 12 to 14 minutes in 2051.

The Economic Appraisal Report (Appendix E) sets out the economic case for the Project. Where impacts can be quantified and given a monetary value this is done for costs and benefits from now until 60 years after the Project opens. The costs and benefits are converted into 2010 prices as required by the DfT and discounted using the HM Treasury discount rates. The Present Value of Costs is £750.498 million and the initial Present Value of Benefits (PVB) is £358.320 million (excluding journey time reliability and wider economic impacts). With journey time

[3] https://trlsoftware.com/products/junction-signal-design/junctions/arcady/
[4] https://trlsoftware.com/products/junction-signal-design/junctions/picady/

reliability and wider economic impacts included, the adjusted PVB increases to £691.984 million producing an adjusted Benefit Cost Ratio (BCR) of 0.92.

Changes in the number of accidents, air quality, noise and greenhouse gases have been assessed, together with an assessment of impacts during construction. These have been monetised and are included in the economic appraisal. This report also covers other environmental, social and economic impacts that are not given a monetary value but are taken into consideration when assessing the overall worth of the Project.

A series of sensitivity tests were undertaken to consider how sensitive the flows, journey times and travelled distances are to changes in some of the key assumptions. This scenario testing is required by the DfT to demonstrate the robustness of the core results which are being relied on as the main evidence. Demand sensitivity tests were undertaken to assess the impact of low and high traffic growth levels on the benefits. Additionally, a core scenario sensitivity test around costs has been undertaken. The low sensitivity was shown to reduce the adjusted BCR from 0.92 to 0.78, whilst the high sensitivity increases the adjusted BCR to 0.99.

1 Introduction

1.1 Introduction and purpose of this document

1.1.1 This document comprises the Combined Modelling and Appraisal ("ComMA") that has been produced to support the DCO (Development Consent Order) application for the A66 Northern Trans-Pennine Project ('the Project').

1.1.2 The purpose of the ComMA report is to inform decision makers and stakeholders on how the evidence underpinning the business case has been developed from the initial identification of the underlying problem through the collection of data and the production of any supporting traffic models and the forecast impacts of the Project on the strategic and local highway network. road safety and the economy.

1.2 Structure of the document

1.2.1 The report is structured as follows:

- Chapter 2: Local transport situation
- Chapter 3: Data Sources
- Chapter 4: Transport Model
- Chapter 5: Traffic Forecast
- Chapter 6: Economic Appraisal
- Chapter 7: Sensitivity tests
- Chapter 8: Summary

1.2.2 The report is accompanied by the following appendices containing supporting information:

- Appendix A – ComMA Summary
- Appendix B – Transport Data Package
- Appendix C - Transport Model Package
- Appendix D – Transport Forecast Package
- Appendix E – Transport Economic Package

1.3 Project background

1.3.1 The A66 Northern Trans-Pennine (NTP) Project ('the Project') is proposed by National Highways. Options appraisal has been undertaken through a staged process (**3.2 Environmental Statement Chapter 3: Assessment of Alternatives**) and a Preferred Route was announced in March 2020. The design has been developed, assumptions tested and validated, and an Environmental Impact Assessment (EIA) undertaken in support of an application for a DCO. The design has continued to develop throughout the preliminary design stage based on modelling work, stakeholder engagement and feedback from statutory consultation.

1.3.2 The A66 is a key national and regional strategic transport corridor and link for a range of travel movements. It carries high levels of freight traffic and is an important route for tourism and connectivity for nearby communities. There are no direct rail alternatives for passenger or freight movements along the corridor.

1.3.3 Despite the strategic importance of the A66, the route between the M6 at Penrith and the A1(M) at Scotch Corner is only intermittently dualled and has six separate sections of single carriageway. The route also carries local slow moving agricultural vehicles and other traffic making short journeys, which can have an impact on other users, especially on the single carriageway sections. The variable road standards, together with the lack of available diversionary routes when incidents occur, affects road safety, reliability, resilience and attractiveness of the route.

1.3.4 If the existing A66 route is not improved, it will constrain national and regional connectivity and may threaten the transformational growth envisaged by the Northern Powerhouse initiative (Transport for the North, 2019)[5] and the achievement of the Government levelling up agenda.

1.3.5 The A66 forms part of the most direct route between the Tees Valley, north, south and west Yorkshire, the East Midlands, eastern England, north Cumbria, and the central belt of Scotland and Cairnryan (for access to Ireland). The recent improvements to bring the A1(M) carriageway to motorway standards between Leeming Bar and the A66(M) is also expected to increase the attractiveness of south-to-north movements along the A66.

1.3.6 The need for improvements to the A66 corridor was identified in the Northern Trans-Pennine Routes (NTPR) Strategic Study announced as part of the first *Road Investment Strategy 1 (RIS1)* in December 2014 (Department for Transport, 2015a)[6]. Funding for the A66 corridor improvements was committed to in the *Road Investment Strategy 2 (RIS2)* in March 2020 (Department for Transport, 2020)[7].

1.3.7 Subsequently to the Preferred Route Announcement (PRA) it was determined that works are also required to the terminal junctions with the M6 at Penrith (J40)/Kemplay Bank and the A1(M) at Scotch Corner, in order to ensure the entire route achieves consistent standards and meets the project objectives - these also form part of the Project. Work was initially undertaken during the options development stage to develop micro-simulation models for the terminal junctions. These models have since been updated in the preliminary design stage to reflect the latest junction designs and traffic demand.

1.4 Project objectives

1.4.1 We have been appointed by the Secretary of State (SoS) to be the strategic highways company and therefore highway authority, traffic authority and street authority for the *Strategic Road Network Initial Report (SRN)* (Highways England, 2017)[8] and pursuant to the

[5] Transport for the North (2019) Strategic Transport Plan
[6] Department for Transport (2015a) Road investment strategy: 2015 to 2020
[7] Department for Transport (2020) Road investment strategy: 2020 to 2025
[8] Highways England (2017) Strategic Road Network Initial Report

Infrastructure Act 2015. The objectives for the project are presented by theme in Table 1-1.

Table 1-1: A66 Project objectives

Theme	Project Objectives
Economic	Regional: Support the economic growth objectives of the Northern Powerhouse and Government levelling up agenda.
	Ensure the improvement and long-term development of the SRN through providing better national connectivity including freight.
	Maintain and improve access for tourism served by the A66.
	Seek to improve access to services and jobs for local road users and the local community.
Transport	Improve road safety, during construction, operation and maintenance for all, including road users, non-motorised users (NMU), road workers, local businesses and local residents.
	Improve journey time reliability for road users.
	Improve and promote the A66 as a strategic connection for all traffic and users.
	Improve the resilience of the route to the impact of events such as incidents, roadworks and severe weather events.
	Seek to improve NMU provision along the route.
Community	Reduce the impact of the route on severance for local communities.
Environment	Minimise adverse impacts on the environment and where possible optimise environmental improvement opportunities.

1.4.2 Part 4 Aims and Objectives of *Highways England: Licence* (Department for Transport, 2015b)[9] states that National Highways has a duty to *"minimise the environmental impacts of operating, maintaining and improving its network and seek to protect and enhance the quality of the surrounding environment" and "conform to the principles of sustainable development".* Since the publication of this document in 2015, Highways England became known as National Highways therefore it is now the National Highways licence.

1.5 Project description

1.5.1 The project includes upgrading the existing single lane sections of the A66 to dual two-lane all-purpose roads with a speed limit of 70 miles per hour (mph), with the exception of a section of the A66 from the M6 junction 40 through Kemplay Bank which will have a speed limit of 50mph. The project also includes amendments to existing junctions and accesses within these sections.

1.5.2 The project has been split into eight schemes. Full details of the Project schemes are provided in the **3.2 Environmental Statement, Section 2.6 Project Description.**

[9] Department for Transport (2015b) Highways England: Licence

1.6 Analytical Assurance

1.6.1 In producing the analysis contained within this document Amey/Arup have taken on the role of Analytical Lead, as defined in the Analytical Assurance Framework[1]. Amey/Arup are therefore responsible for:

- analysis design;
- producing the analysis
- a review the analysis results including a check as to whether the original question has been answered; and
- applying RIGOUR. This means that the following principles are applied:
  - **R**epeatable;
  - **I**ndependent;
  - **G**rounded in reality;
  - **O**bjective;
  - have understood and managed **U**ncertainty; and
  - the results should address the initial question **R**obustly.

1.6.2 AmeyArup designed the analysis in response to the Analytical Requirements Report through the production of the Appraisal Specification Report. The analysis has been produced and checked in line with our quality procedures (ISO 9001:2015) and the principles of RIGOUR have been applied. AmeyArup have provided the first and second lines of assurance in line with their quality procedures with reviews of the analysis being undertaken.

1.6.3 A summary of key figures and information from this report can be found in Appendix A: ComMA Summary.

[1] Highways England, Analytical Assurance Framework, May 2018

2 Local transport system

2.1.1 The A66 between Penrith and Scotch Corner currently operates as an all-purpose trunk road as part of the SRN in the north of England, linking the A1(M) in the east to the M6 in the west. The SRN are those roads which are the responsibility of the Secretary of State for Transport and managed by National Highways. The A66 is currently a combination of single carriageway and dual carriageway sections in each direction. There is currently around 18 miles of single carriageway and partly dual carriageway in each direction.

2.1.2 The A66 provides an important strategic, regional and local route, connecting east and west coasts, as well as providing local access (Figure 2-1). It is the most direct route between the Tees Valley, North Yorkshire, South Yorkshire, parts of West Yorkshire, the East Midlands, Eastern England and North Cumbria, Glasgow, and much of the central belt of Scotland and Cairnryan (for access to Northern Ireland and the Republic of Ireland). This emphasises the importance of the A66 in terms of strategic connectivity across the UK.

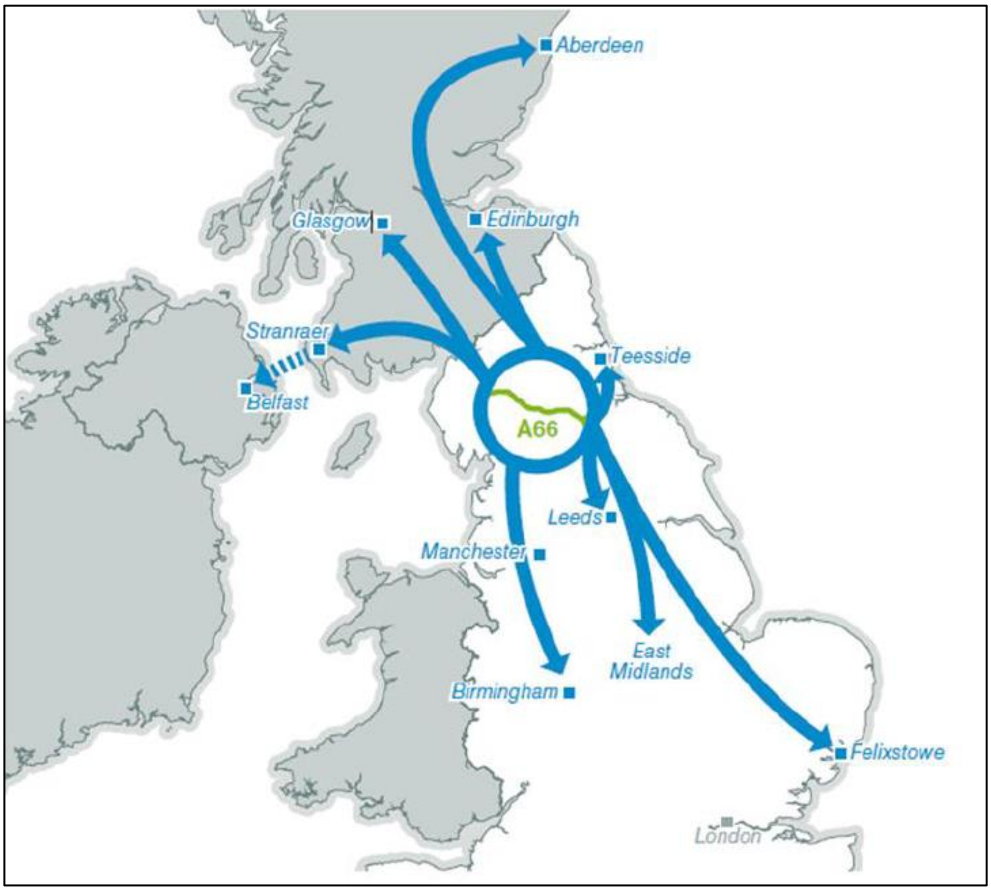

Figure 2-1: A66 key strategic links

2.1.3 There is a lack of public transport infrastructure in the A66 corridor, with minimal bus service provision and no direct east-west rail connections.

2.1.4 For key journeys across the UK, such as trips from the east and south east of England to the north west of England or Scotland, the A66 is the most direct and quickest route. The only strategic alternative east-west route for road traffic in the north of England is the M62 or the A69, both of which require a significantly longer journey time.

2.1.5 The main transport-related issues identified on the A66 within the Project objectives are:

- road safety
- journey times
- journey reliability and route resilience
- local severance.

2.2 Existing traffic flows

2.2.1 In the latest modelled year, 2019, around 19,900 vehicles travel along the A66 each day in both directions, as shown in Table 2-1. Between 18 to 28% (depending on scheme section and location) of vehicles identified as Heavy Goods Vehicles (HGV). The HGV proportion increases as the Average Annual Daily Traffic (AADT) decreases, for example the busier sections of the route around Penrith (i.e. at Scheme 1 and 2) show lower HGV proportions (less than 20%), while between Schemes 4/5 and Scheme 11 the proportion of HGVs is in excess of 22%.

2.2.2 The typical proportion of HGVs expected (as a proportion of AADT[10]) is 15% on motorways, 12% on trunk roads and 8% on principal roads. Therefore, it is noted that the percentage of HGVs is significantly higher than the average figure for other road types for the majority of the route. 2019 base year modelled flows on the A66 and surrounding roads are shown in Figure 2-2 and Figure 2-3 (observed data provided where appropriate counts exist on scheme sections).

Table 2-1: A66 2019 Annual Average Daily Traffic Flow

	Observed AADT	Observed % HGV	Modelled AADT	Modelled % HGV
Scheme 1 - M6 J40	28,445	18.8%	31,748	18.3%
Scheme 2 - Kemplay Bank	-	-	22,100	19.5%
Scheme 3 - Penrith to Temple Sowerby	19,495	23.2%	19,618	21.6%
Scheme 4 - Temple Sowerby to Appleby	18,096	23.3%	18,429	23.7%
Scheme 6 - Appleby to Brough	15,840	27.8%	16,164	27.9%
Scheme 7 - Bowes Bypass	18,716	24.9%	18,713	22.3%
Scheme 8 - Cross Lanes to Rokeby	16,532	27.3%	16,453	26.5%
Scheme 9 - Stephen Bank to Carkin Moor	-	-	17,662	24.0%

[10] AADT: Annual Average Daily Traffic - the total volume of vehicle traffic of a highway or road for a year divided by 365 days.

	Observed AADT	Observed % HGV	Modelled AADT	Modelled % HGV
Scheme 11 - A1(M) junction 53 Scotch Corner	-	-	19,479	23.4%
Average	-	-	20,041	22.5%

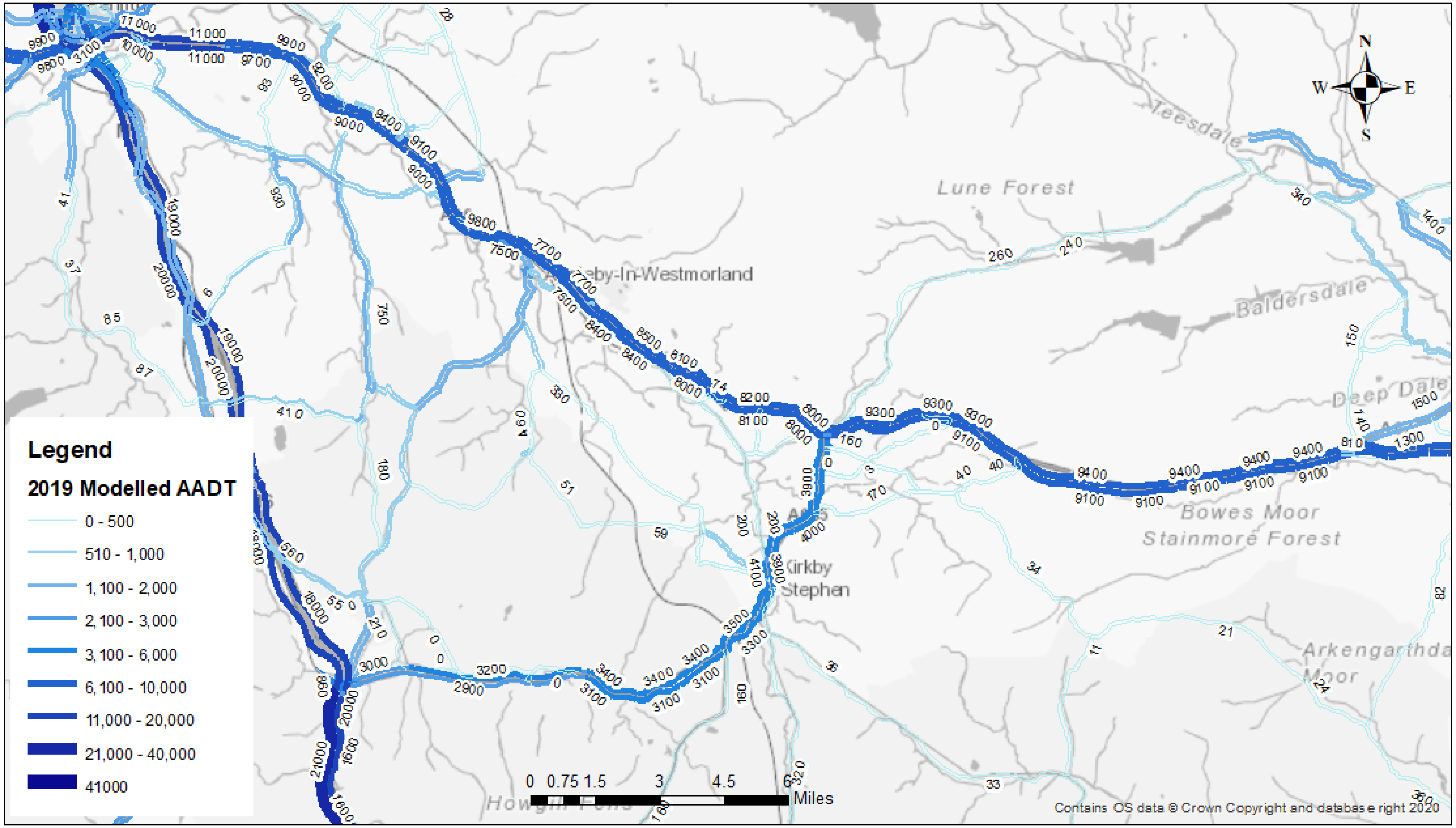

Figure 2-2: 2019 modelled AADT across A66 – Penrith to Bowes

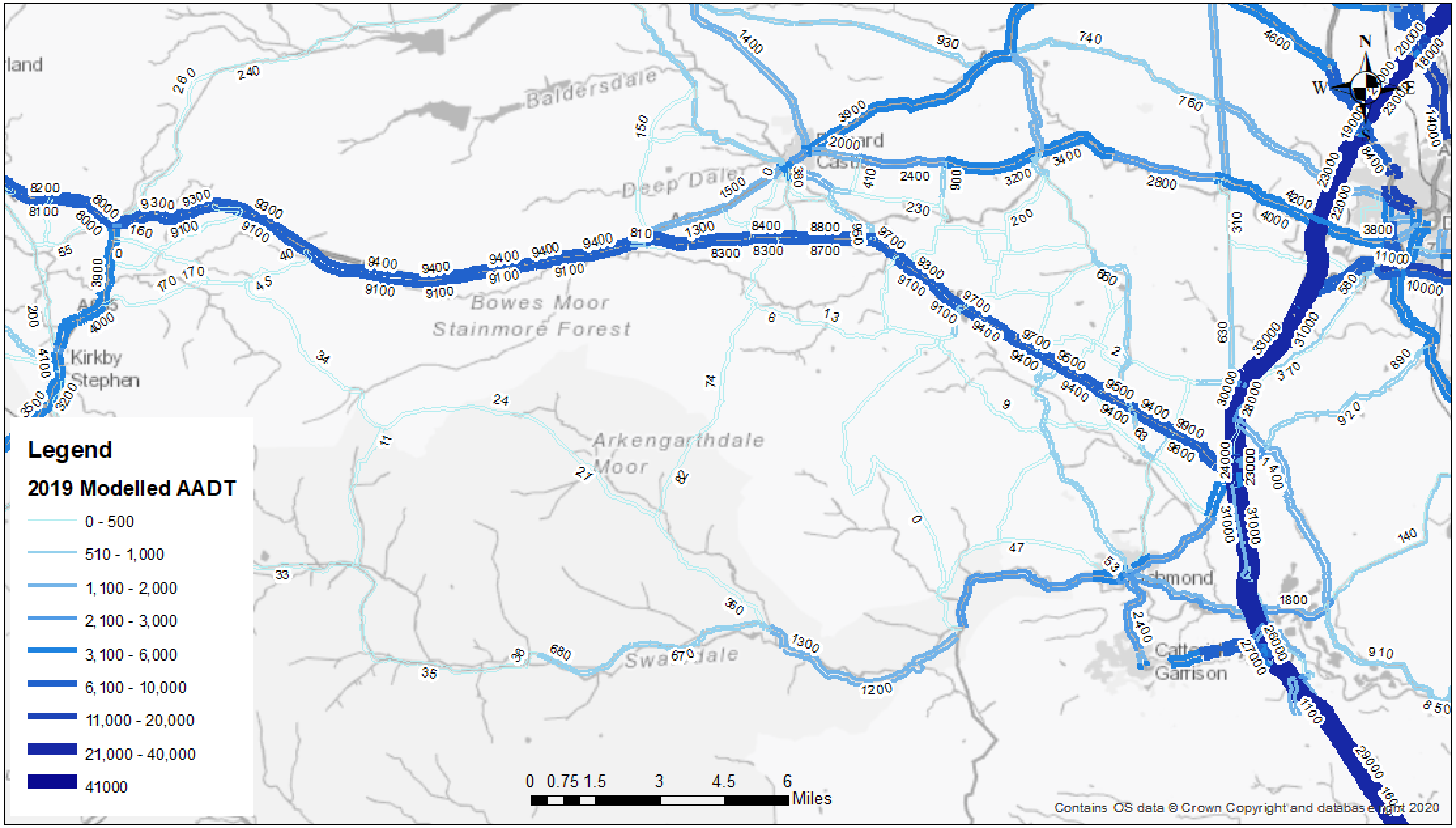

Figure 2-3: 2019 modelled AADT across A66 - Brough to Scotch Corner

2.2.3 Monthly flow profiles of weekday traffic in 2019 is shown at 3 locations along the A66 route as follows:

- Between Kemplay Bank and M6 J40 at the western end of the A66 (Figure 2-4)
- Near Appleby towards the central section of the A66 (Figure 2-5)
- East of Bowes at the eastern end of the A66 (Figure 2-6).

2.2.4 The graphs show that the A66 is affected by seasonality with higher traffic flows during May, June and August on the rural sections near Appleby and east of Bowes, with lower flows during the winter months (for instance January and December). However between Kemplay Bank and Junction 40 the flow remains consistent throughout the year, although there is a noticeable decrease during the AM and PM peak periods in August, which reflects less commuting and school traffic occurring during traditional holiday times. At this location however traffic volumes are known to be particularly variable by day, as can be seen in Figure 2-7, which shows the variation in traffic flow by day for weekdays in 2019. The flows for Fridays are shown to peak from 13:00 onwards until 18:00. This pattern is reflected to a lesser extent on Mondays and is particularly influenced by leisure traffic heading to the Lake District and the North Pennines Area of Outstanding Natural Beauty (AONB) on a Friday afternoon / evening, and additionally by traffic going to and coming from Center Parcs on Monday and Friday afternoons.

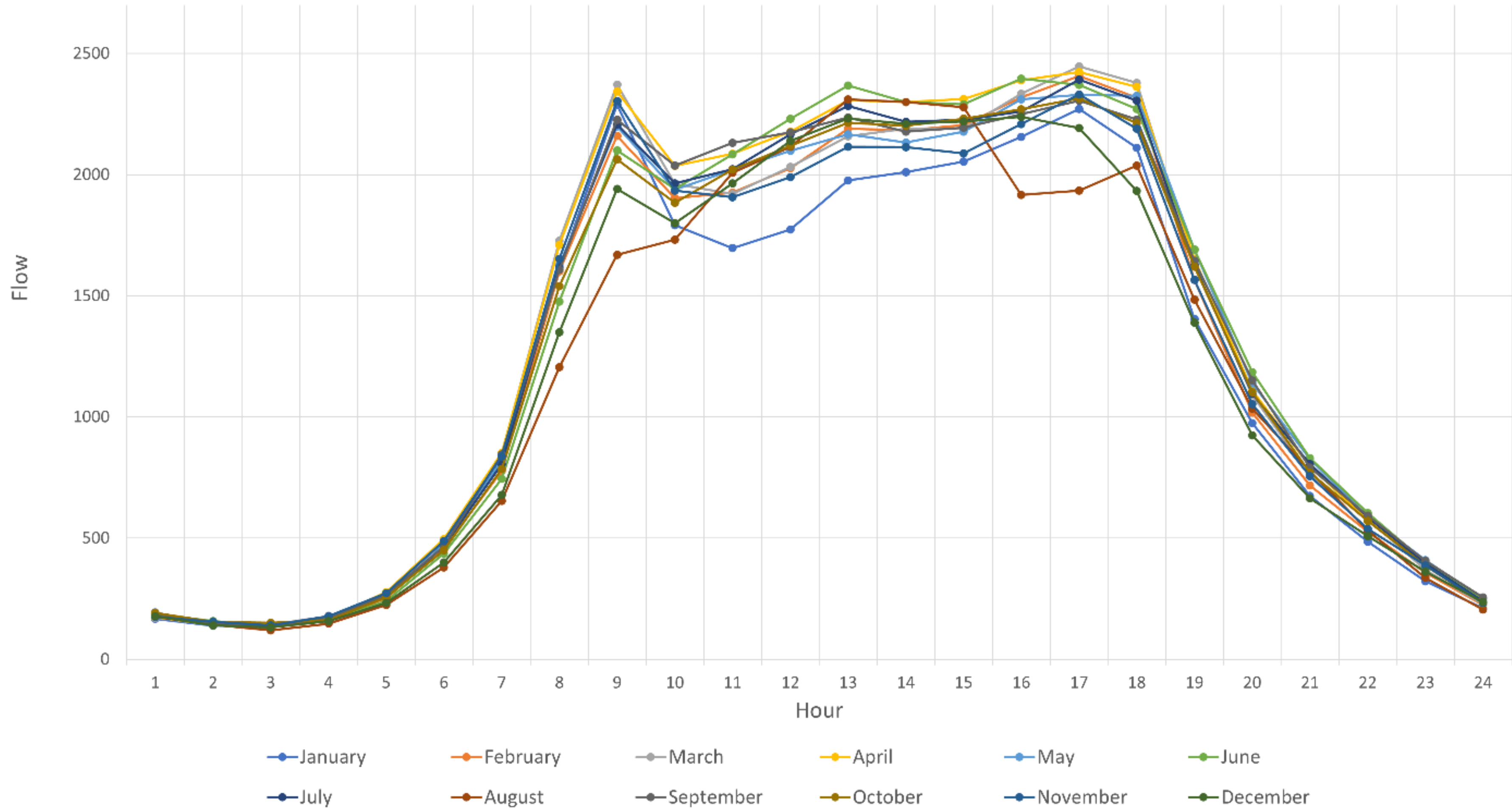

Figure 2-4: A66 Weekday Flow by Month between Kemplay Bank and M6 J40 (Two-way)

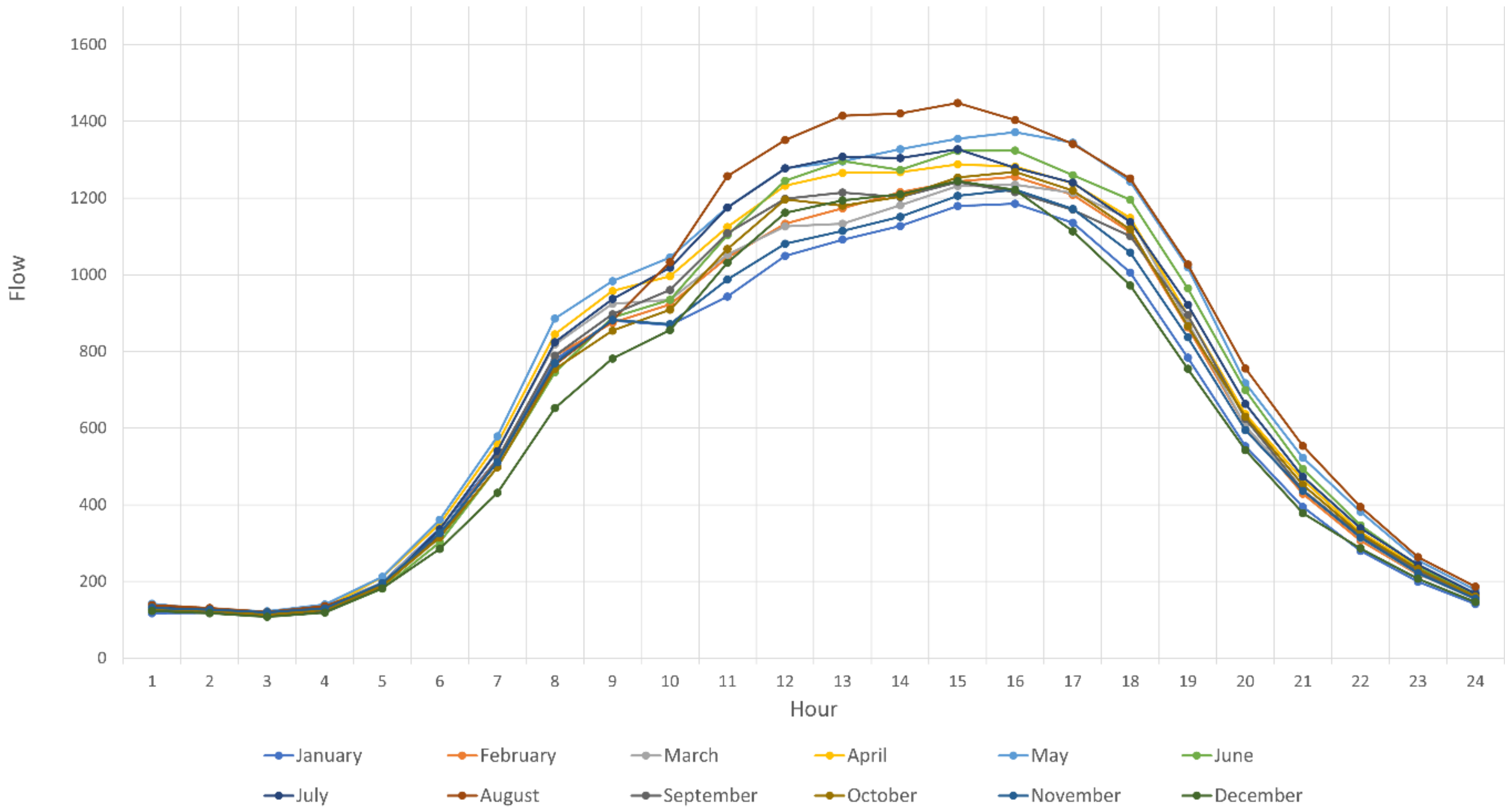

Figure 2-5: A66 Weekday Flow by Month at Appleby (Two-way)

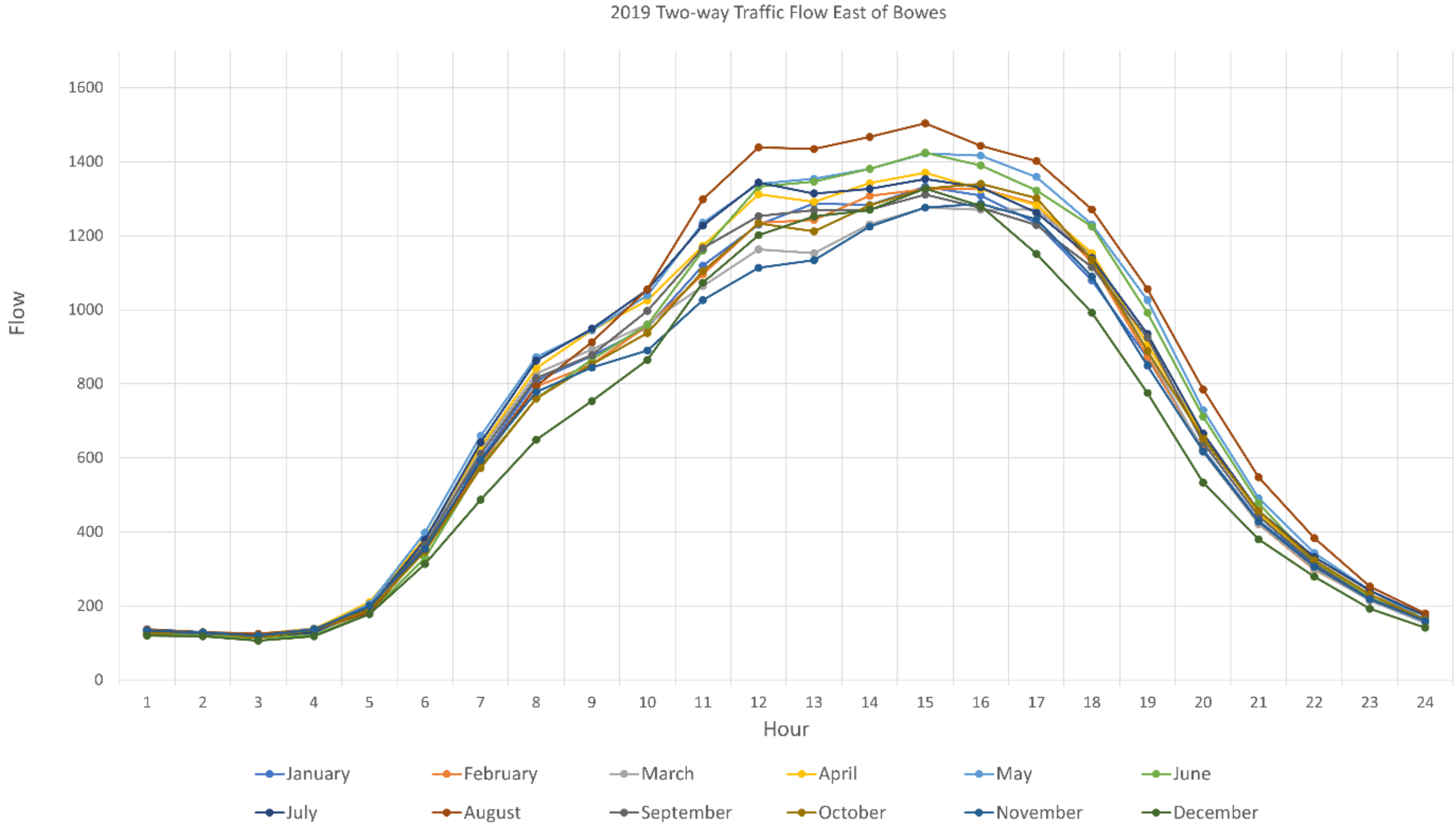

Figure 2-6: A66 Weekday Flow by Month east of Bowes (Two-way)

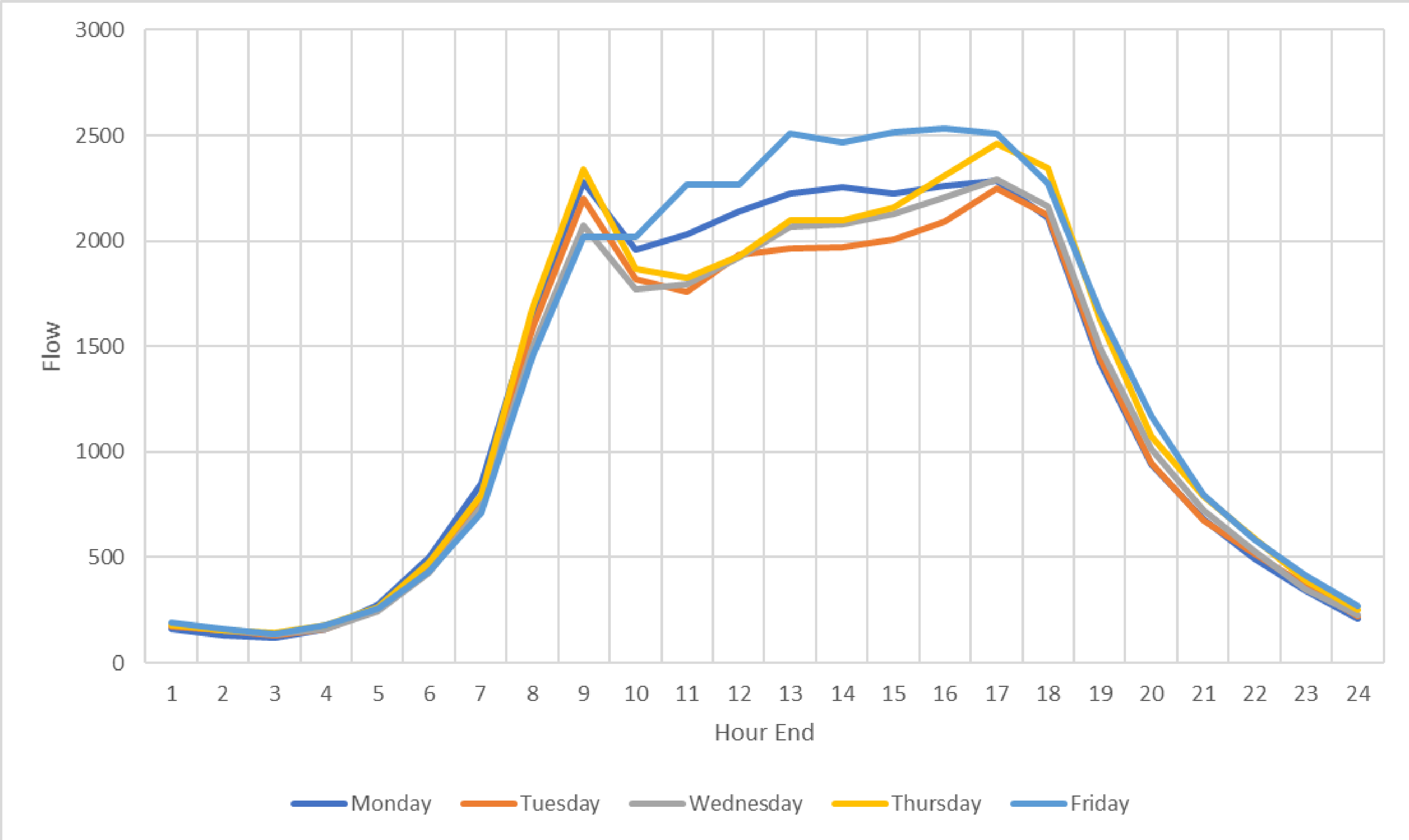

Figure 2-7: A66 2019 flow by weekday between Kemplay Bank and M6 J40 (Two-way)

2.3 Demand for travel

Route function

2.3.1 The A66 provides an important strategic, regional and local route connecting east and west coasts, providing a strategic link between north east England and south west Scotland, as well as providing local access.

A66 as a strategic route

2.3.2 The A66 is a Trans-Pennine link that is a key route through north-eastern England. The A66 connects England's west to east coast through the local authorities of Cumbria, North Yorkshire and County Durham.

2.3.3 While traffic flows are not particularly high along this route, the route faces significant safety and journey time reliability issues due to a combination of single and dual carriageway sections, poor legacy road designs, and mixed usage between cars, NMU and a high percentage of HGVs.

2.3.4 Traffic analysis of the A66 indicates that 56% of westbound traffic uses the A1(M), 49% of eastbound traffic comes from the M6/A74 (M) with only 20% of all the A66 traffic being forecast to start and end in Cumbria or Yorkshire and the North East. This highlights that traffic is using the A66 as part of a longer route, due to the A66 being one of only two east-west links across the country between the M62 in the south and Scotland in the north (the other being the A69).

2.3.5 The A66 is the most direct route between the Tees Valley, North Yorkshire, South Yorkshire, parts of West Yorkshire, the East Midlands, Eastern England and North Cumbria, Glasgow, and much of the central belt of Scotland and Cairnryan (via A75, for access to Northern Ireland and the Republic of Ireland).

2.3.6 For some key journeys, for example trips from the east and south east of England to the north west of England or Scotland, the A66 is by far the most direct and quickest route. For example, for a journey between Ferrybridge (A1/M62 junction) to Penrith (M6/A66 junction), via the A66 and A1(M), the distance is 172km (107mi) and average journey time is 1hr 56 minutes. However, via the M62 and M6 the distance is 235km (146mi) and average journey time is 2hr 34 minutes. The route, therefore, provides a significant opportunity to improve strategic network resilience as at present there is no continuous east-west dual carriageway Trans-Pennine crossing north of the M62.

2.3.7 There are no direct rail alternatives for passenger or freight movements along the A66 corridor and the bus service provision is very limited. This emphasises the reliance on the SRN for local, regional and strategic journeys.

2.3.8 The A1 Leeming to Barton improvement scheme, which upgraded the existing dual carriageway to three lane motorway standards up to the junction with the A66 at Scotch Corner, was completed in March 2018.

This made the A1/A66 route even more attractive as a strategic route, as well as providing enhanced alternative routes (for example to M6 or M62) during times of disruption or increased traffic.

A66 as a local and regional route

2.3.9 In addition to its strategic function, the A66 is an important link to local and regional services, employment and education opportunities for communities and towns along the route, as well as providing a commuter link to the Tees Valley and Cumbrian towns. This is particularly important given that there is very little public transport provision along the route, with no comparable rail route and very limited bus service provision.

2.3.10 Lower Super Output Areas (LSOA) with high income deprivation are located towards the east in areas such as Newcastle upon Tyne, Middlesbrough and Sunderland and are therefore outside of the A66 Project area. Improvement of the A66 will however, improve accessibility of these LSOAs to areas of employment, education and leisure activities.

2.3.11 Due to its rural nature, large areas of the A66 corridor lack access to key local services (for example, GP surgeries, primary schools and supermarkets). This indicates a dependency on effective highway links to access services, employment and education opportunities for economic growth. To emphasise this point, Gross Value Added (GVA) per head in the areas surrounding the A66 corridor are lower than the national average: £15,475 in County Durham, £22,629 in Eden and £18,237 in Richmondshire, compared to a UK average of £25,3513. This indicates relatively low levels of economic activity, requiring residents to commute over longer distances to access improved employment opportunities and a reliance on strong transport links to maintain the future wellbeing and sustainability of these communities. It also underlines the importance of the Project to support the economic growth objectives of the Northern Powerhouse and Government levelling up agenda.

2.3.12 The route is regularly used by slow moving agricultural vehicles. These can have a significant effect on journey times and reliability throughout the route. This is especially acute on the substandard section around Kemplay Bank Junction, where strategic traffic on the A66, traffic on the A6, local traffic around Penrith and agricultural traffic regularly come together to lock up the entire network.

2.3.13 The A66 is also a key route for abnormal loads, with around 60-70 convoy movements per year. The single carriageway sections and the sub-standard section around Kemplay Bank Junction significantly exacerbate the problems to other traffic due to these large vehicle movements. The A66 provides a key highway link to popular local and regional tourism destinations, though this leads to the route being affected by seasonal increases in traffic demand. High volumes of visitors are attracted to the route corridor and /surrounding region, specifically the North Pennines AONB, Yorkshire Dales National Park, Northumberland National Park and the Lake District National Park.

2.4 Transport problems

2.4.1 The main transport-related issues identified on the A66 within the study are:

- road safety
- journey times
- journey reliability and route resilience
- local severance

Road Safety

2.4.2 The A66 has average casualties[11] 50% higher than the average casualties across SRN [12]. Road traffic accidents are a major cause of incidents and closures on the route.

2.4.3 The A66 has a higher-than-average number of accidents in some sections of the route, with a number of accident cluster sites, as shown in Figure 2-8. A number of these sites are either located in single carriageway sections or in dual sections adjacent to single carriageway sections. Varying standards along the route with a mixture of single and dual carriageway sections leads to difficulties with overtaking, poor forward visibility, and difficulties at junctions as a result of short merges and diverges and right turning traffic off and on to the A66.

2.4.4 Between 2013 and 2019, there were 255 accidents which occurred along the route, equating to an average of 36 accidents per year. Of the 255 reported accidents, 74% resulted in slight injuries, 21% resulted in serious injuries and 5% resulted in fatality. Over the seven-year period, accidents which resulted in fatalities increased, with five fatal accidents in 2015, including three which involved head-on collisions at the Warcop bends and at Crackenthorpe. There were also three fatalities in both 2017 and 2018, see Table 2-2.

Table 2-2: Number of Accidents and Accident Severity by Year

Year	No. of Accidents			
	Fatal	**Serious**	**Slight**	**Grand Total**
2013	0	11	28	39
2014	0	7	36	43
2015	5	10	30	45
2016	1	5	26	32
2017	3	9	26	38
2018	3	7	31	41
2019	2	4	11	17
Grand Total	14	53	188	255

[11] Casualties per million vehicle kilometres travelled

[12] 29 casualties on average per hundred million vehicle miles on route compared to 19 casualties on average across SRN and 24 casualties on average across dual carriageway A-roads,

2.4.5 In some cases, accidents caused multiple casualties; the 255 accidents resulted in 466 casualties, of which 27 were fatal, 120 were serious and 319 were slight. The casualties' distribution by year is shown in Table 2-3. The highest casualties over a seven-year period was recorded in 2015 with 12 fatalities.

Table 2-3: Number of Casualties by Year

Year	No. of Casualties			
	Fatal	Serious	Slight	Grand Total
2013	0	27	39	66
2014	0	11	66	77
2015	12	22	51	85
2016	1	16	37	54
2017	5	17	36	58
2018	6	12	57	75
2019	3	15	33	51
Grand Total	27	120	319	466

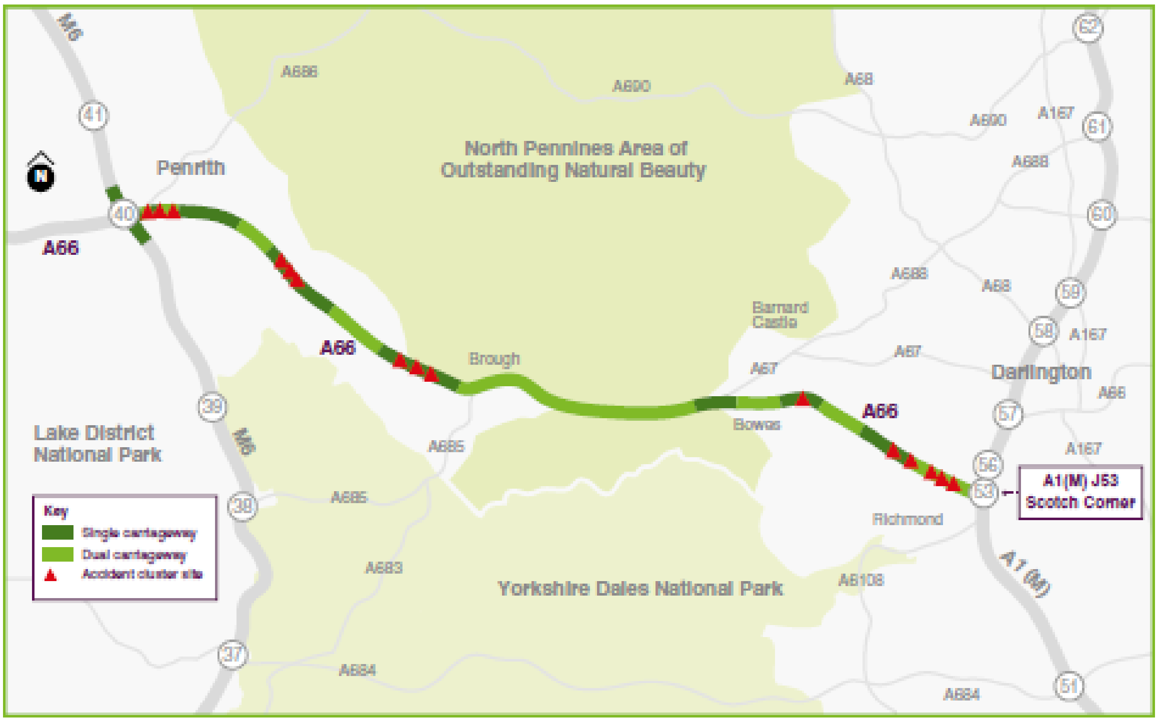

Figure 2-8: Accident Cluster Sites

2.4.6 Figure 2-8 shows a strong correlation between accident cluster sites and the remaining sections of single carriageway. Following investigations of sections of single carriageway with a poor safety record and as a precursor to a dualling scheme, a number of interim safety improvements have been introduced along the route, some of which have involved reductions in the speed limit, as described below:

- The speed limit through Kirkby Thore village is 40mph, with average speed enforcement cameras installed in 2016.
- A 50mph speed limit was introduced between Appleby and Brough in 2016.
- A scheme to provide a right turn lane at Llama Karma Kafe was completed in 2016, following a number of incidents involving eastbound vehicles waiting to turn right into the café.
- A safety improvement scheme has also been implemented at Ravensworth, which reduces the speed limit to 50mph in 2017.

2.4.7 Given the accident numbers occurring on the route between 2013 and 2019 it is difficult to state categorically if these small safety schemes have successfully impacted on the accident rate experienced on this route.

Journey Times and Journey Time Reliability

2.4.8 The A66 is not a highly congested route. However, journey times increase in peak periods and this is exacerbated by changing standards along the route from dual to single carriageway and vice versa. In addition to the changing standards, 40mph and 50mph speed limits have been adopted on some single carriageway sections.

2.4.9 To illustrate the impact on journey times, Teletrac Navman journey time data covering the whole of 2019 has been analysed. For the analysis, the route has been split according to the transitions between single and dual carriageway. Figure 2-9 displays the sections the route was split into for analysis, along with the respective codes for each section. Figure 2-10 displays the speed limits present along the route, representing the theoretical free-flow speeds currently achievable.

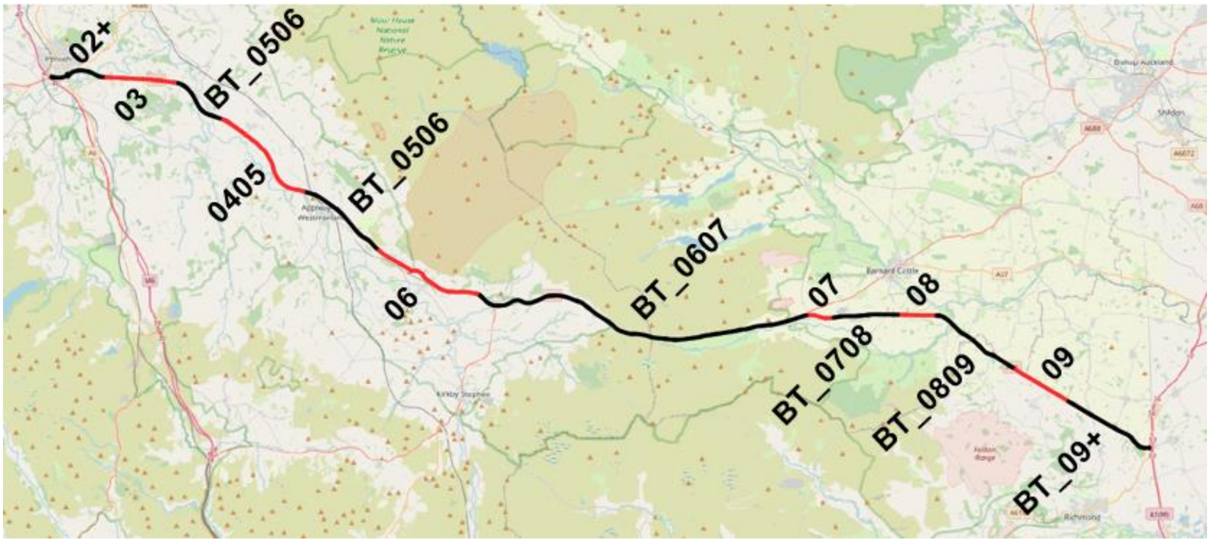

Figure 2-9: TeleTrac Navman analysis A66 Project sections (black – dual carriageway, red – single carriageway)

Figure 2-10: A66 Speed Limit Variation

2.4.10 Figure 2-11 displays the average daily speed per month for each section eastbound and westbound respectively on weekdays (Monday-Friday) between 07:00 and 19:00 for cars.

Scheme ID	January	February	March	April	May	June	July	August	September	October	November
A66_EB											
02+	37	37	37	35	34	35	34	33	32	32	36
03	52	53	53	50	51	50	50	49	52	52	52
BT_0304	69	70	70	67	66	68	68	63	67	66	66
0405	44	47	46	44	44	45	42	43	45	45	45
BT_0506	67	68	68	67	66	63	67	66	67	67	68
06	48	48	48	47	47	42	46	45	47	48	47
BT_0607	66	67	68	67	67	69	66	69	69	68	68
07	58	57	58	57	58	58	57	56	57	58	58
BT_0708	68	65	68	66	66	66	62	63	65	66	67
08	57	57	57	55	55	56	50	54	55	55	57
BT_0809	64	66	66	64	63	65	63	61	64	65	65
09	48	48	49	47	47	48	47	45	47	48	48
BT_09+	61	62	61	60	60	59	59	60	59	60	59
A66_WB											
02+	37	37	36	35	35	34	33	37	32	33	33
03	49	52	51	50	48	50	47	48	50	50	50
BT_0304	67	70	70	68	63	68	67	64	67	66	66
0405	46	46	46	45	45	44	43	45	45	43	46
BT_0506	65	69	67	68	67	65	66	67	64	66	66
06	49	49	49	50	49	44	49	48	49	49	48
BT_0607	66	67	66	68	67	66	66	67	67	67	67
07	55	54	55	55	54	55	53	53	53	53	54
BT_0708	62	63	63	64	63	64	60	63	62	62	64
08	52	51	51	49	51	51	45	49	49	52	51
BT_0809	65	66	66	66	65	66	64	63	65	65	66
09	48	47	48	45	45	46	45	44	46	47	48
BT_09+	58	60	59	57	56	58	55	57	56	57	60

Figure 2-11: Average daily speed (mph), Monday – Friday, 07:00 – 19:00, car only

2.4.11 The data shows that speeds are inconsistent across the entirety of the route throughout the year. Sections of the A66 which are dualled generally show speeds approximately 5mph slower than the speed limit. Single carriageway sections of the A66 consistently show higher levels of relative delay, with average speeds across most sections and months around 45-50mph. This represents a speed 10-15mph below the speed limit of a standard single carriageway trunk road (60mph) and 15-20mph below that observed on the dual sections. The repeated widening and narrowing of the road, along the fact that some sections of road do not match modern standards, can cause significant congestion and delay[13] due to lack of overtaking opportunities and slow-moving traffic. This slow-moving traffic is partly due to a high proportion of HGVs and the frequent use of the route by agricultural vehicles. Delay and congestion in addition to the average is also present in months containing bank holidays and school holidays.

2.4.12 Figure 2-12 displays the respective speeds for Fridays only.

Scheme ID	January	February	March	April	May	June	July	August	September	October	November	Decembe
A66_EB												
02+	39	36	33	29	29	30	31	27	26	28	27	34
03	50	51	51	47	46	45	48	45	48	48	46	49
BT_0304	70	70	68	68	68	70	71	60	70	68	65	67
0405	47	45	44	46	45	42	45	39	45	45	46	45
BT_0506	71	67	67	68	66	70	68	66	68	66	67	66
06	47	46	48	48	46	44	46	44	46	45	46	48
BT_0607	68	65	67	68	68	71	69	65	68	65	68	70
07	59	58	59	58	57	57	55	55	58	57	56	59
BT_0708	70	67	64	65	65	68	61	62	69	66	66	68
08	57	57	55	54	55	55	47	51	53	55	55	56
BT_0809	67	65	64	61	60	66	60	45	62	65	65	61
09	49	49	47	45	45	45	39	36	46	46	46	44
BT_09+	63	62	59	58	56	60	57	58	59	58	59	60
A66_WB												
02+	38	36	39	30	28	30	25	30	25	26	32	35
03	49	49	50	41	41	41	39	42	44	46	48	46
BT_0304	72	72	71	63	64	58	61	62	61	65	68	65
0405	45	46	44	43	43	39	42	42	44	45	46	45
BT_0506	69	68	70	71	66	66	69	66	69	67	68	68
06	49	48	48	50	47	43	47	47	47	47	48	48
BT_0607	68	66	67	67	66	66	69	66	68	68	68	68
07	54	54	53	53	52	49	50	51	51	52	53	54
BT_0708	64	64	63	63	63	62	63	63	64	63	64	66
08	51	51	50	46	46	48	41	46	49	46	51	49
BT_0809	67	67	66	64	62	65	61	64	63	59	66	66
09	49	44	45	40	38	38	31	35	39	40	43	41
BT_09+	59	58	57	45	45	42	31	37	49	44	54	54

Figure 2-12: Average speed (mph), Fridays, 07:00 – 19:00, car only

2.4.13 Speeds on a Friday show significant deterioration toward the eastern and western ends of the project, associated with delays at Kemplay Bank (scheme 02+), and at scheme 03, associated with the additional traffic to and from Center Parcs and on scheme 09. Site observations suggest delays in this location are caused by traffic attempting to access the Mainsgill Farm shop car park. Eastbound delays can be caused by traffic queueing within the carriageway waiting for a gap in the oncoming traffic to turn right into the car park. In the westbound direction, delays are also apparent, as individual vehicles slow to turn into the car park, any vehicles following also slow down. The overall slowing of westbound traffic at this location creates further difficulties for traffic wishing to merge in turn accessing the single carriageway from the dual carriageway section (to the west of the Warrener Lane Junction). The

[13] To evidence how the varying standard of the A66 route and lack of diversionary routes affect journey time variability due to major incidents, various National Highways datasets have been identified and analysed. To assist in the assessment of road closures resulting from accident incidents, Stats 19 and National Incident Liaison Officer (NILO) data was used. Network Occupancy Management System (NOMS) data was used for the assessment of maintenance closures. Command and Control data was used for the assessment of accident, maintenance and weather-related closures. In addition to this 2018 TrafficMaster journey time data was used to calculate the standard deviation of journey time for the single and dual carriageway sections.

resultant queue then impacts speeds on the upstream dual carriageway section (BT_09+). Though speeds are reduced throughout the year, the reduction is particularly acute April – August, with particular focus on the July-August school summer holidays.

2.4.14 Figure 2-13 focuses upon Fridays identified as being bank holidays or school holidays.

Scheme ID	January	February	April	May	July	August	November	December
A66_EB								
02+	39	32	31	17	35	27	22	36
03	48	50	48	38	47	45	44	50
BT_0304	70	68	67	72	71	60	67	72
0405	45	45	46	44	47	39	42	46
BT_0506	72	70	68	70	69	66	69	72
06	48	44	47	39	48	44	46	48
BT_0607	68	65	68	70	64	65	71	72
07	60	57	60	55	53	55	57	57
BT_0708	70	62	65	65	55	62	68	67
08	57	58	54	52	43	51	44	54
BT_0809	68	63	58	48	40	45	62	54
09	49	47	43	42	35	36	37	38
BT_09+	64	65	56	58	53	58	55	59
A66_WB								
02+	38	34	26	24	21	30	38	35
03	52	48	33	35	37	42	49	41
BT_0304	70	74	56	70	60	62	68	60
0405	45	44	44	45	43	42	46	40
BT_0506	69	71	70	57	71	66	71	69
06	50	47	49	43	49	47	51	48
BT_0607	70	71	67	62	69	66	69	69
07	58	54	53	51	49	51	54	52
BT_0708	67	67	62	57	62	63	66	68
08	52	51	45	46	39	46	51	43
BT_0809	70	70	62	62	62	64	67	68
09	50	43	36	36	27	35	45	30
BT_09+	61	56	34	41	30	37	34	38

Figure 2-13: Average speed (mph), Fridays (bank holidays / school holidays), 07:00 – 19:00, car only

2.4.15 Again, average speeds during bank/school holiday Fridays show even greater levels of speed reductions, with average speeds as low as 21mph experienced at Kemplay Bank eastbound and 27 mph westbound at Mainsgill Farm in July.

2.4.16 The 40mph and 50mph speed limits highlighted Figure 2-10 have been adopted on single carriageway sections as a result of safety concerns and local severance problems. The high percentage of HGVs (22.5% compared to the national average of 12%), the variation of speed limit, the variation in road standards and geometry along the route, the increased demand experienced during bank / school holidays and the impact of local destinations along the route all result in slow-moving traffic, longer journey times and unreliable journeys - evidenced by the turbulent speeds along the route shown in Figure 2-11 – Figure 2-13.

2.4.17 Consistency of journey times during incidents has been identified by stakeholders and businesses[14] as a major issue for the A66 between Penrith and Scotch Corner. Due to the varying standard of the route and lack of suitable diversionary routes, the route's ability to maintain smooth traffic flow during periods of disruption such as road traffic accidents and severe weather events is poor. The high elevation of the route at Bowes Moor and Stainmore and severe weather events are common in this area, making the route particularly vulnerable to accidents.

2.4.18 The ability to keep the route open during accidents, incidents and other disruptions is significantly affected by the existence of the single carriageway sections. Generally, traffic movements can be better managed when incidents happen on dual carriageway sections. This is because:

- Where only one lane is affected by the incident, traffic can continue to flow on the second lane
- Emergency services can access and clear the incident more quickly

2.4.19 The central reserve prevents traffic flow in the opposite direction from being affected. If necessary, HGVs have enough space to turn around and take a different route.

Local Severance

2.4.20 There are local severance issues where the local road network intersects with the A66 carriageway, causing delays and road safety issues, such as in Kirkby Thore.

2.4.21 The majority of communities along the route have had bypasses built through previous interventions. Kirkby Thore, which has a population of 758[15], is the only remaining settlement along the A66 without a bypass. The A66 passes directly through part of the village, causing issues of noise and severance, especially due to the high proportion of HGV traffic.

2.4.22 There are also issues of severance for walkers, cyclists and horse-riders (WCHs) who wish to cross over the A66, with poor crossing provision in some areas. These are discussed further in the **2.4 Walking, Cycling and Horse Riding Proposals** which also forms part of the Application.

2.4.23 The A66 also causes ecological severance, with the existing route acting as a barrier to existing habitats, and the A66 project provides opportunities to enhance connectivity and provide habitats of greater ecological value than those that are lost, for example by altered

[14] 20 Local Business and Stakeholders were interviewed in 2019 in relation to the improvements proposed by the Project. The majority of businesses interviewed raised concerns that there were few or no appropriate diversion routes from the A66 if there was an incident. Businesses found that diversion routes were very congested and could take hours to navigate. Some of the companies spoken to were concerned that both light and heavy vehicles were using inappropriate country lanes through villages as diversions, causing further delays for local traffic. In total 75% of the businesses surveyed cited issues surrounding resilience on the A66. Businesses and stakeholders included, Aggregate Industries, British Gypsum, Centre Parcs, PD Ports, Tees Valley Combined Authority and Teesside International Airport

[15] UK Census (2011). "Local Area Report – Kirkby Thore Parish (E04002545)". *Nomis*. Office for National Statistics..

management of retained habitat or providing treelines and hedgerows to provide safe commuting routes for wildlife. This is discussed further within the **3.2 Environmental Statement Chapter 6 Biodiversity**.

Businesses, Freight and Port Operators

2.4.24 The A66 is an important route for freight traffic, with HGVs comprising on average 22.5% of total vehicles on the route between Scotch Corner and Penrith, with select sections seeing 29% of total vehicle traffic as freight movements. The typical proportion of HGVs expected (as a proportion of AADT) is 12% on trunk roads and 8% on principal roads.

2.4.25 In the event of a closure on the A66, there are limited diversion routes and this leads to delays, longer journey distances and longer journey times. Depending upon the location of the closure, this can be particularly problematic, for instance, for a closure of the A66 between Scotch Corner and Bowes – journey distance 24km (15miles), the diversion route follows the A1(M), A66(M) and the A67, and is 43km (27miles) in length. This route has 30mph speed restrictions through Darlington, weight restrictions at Barnard Castle and is unsuitable for abnormal loads due to the width of the road. In the event of a closure between Penrith and Brough – journey distance of 34km (21miles), the diversion route follows the M6 and A685, and is 53km (33miles) in length. This route has a speed limit of 30mph through Kirkby Stephen and 40mph through Brough, and vehicles weighing in excess of 18 tonnes are restricted from using the A685 between Brough and Kirkby Stephen, with the exception of access, permit holders or vehicles moving livestock.

2.4.26 In the event of a full route closure, or due to weight restrictions, the diversion route for heavy goods vehicles is significantly longer than the direct distance of 80km (50miles) as it uses the A1(M), the A69 and the M6 and has a length of 184km (115miles). Freight traffic will often use the diversion route if delays are likely to be long term, but sometimes will remain on the A66 waiting for the traffic to clear, either because they cannot physically turn back due to lack of turning facilities, or the driver does not have the required driving hours left to reach the nearest truck stop or rest location. Due to weight restrictions and height restrictions on highways structures, and also the proximity of buildings to the carriageway, it is not feasible to enable HGV traffic to use the shorter diversion routes.

2.4.27 These diversion routes and their impacts in terms of travel distance are summarised in Table 2-4 and shown in Figure 2-14 and Figure 2-15.

2.4.28 In light of the above, it is clear that freight and transport businesses will benefit from improvements to journey time reliability across the A66 and coupled with additional capacity on the carriageway, the Project is likely to enhance the ability of local businesses to transport their goods efficiently. For instance, the A66 is on a key route between the ports of Teesport, Grimsby and Immingham to north west England and Scotland. Teesport accounts for 28.4 million tonnes of cargo, and Grimsby and Immingham for 54 million tonnes of cargo, showing the importance of transport improvements to the freight industry in the region.

Table 2-4: Diversion Routes

Route	Direct distance	Approximate Diversion distance	Distance change	Notes
Scotch Corner – Bowes	24km (15mi)	43km (27mi)	80% increase	30mph through Darlington. Weight restrictions at Barnard Castle Unsuitable for abnormal loads
Penrith – Brough	34km (21mi)	53km (33mi)	57% increase	30mph through Kirkby Stephen 40mph through Brough. Weight restrictions on A685
Scotch Corner – Penrith	80km (50mi)	184km (115mi)	130% increase	

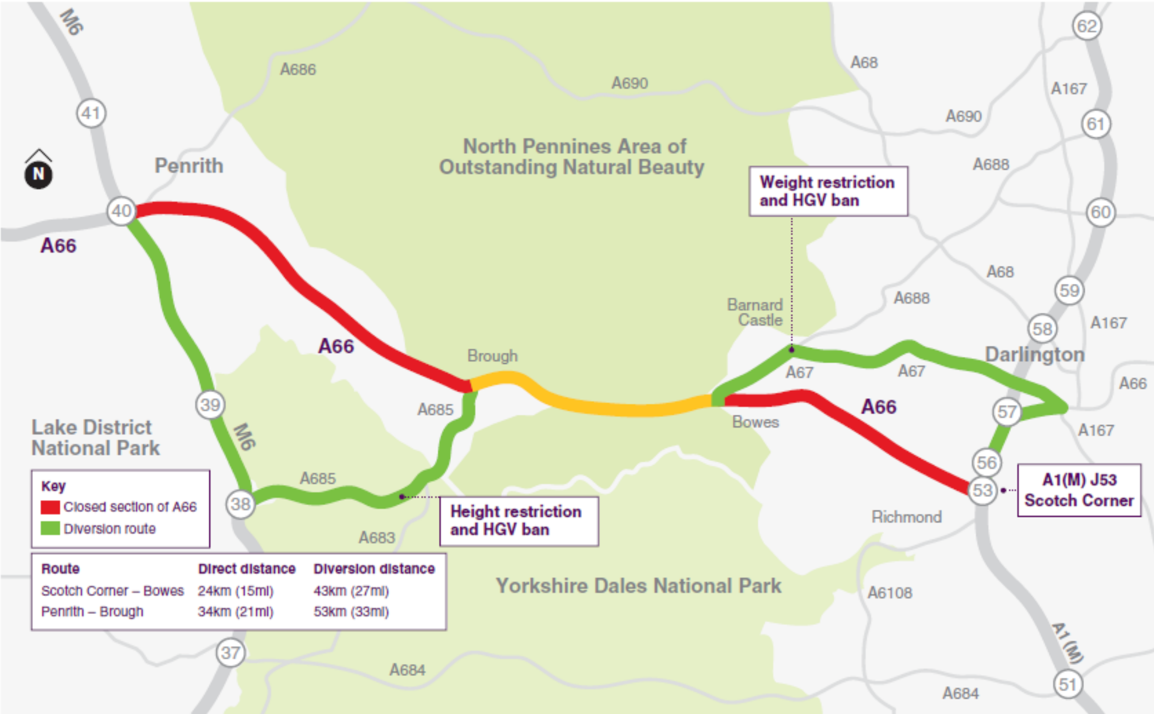

Figure 2-14: Local Diversion Routes

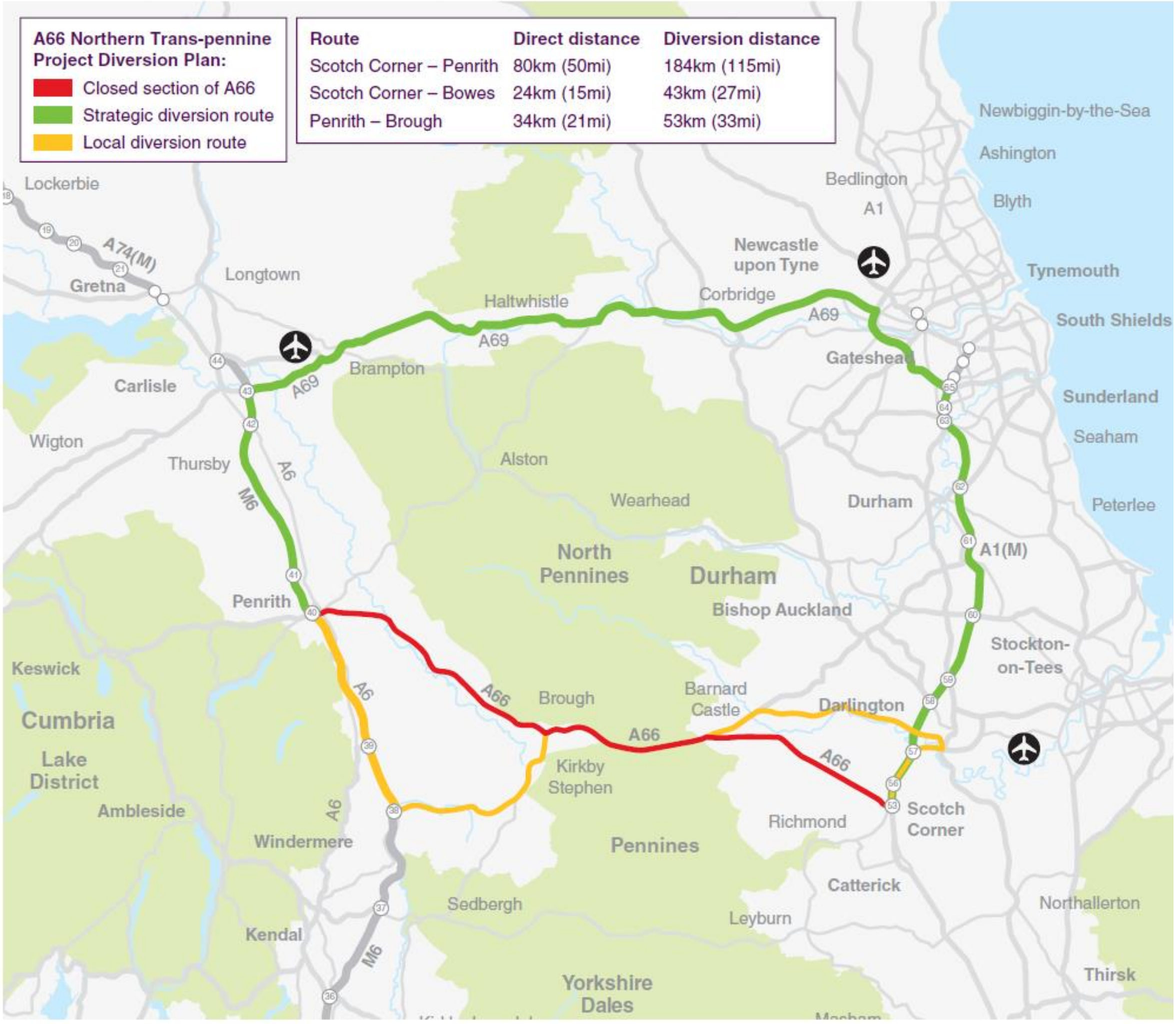

Figure 2-15: Long distance diversion routes

3 Data Sources

3.1 Introduction

3.1.1 The transport model built to support the DCO application is known as the A66TM (A66 Traffic Model). Initial model development undertaken in the earlier stages of this study, namely PCF (Project Control Framework[16]) Stages 1 and 2, was based upon the North Regional Traffic Model (NRTM). The traffic model has since been updated in PCF Stage 3, using data available via the development of the second-generation Regional Traffic Models (RTM2). The RTM2 are discussed in Section 3.2 below.

3.1.2 The model is based on observed data. The process to collect data and to use this within the model has been undertaken in line with the DfT Transport Analysis Guidance (TAG) and agreed with National Highways' Transport Planning Group, and through consultation with Stakeholders. A discussion on the impact of Covid-19 on the ability to collect data is contained in Section 3.3, and explains why the latest data used within the model comes from 2019.

3.1.3 The following categories of data have been used to develop the model:

- Volumetric count data (traffic counts) – used to calibrate and validate the volume of traffic flows in the model
- Journey time – data, used to validate the model's representation of delay
- Demand data – used to build the model's matrices
- Mapping and network data - used to construct the model's network

3.1.4 This chapter details the data collected and its application within the model. A full description of the data collected is contained in Appendix B: Transport Data Package.

3.2 Second Generation Regional Traffic Models

3.2.1 National Highways uses its Regional Traffic Models (RTMs) to develop and appraise large-scale infrastructure projects to enhance the capacity of the English SRN in line with its licence conditions, as well as support its analytic capability in broader areas. These enhancements will provide better journeys for the country's travelling public.

3.2.2 The five second-generation models, covering the North, Trans-Pennine, Midlands, South East and South West regions, are amongst the largest and most complex traffic models of their kind in the world. They replicate travel patterns in 2019 and improve on the first-generation RTMs by extending detail within the models to support early scheme development and policy testing and have been developed to allow the forecasting of a

[16] The Project Control Framework (PCF) is the framework that was launched by the then Highways Agency (now National Highways and Department for Transport on 1st April 2008 to ensure that major improvement projects are delivered which meet customers' aspirations in a cost efficient and timely manner. The project lifecycle contains 8 stages, inclusive of stage 0. A project team typically has to go through these stages to successfully deliver the project. PCF stage 1 focuses on Options Identification, PCF2 on Option Selection, and PCF3 on Preliminary Design.

range of scenarios in a 'post-Covid-19 world'. This will allow NH to make decisions using a sound, up-to-date evidence base.

3.2.3 The updated, second-generation models have a clear set of high-level objectives, namely:

- To provide the basis for the development and appraisal of RIS2 and subsequent Road Investment Strategy (RIS) pipeline schemes. It is envisaged that the models will support the RIS schemes in two alternative ways:
  - PCF Stage 0 assessments, which will make use of the regional models 'as is'; or
  - PCF Stage 1-3 assessments, which will use the models as the foundation of more localised models to enable the required outputs to be generated.
- To ensure that a common approach is employed using common data sources and software to ensure consistent outcomes between regional models; and
- To support wider policy work and decision-making across National Highways, including such areas as air quality and wider economy modelling.

3.2.4 Technical consistency between the five regional models is key to delivery. In order to facilitate this and to assist and promote collaborative delivery, Technical Consistency Groups (TCG) were formed for each of the main modelling activities. These include:

- Data
- Network Coding
- Matrix Development
- Calibration and Validation
- Variable Demand Modelling and Forecasting
- End User

3.2.5 The role of each of the groups was to work collaboratively to consider ideas and proposals to ensure that all elements of that work stream are undertaken in a consistent manner and to try to reach a consensus on the best approach in agreement with the National Highways. National Highways Transport Planning Group (TPG) were informed of all discussions and decisions made by the group and were also able to raise issues arising on their models for discussion at a group level.

3.2.6 A simple example of the value that the TCGs added is in the development of the Regional Models Coding Manual that was developed by the Network Coding TCG. This manual was derived from a variety of different sources, following recognised best practice, and guidance where available. It provided a detailed advice on how to code the traffic model network (within the SATURN software) to ensure a consistent set of networks were developed across the country.

3.3 The impact of Covid-19 on traffic data collection

3.3.1 The A66TM base year is 2019, in line with the RTM2 models and representing the most recent year experiencing "normal" network conditions prior to the Covid-19 pandemic. Traffic data has not been collected from the end of March 2020 to October 2021, and from December 2021 to February 2022 in line with TAG guidance. TAG Unit M1.2[17] states that *"surveys should typically be carried out during a 'neutral', or representative, month avoiding main and local holiday periods, local school holidays and half terms, and other abnormal traffic periods."* Traffic conditions during the above-mentioned periods can be seen to be abnormal, as discussed below, due to the disruption caused by the Covid-19 pandemic.

3.3.2 Figure 3-1 below shows the variation on flow on the A66 and all of the SRN network within the North of England[18] between 2019 and 2021. The data has been compiled from all permanent Automatic Traffic Count (ATC) sites on the SRN that National Highways (NH) use to monitor traffic levels. The figure shows that between mid-March 2020 to the end of 2021 the variation in traffic flow has been considerable due to the disruption to peoples travel patterns caused by the restrictions imposed on peoples work, leisure and social patterns. The impact on different roads and different vehicles also differs by time, for instance:

- Traffic levels in 2019 follow a standard pattern, i.e. traffic levels drop in late December, and remain low throughout January and February. Traffic levels are high on the A66 during late July and August due to the high level of leisure trips associated with the holiday periods. However, traffic levels within all other months are relatively stable, and therefore data collected during these periods would be representative.
- However, in 2020, and 2021 traffic flow variation is very high, and is dependent upon the Covid-19 pandemic restrictions. When considering all traffic vehicles (cars, Light Goods Vehicles (LGVs) and HGVs), there is a greater decrease in traffic flow following the initial Covid-19 pandemic restrictions announced in March 2020 when compared with HGV only traffic.
- A66 traffic rebounds above the 2019 average during summer 2021 (all vehicles and HGVs only) whereas SRN traffic in northern England remains between 90% to 100% of the 2019 average.

3.3.3 The variability of this data by time of year, road, and by vehicle type illustrates why traffic data collected during this time would be considered to be abnormal. The abnormal traffic flows are representative of the abnormal traffic patterns being undertaken which means that any origin destination data collected would be unreliable. Travel time and congestion data would also not represent the travel conditions that would usually be experienced.

[17] Dft Transport Analysis Guidance Unit M1.2 Data Sources and Surveys
[18] The North of England in this instance refers to anything north of M6 Junction 16 and the M1 junction 30.

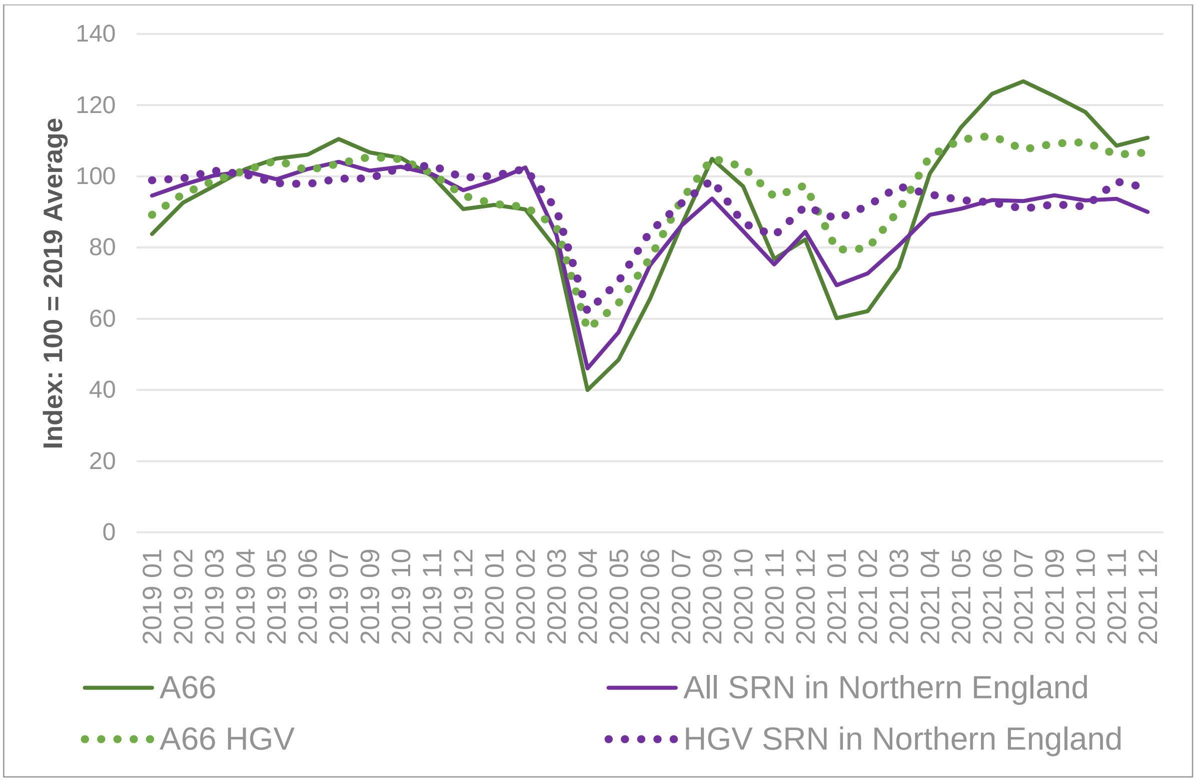

Figure 3-1: A66 and SRN Traffic Flow Volumes 2019-2021

3.4 Volumetric count data

3.4.1 This section first outlines the various sources of volumetric count data that was collected, then provides details on how it was rebased to a consistent time period and applied in the model. Data sources discussed in this section include WebTRIS (National Highways SRN counts), DfT data and local authority data from Durham, Cumbria and the North East Combined Authority. Additionally, survey data from RTM2 (undertaken in March 2020), A66 PCF Stages 1 and 2 as well as Teletrac Navman data are discussed in this section.

WebTRIS data

3.4.2 National Highways have an extensive set of permanent monitoring sites across the SRN which is accessed via the WebTRIS website. These measure the volume of traffic on the network and provide continuous output. This enables the derivation of robust seasonality profiles and hourly volumes at specific sites.

3.4.3 Data for March 2019 has been collected from the WebTRIS system. Figure 3-2 shows the WebTRIS counts within the A66 modelled area. The data was cleaned in the following manner:

- Removal of days with a single missing 15-minute time slice;
- Only sites with weekday data for at least 2 full weeks in March were used;
- Statistical tests such as Interquartile Range (IQR)/Median, IQR rule were applied on both Mon-Fri and Mon-Thu demand;
- 95% confidence level was calculated;
- Removal of erroneous Motorway Incident Detection and Automatic Signalling (MIDAS) sites (more than 30% variability from the mean was excluded);
- Vehicle segmentation was undertaken using WebTRIS (lengths) and light vehicles have been split into cars and LGVs using MCC data for 2016-2018.

3.4.4 A single count from 2018 on the M6 has also been used due to the lack of consistent 2019 WebTRIS data in this area. In this instance a number of checks have been made with available WebTRIS data from other sites (and other time periods) to ensure the synthesised count is reasonable.

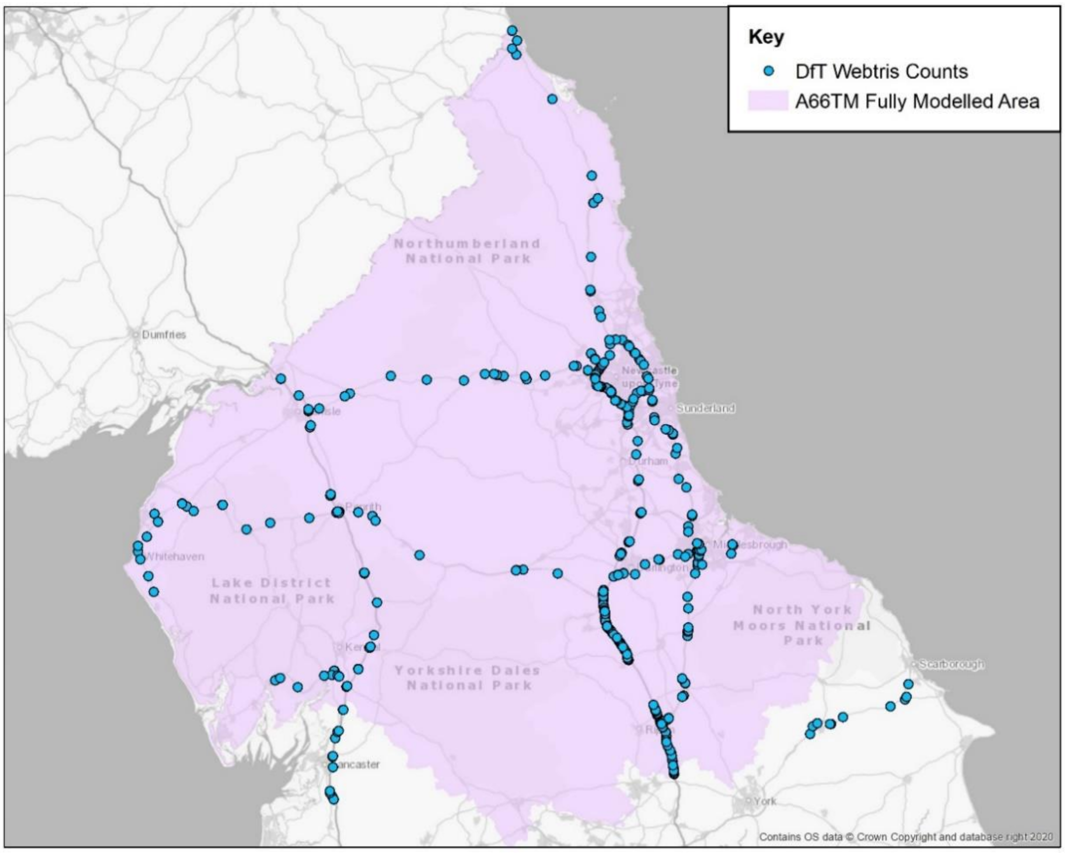

Figure 3-2: National Highways WebTRIS Counts

DfT ATC data

3.4.5 The DfT's road traffic statistics team have approximately 300 automatic traffic counters at locations on Great Britain's road network. The automatic traffic counters are permanent installations and record information including vehicle length and wheelbase, to classify vehicles. The locations are a stratified sample to provide sufficient observations so that in-year and year on year traffic variations can be estimated by road type and vehicle type.

3.4.6 The DfT ATC counts within the A66TM modelled area are shown in Figure 3-3.

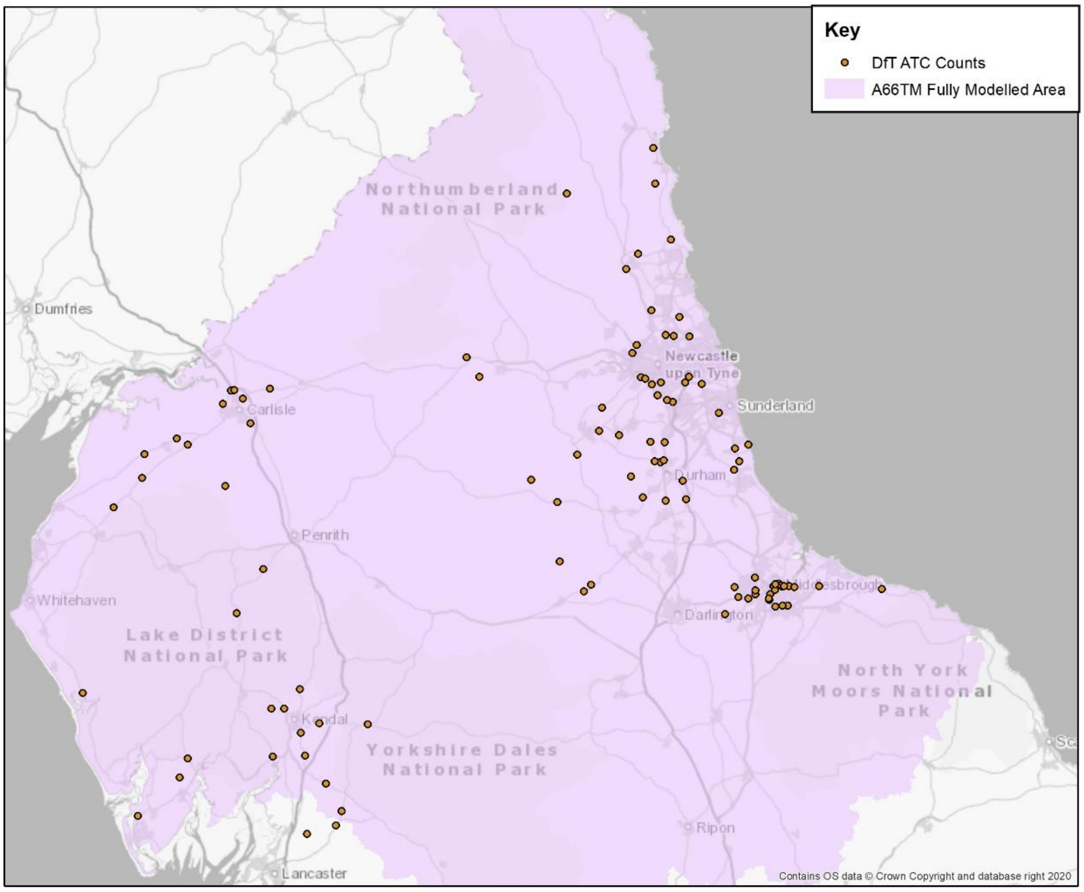

Figure 3-3: DfT ATC Count locations

Local Authority data collection

3.4.7 Additional data was sourced from Local Authorities to supplement data collated from other sources. Permission has been sought to use local authority traffic count data collected from Durham, Cumbria and the North East Combined Authority which includes Gateshead, Newcastle, Sunderland and Northumberland collected as part of the RTM2 data collection exercise. This is shown in shown in Figure 3-4 below.

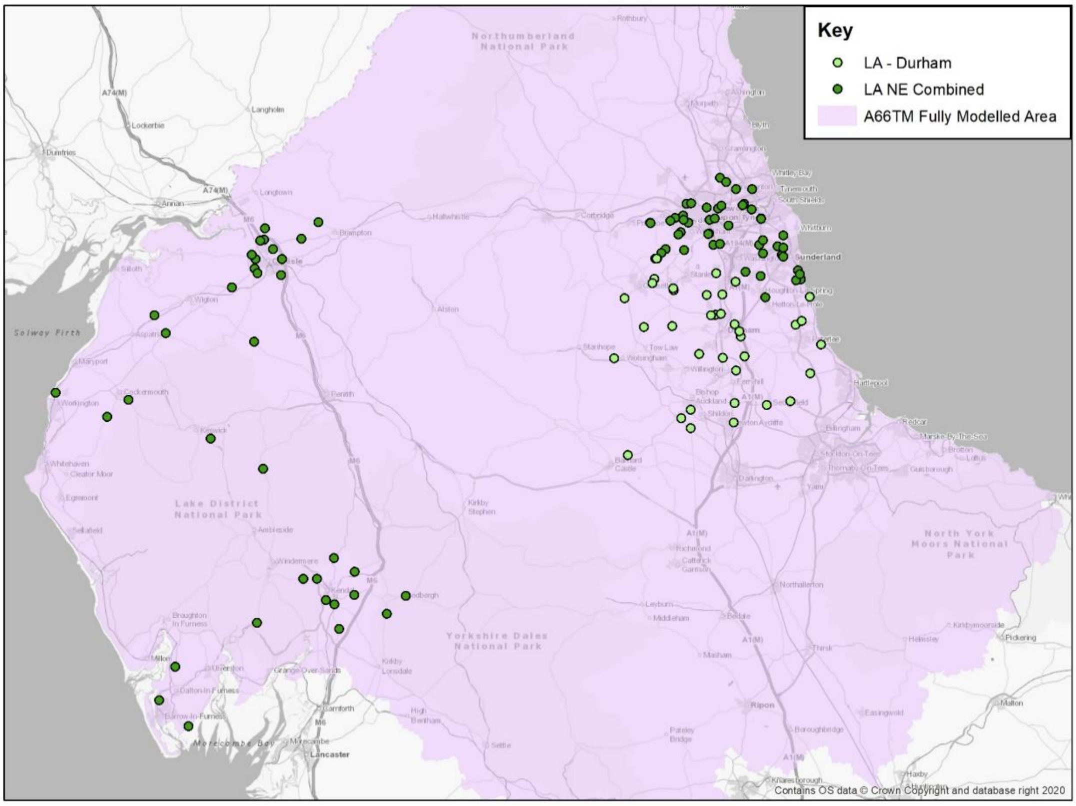

Figure 3-4: Local Authority data - Durham, Cumbria and NECA (Gateshead, Newcastle, Sunderland, Northumberland)

Cumbria County Council data

3.4.8 A number of additional traffic counts were available from Cumbria County Council due to data collections for the update to the Penrith traffic model, covering roads in and around Penrith in June 2018. These are shown in Figure 3-5 below.

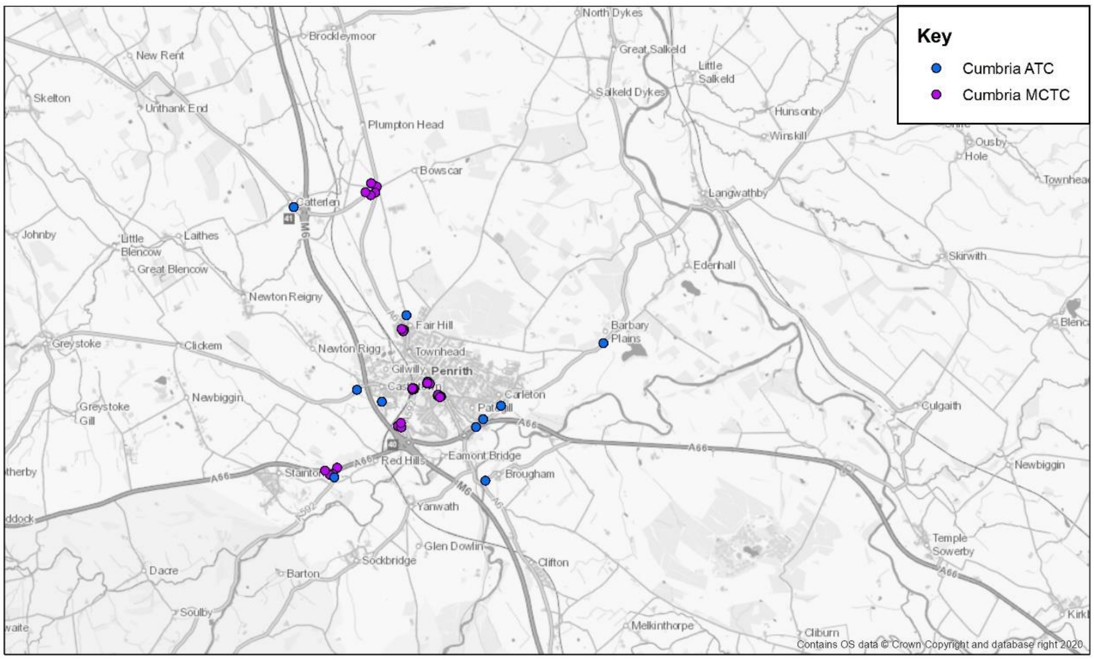

Figure 3-5: Cumbria ATC and MCTC

March 2020 traffic surveys

3.4.9 A data collection exercise was undertaken prior to Covid-19 pandemic lockdown in March 2020, by Nationwide Data Collection (NDC) and Advanced Traffic Research (ATR). The traffic count surveys were undertaken on non-SRN roads using ATCs and the sites within the A66TM modelled area are shown in Figure 3-6 below.

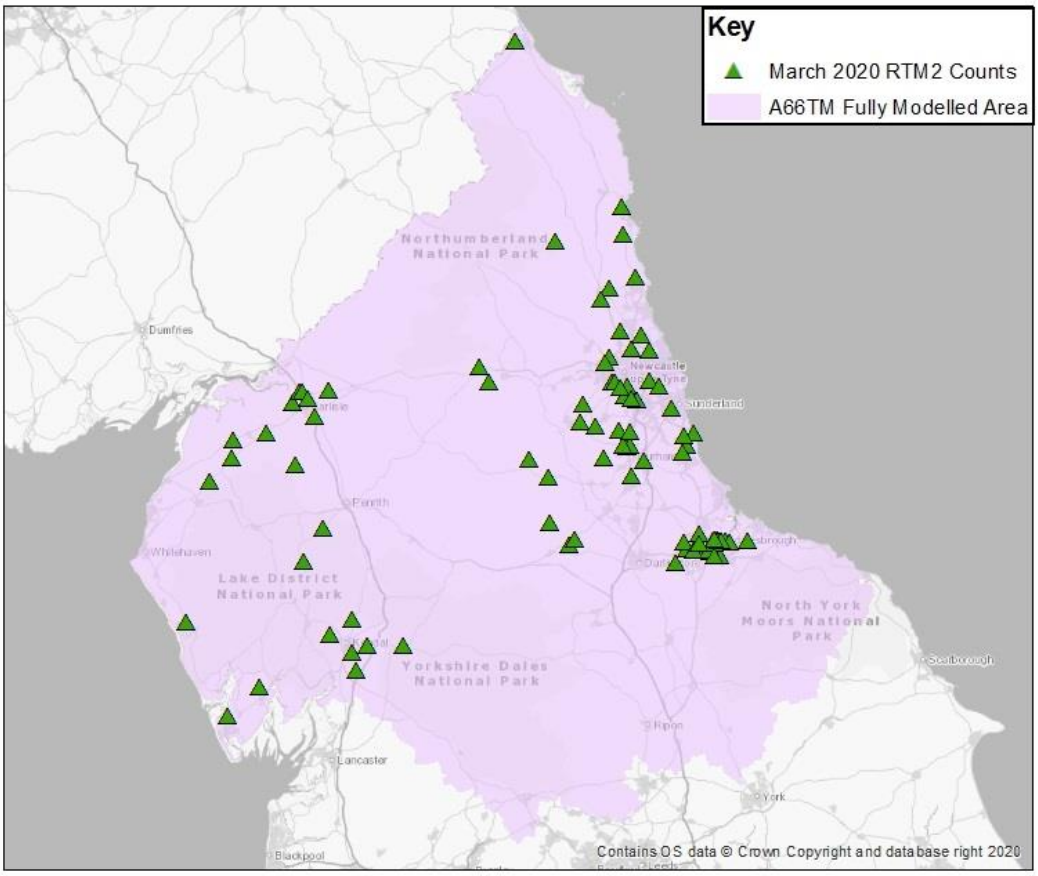

Figure 3-6: RTM2 March 2020 Traffic Survey locations

A66 PCF Stage 1 and 2 traffic count data

3.4.10 As part of the A66 PCF Stage 1 and 2 assessment work, traffic count surveys were undertaken during November and early December 2017 along the A66 corridor. November is classed as a neutral month in TAG Unit M1.2 – Data Sources and Surveys. December is not classed as a neutral month due to the Christmas Holiday period, however traffic conditions in early December can be considered to be normal as people remain in work, and the schools remain open.

3.4.11 The types of survey undertaken were:

- Automatic Traffic Counts (ATC) – 2 weeks duration, 24-hour coverage
- Manual Classified Link Counts (MCC) – 7 days duration, 24-hour coverage
- Manual Classified Turning Counts (MCTC) – 12 hours duration.

3.4.12 Each of the surveys undertaken provided data across the model time periods. The locations of these surveys and other new counts sourced is shown in Figure 3-7.

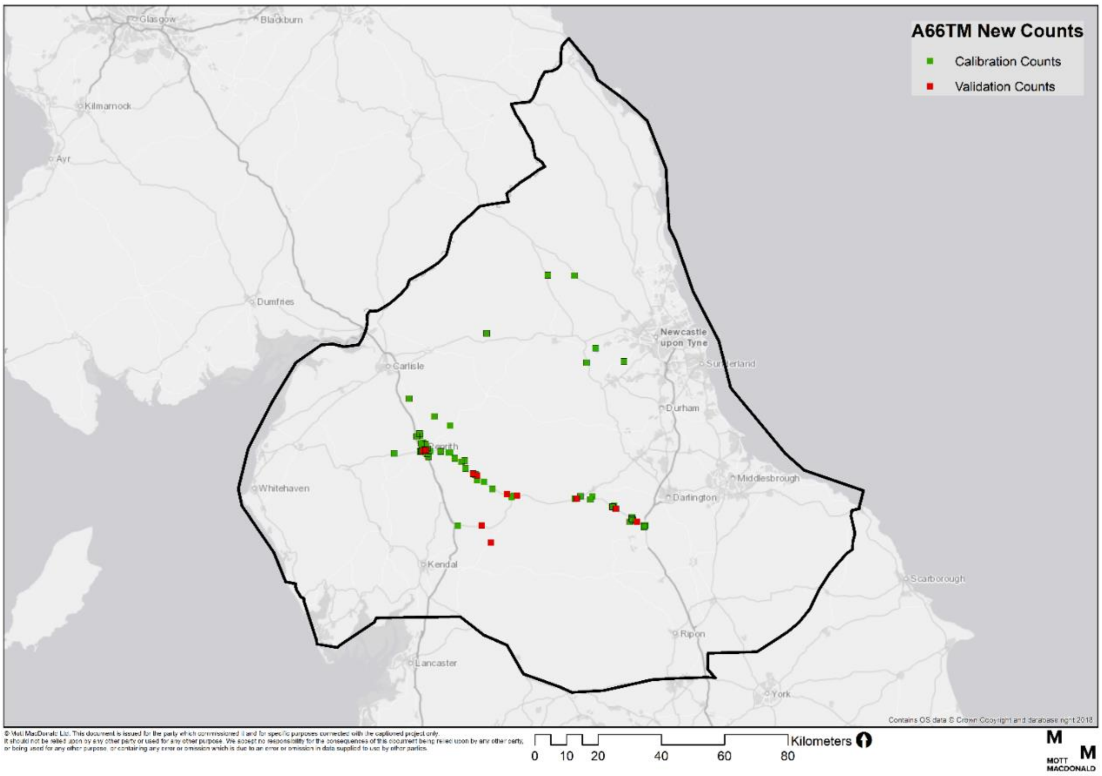

Figure 3-7: Stage 1 new traffic counts

Teletrac Navman data

3.4.13 Alternative approaches and data sources were explored to infill missing data. An approach identified was the innovative method of generating synthesised counts making use of the DfT Teletrac Navman dataset.

3.4.14 Teletrac Navman provide processed anonymised Global Positioning Service (GPS) data for the fleet of vehicles it operates - approximately 0.5% of all vehicles on the roads. By developing a relationship between Teletrac Navman data and known count locations, this relationship can be used to calculate traffic flows at location where the flow is not known.

3.4.15 Out of 475 count locations across the network, around 60 sites have been synthesised in this manner. In terms of the sites chosen for inclusion within the A66TM update all of the sites chosen are typically low flow sites (less than 400vph) and are mostly outside of the detailed model area. Checks of all Teletrac Navman counts have been made (against RTM1 counts) to ensure that the synthesis process is generating realistic counts. The location of the Teletrac Navman data points are shown in Figure 3-8.

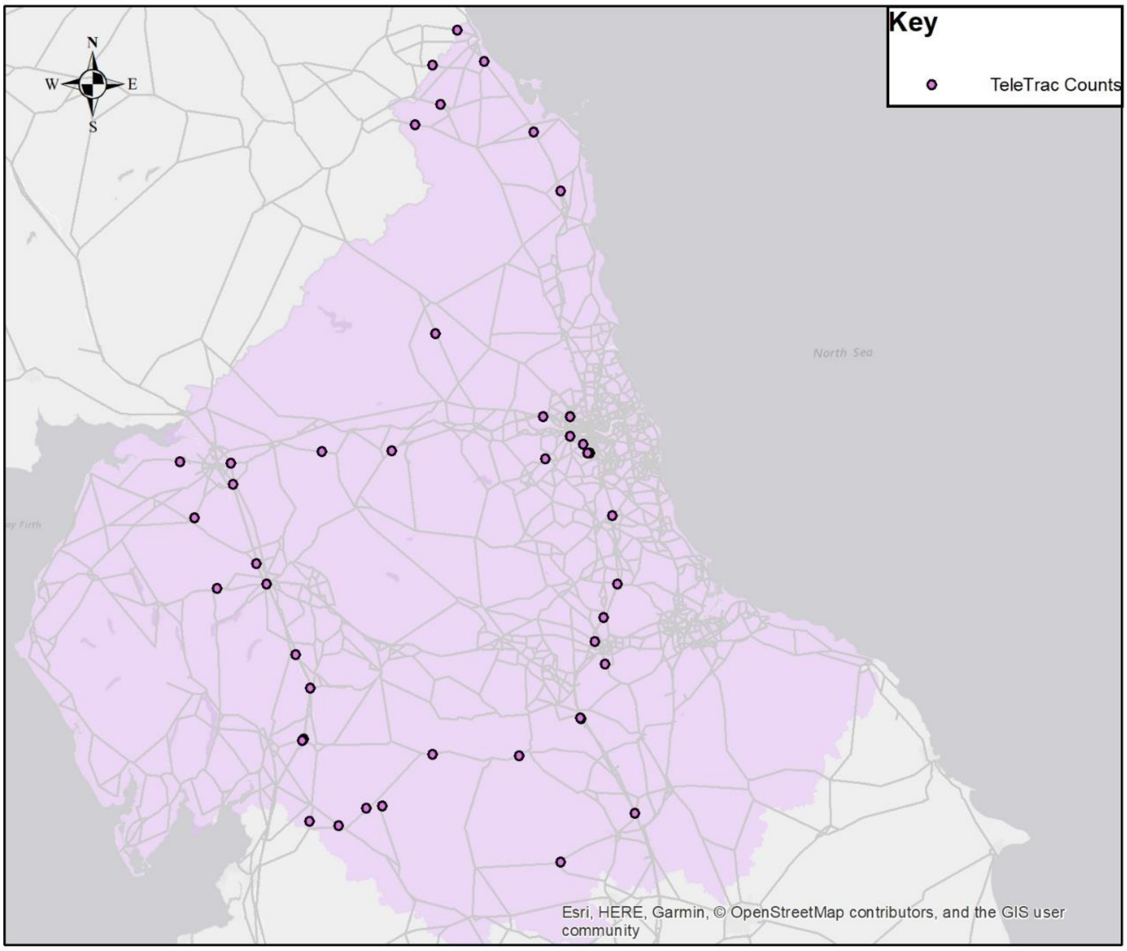

Figure 3-8: Teletrac Navman Count Locations

Rebasing of traffic count data to a common year / month

3.4.16 The A66TM represents average weekday (Monday to Friday) conditions in March 2019. Therefore, any data obtained outside of March 2019 has been rebased to March 2019 to provide a consistent dataset. The methodology for rebasing, was applied using the methodology developed within the development of RTM2, where factors were developed on a regional basis by road type. Table 3-1 shows annual rebasing adjustment factors adopted for the data within the A66TM for different road types, based on data from the NRTM detailed model area (the model upon with the A66TM is based). The adjustment factors for Motorways and Trunk roads appear to show greater growth on these roads compared to the local network.

Table 3-1. Motorway Annual Adjustment Factors by Year and RTM relative to 2019

Year	Motorway	Trunk Road	Principle Road	Minor Road
2015	1.08	1.11	1.03	1.03
2016	1.05	1.08	1.01	1.01
2017	1.03	1.06	0.99	0.99
2018	1.02	1.06	1.00	1.00
2019	1.00	1.00	1.00	1.00

3.4.17 Table 3-2 provides the monthly adjustment factors that have been applied for the respective road types. It is noticeable that the flow on Motorways and trunk roads are on average high between April and October.

Table 3-2. Trunk Motorway Roads Monthly Adjustment Factors by Month and RTM relative to March (aggregated over 2016-2019)

Minor	Motorway	Trunk Road	Principle Road	Minor Road
January	1.07	1.08	1.06	1.03
February	1.02	1.01	1.02	1.00
March	1.00	1.00	1.00	1.00
April	0.97	0.92	0.97	1.00
May	0.95	0.89	0.92	0.95
June	0.95	0.89	0.94	0.97
July	0.95	0.87	0.99	1.09
August	0.91	0.83	0.94	1.00
September	0.95	0.89	0.96	0.96
October	0.95	0.92	1.00	0.98
November	0.97	0.98	0.98	0.97
December	1.00	1.00	0.99	0.97

Volumetric count data priority

3.4.18 The review of the data sources, both observed volumetric data (for example, March 2020 surveys, Local Authority data, WebTRIS) and the interim data sources (for example DfT MCC, expanded Teletrac Navman data, RTM1 data), has identified relative strengths and weaknesses of these data sets. In line with the methodology applied for NRTM2, a set of criteria has been applied to select which counts to use.

3.4.19 For the SRN, WebTRIS data was to be used where possible with other data considered in line with that for non-SRN roads. For non-SRN roads, where viable datasets are available, an assumed hierarchy of counts based on the relative strengths of each data set has been used, whereby the counts higher up the hierarchy was used as a priority over counts further down:

- DfT ATC data;
- Local Authority data, High Speed Rail (HS2) data, or other volumetric data derived from other sources that pass the statistical reliability tests;
- March 2020 surveys that pass the statistical reliability tests;
- Local Authority data, HS2 data, or other volumetric data derived from other sources that fail the statistical reliability tests, but a ‘deeper dive’ indicates there is data that can be used (albeit of a lower quality);
- March 2020 surveys that fail the statistical reliability tests, but a ‘deeper dive’ indicates there is data that can be used (albeit of a lower quality);
- DfT MCC data;
- Teletrac Navman data; and finally
- RTM1 count data

Selected traffic data (screenlines and ad-hoc)

3.4.20 The selected traffic data for use in model calibration and validation are shown in Figure 3-9 and Figure 3-10. Figure 3-9 details the source of each traffic count used, with Figure 3-10 detailing whether the count is used in calibration or validation and whether it is located on a screenline is in an independent (ad-hoc) location.

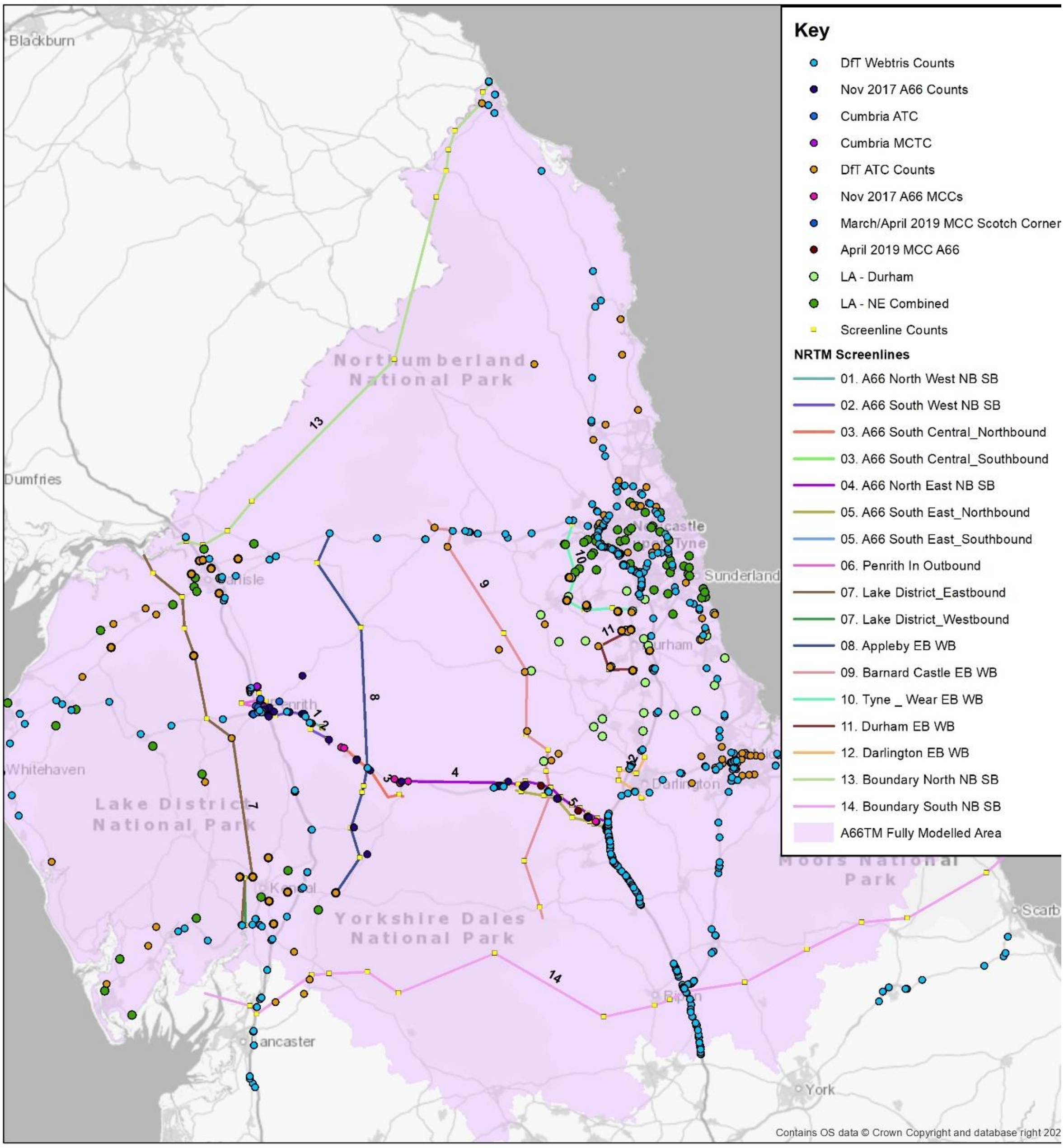

Figure 3-9: Processed Data and Screenlines for Calibration and Validation

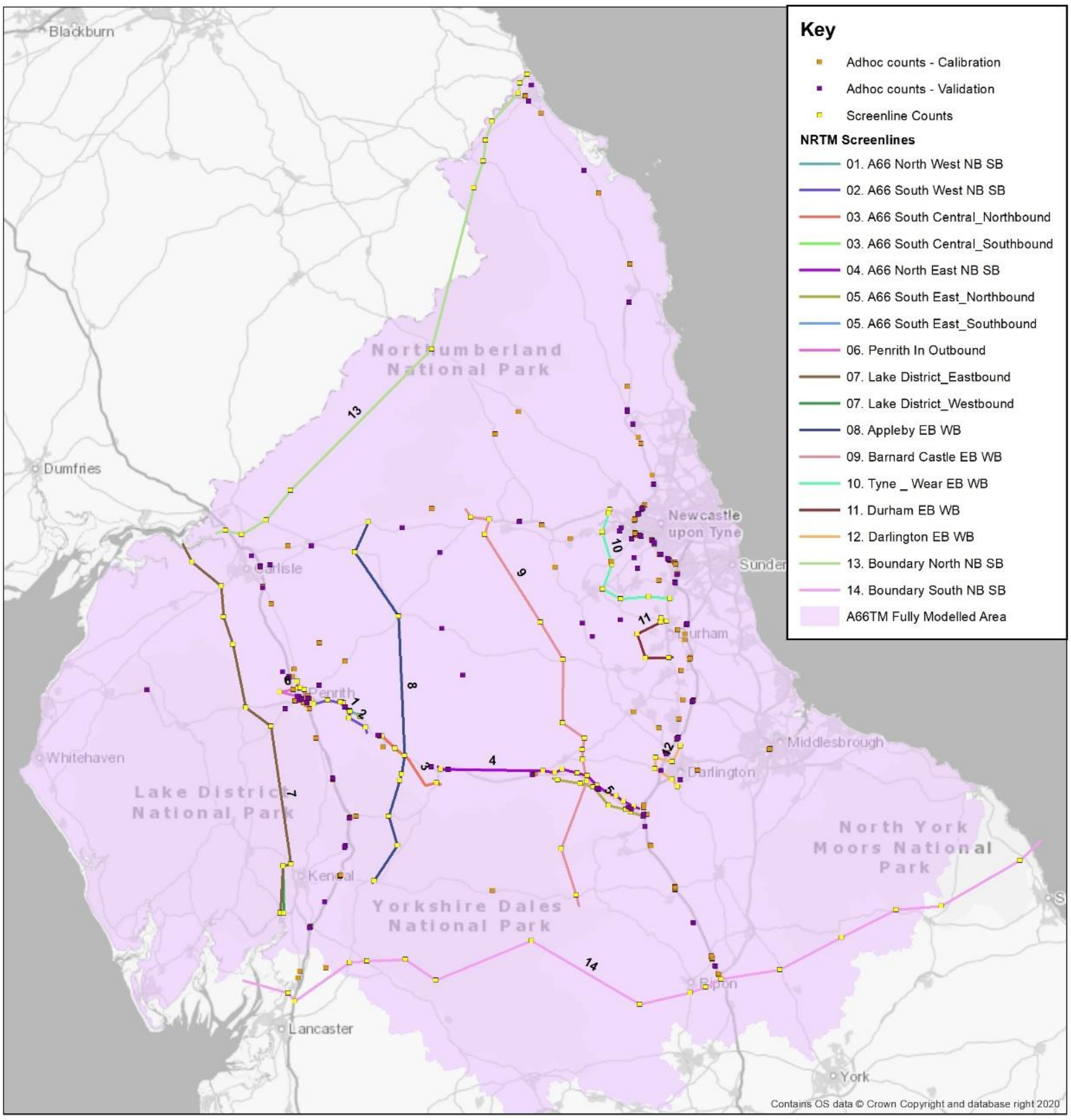

Figure 3-10: Screenlines and Adhoc Count locations

3.5 Journey time data

3.5.1 The section outlines the journey time data collected, how it was processed and how it was applied in the model (journey time routes)

Teletrac Navman GPS dataset

3.5.2 Journey time data has been obtained from the DfT's Teletrac Navman GPS dataset for the North. The data contains average journey times for each link in the OS MasterMap Highways Network mapping product in 15-minute intervals and has been provided for North England region for March, June and October 2019, for three representative (neutral) months.

3.5.3 The journey time data has the following variables:

- Link ID – based on GIS layer supplied which can be cross-referenced to the ITN network;
- Date – YYYY-MM-DD format;

- Time Period – 15-minute intervals;
- Vehicle class – Cars, LGVs (up to 3500kg), HGVs (up to 7500kg), HGVs (over 7500kg), Buses, Taxis, Motorised caravans, other vehicles, Unknown;
- Number of Observations;
- Average Journey Time;
- Sum of Squares Journey Time.

Journey time routes

3.5.4 The 2019 Teletrac Navman data has been used to develop the observed journey times. The median journey time from the three months of data for each route segment within each time period was identified. The total route journey time is the sum of the median times for each segment. This methodology follows the practice used within the journey time processing of the RTMs.

3.5.5 The journey time routes for model validation have been retained from PCF Stage 2 with the addition of extra routes to ensure good coverage of any *potential* A66 diversion route, for example a route that traffic may choose to use as an alternative to the A66. The journey time routes are shown in Figure 3-11.

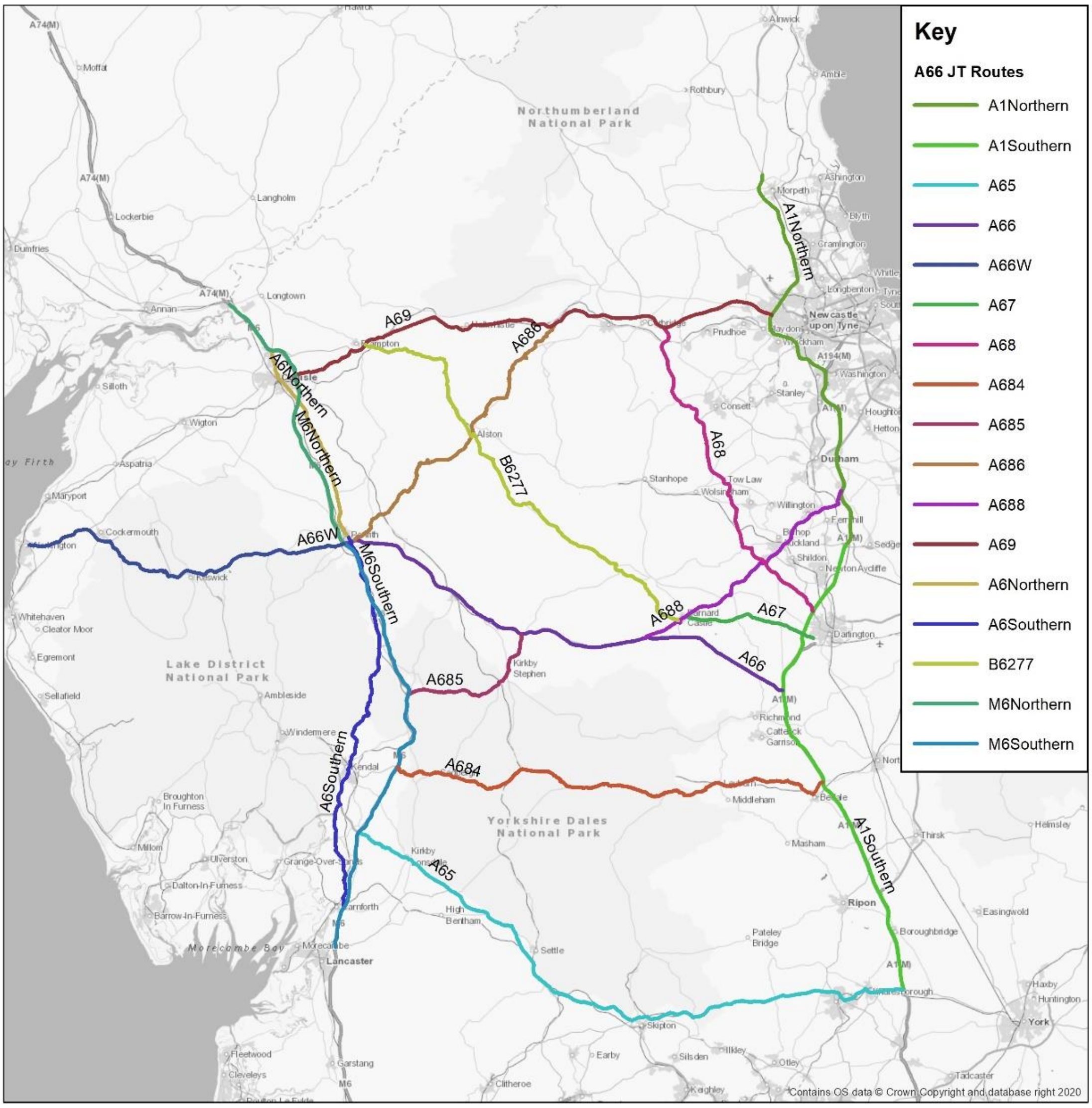

Figure 3-11: Journey Time Routes

3.6 Travel Demand data

3.6.1 Travel demand data refers to the movements that people make in terms of their origins and destinations. Taken at an aggregate level, these movements form trip matrices which represent all movements within a network, often referred to as the trip distribution. A key element of the work during PCF Stage 3 was the update of the demand data. The following methodology was applied to undertake the update:

- Person trip (car) matrices within the PCF Stage 2 A66TM were checked against 2019 TIS (Travel Information System) data collected as part of the RTM update
- The freight matrices were updated using MDS Transmodal 2015 data
- The model was revalidated to 2019 using count data.

3.6.2 This section provides further detail of the process followed.

TIS data

3.6.3 The A66TM at PCF Stage 2 was based upon the 2015 RTM1 matrices. This was based on 2015 Mobile Network Data (MND) matrices developed by Telefonica. In the update of the A66 traffic model , analysis was undertaken to compare the shape of the 2015 and 2019 TIS matrices to check that the underlying demand patterns in the A66TM matrices remain valid. The check concluded that the trip patterns within the modelled area were consistent.

3.6.4 Given that there have been no significant developments within the area since 2015 that would significantly affect the patterns of movement on the A66, and in the absence of any other available data, it is considered that the traffic distribution patterns from the 2015 data provided the best starting point for the Stage 3 modelling work.

HGV data

3.6.5 HGV freight demand has been imported from a 2018 version of the Transport for the North (TfN) Northern Highway Assignment Model (NoHAM). The data comprises 2018 base year HGV demand matrices. These matrices were developed from data supplied by MDS Transmodal.

3.6.6 TfN developed the matrices from the data in a conversion process with two main steps:

- Splitting annual HGV Passenger Car Units (PCUs) between rigid vehicles and articulated vehicles using a methodology developed by MDS Transmodal using DfT regional data as a source.
- Splitting daily data to time period data. This follows a methodology provided by Ian Williams[19], which uses a variety of time profiles that distinguish between different types of HGVs, LGVs and different road types to develop a temporal split. The methodology uses WebTRIS analysis to create separate time profiles for the categories: Motorways, Urban A-road and Rural A-road. Sites are classified to enable traffic volume index tables to be produced by hour and weekday allowing weighted profiles by hour and day to be created.

LGV data

3.6.7 LGV data has been sourced from Teletrac Navman. This data is a record of the GPS movements from vehicles fitted with certain proprietary satellite navigation systems. Each record in both Origin-Destination (OD) dataset relates to a single trip from a Teletrac Navman vehicle. Note: a trip in the Teletrac Navman data set is defined as being from “ignition on” to “ignition off” status for the vehicle. While data is available for all vehicle types it is considered to be most robust for LGVs given the relative prevalence of satellite navigation and vehicle tracking systems within LGV fleets.

3.6.8 The following vehicle types are included:

[19] Ian Williams is a freight modelling specialist who has been providing advice to National Highways on the development of freight matrices within the RTM2 commission.

- Cars
- LGVs (up to 3500kg)
- HGVs (up to 7500kg)
- HGVs (over 7500kg)
- Buses (including minibuses)
- Taxis
- Motorised caravans
- Other vehicles
- Unknown

3.7 Mapping and network data

3.7.1 In PCF Stage 1, the modelled highway network is based on the NRTM network with refinements along the A66 Project corridor.

3.7.2 In PCF Stage 2, minor changes were made to further refine network representation. This comprised of:

- A small number of signal timing and centroid connector updates in the North-East area to reduce model noise
- Updated Value(s) of Time (VOT) and Value(s) of Operating Cost (VOC) aligned to the latest November 2018 TAG Databook
- Stacking capacity refinements at the M6-J40, Kemplay Bank, and Scotch Corner to improve capacity representation, following the RTM coding manual approach
- Subtle coding improvements at the Bowes westbound off-slip, and A6108 South entry arm at the Scotch Corner junction
- Updated signal timings at Scotch Corner to match the LINSIG 2017 operational model timings
- Updated centroid connector West of Penrith to improve traffic distribution at that location in the network

3.7.3 For Stage 3, the base year network developed in Stages 1 and 2 was further updated. Network details such as length, road type etc. to check and refine the Stage 1 and 2 data has been taken from the Ordnance Survey's OS MasterMap Highways Network product. Junction details, including signal timing and signal stages, has been taken from the local traffic model of Penrith provided by Cumbria County Council

3.8 References

3.8.1 For further details on the information provided in Section 3, please see Appendix B.

4 Transport Model

4.1 Overview

4.1.1 This chapter summarises the key features of the transport modelling used to produce the traffic forecasts that informed the design of the Project and are used in the appraisal of the Project. A full description of the development of the transport model is presented in Appendix D: Transport Model Package.

4.2 Previous transport models

4.2.1 The modelling used throughout the Project is based on the NRTM. The RTM, of which the NRTM is one have been developed for several purposes including:

- Assessing programme level strategies across the regions
- To provide a starting point for the development of detailed scheme specific models, where availability of networks, volumetric counts and travel demand data can reduce the traffic modelling programme.

4.2.2 The A66TM was originally developed at the early stages of this study, namely PCF Stages 1 and 2. The work was undertaken between 2017 and 2019, to assess the options being considered for the Project. It was based on the NRTM and was built on data collected in or before 2015. All data was rebased (adjusted) such that the model represented conditions in a 2015 base year.

4.2.3 The traffic model has since been updated in PCF stage 3 such that it is suitable to inform the DCO application. The RTMs are typically updated every five years to ensure they are based on the most up to date information available. Therefore, the Project team has taken the opportunity to update the base year model from 2015 to 2019 in parallel to the development of the second generation of the Regional Traffic Models (RTM2). 2019 represents the most recent year experiencing “normal” network conditions prior to the Covid-19 pandemic.

4.3 Model purpose

4.3.1 The traffic model has been developed to analyse the impact of the Project on traffic flows and journey times on the road network. The model has a focus on the area immediately affected by the Project, but it also covers the whole of Great Britain. It includes a representation of the road network and looks at where the demand for trips start and end, split into five user classes. Understanding patterns of travel for different user classes allows for the way the Project provides benefits to businesses and individuals to be assessed. The model produces traffic forecasts for three modelled years: 2029 (opening year), 2044 (design year) and a horizon year of 2051, the furthest year that national travel demand projections are available.

4.4 Model software

4.4.1 Model composition and software is based on the NRTM and keeps the same structure of a highway SATURN supply model and a variable demand model system which uses a combination of the DfT Dynamic Integrated Assignment and DEmand Modelling (DIADEM) Variable Demand Modelling software and a bespoke graphical user interface (GUI) known as the National Highways Integrated Demand Interface (HEIDI).

4.4.2 SATURN operates as a static equilibrium highway assignment model which incorporates both simulation and assignment loops. The highway assignment model uses SATURN software version 11.4.07H.

4.4.3 DIADEM software is designed to enable practitioners to easily set up variable demand models. DIADEM provides a user-friendly method for setting up a multi-stage transport demand model and finding equilibrium between demand and supply, using the SATURN package as the supply model. The variable demand model uses the bespoke version of the software version developed specifically for National Highways.

4.4.4 HEIDI is a bespoke programme developed to assemble trip end data and to organise and implement forecast model runs. HEIDI invokes a DIADEM run which in turn invokes SATURN. HEIDI version 6.2h has been used for the A66 forecast model runs.

4.5 Study area

4.5.1 The TRA is the area of the traffic model considered to provide reliable estimates of traffic when the base traffic model is compared to observed traffic, this has been defined by considering the area across which the Project can be seen to have an impact, otherwise known as the Affected Road Network (ARN).

4.5.2 The ARN, and by extension the TRA has been defined according to Design Manual for Roads and Bridges) DMRB noise (LA 111) and air quality criteria (LA 105), based on forecast AADT / AAWT (Average Annual Weekday Traffic) of implementing the Project.

4.5.3 In terms of Air quality, affected roads are those that meet any of the following criteria:

- Daily traffic flows will change by 1,000 AADT or more; or
- Heavy Duty Vehicle (HDV) flows will change by 200 AADT or more; or
- A change in speed band.

4.5.4 For the noise assessment an affected route is where there is the possibility of a change of 1 dB LA10,18h or more in the short-term or 3 dB LA10,18h or more in the long-term. A change in noise level of 1 dB LA10,18h is equivalent to a 25% increase or a 20% decrease in traffic flow, assuming other factors remain unchanged and a change in noise level of 3 dB LA10,18h is equivalent to a 100% increase or a 50% decrease in traffic flow

4.5.5 The TRA is shown in Figure 4-1.

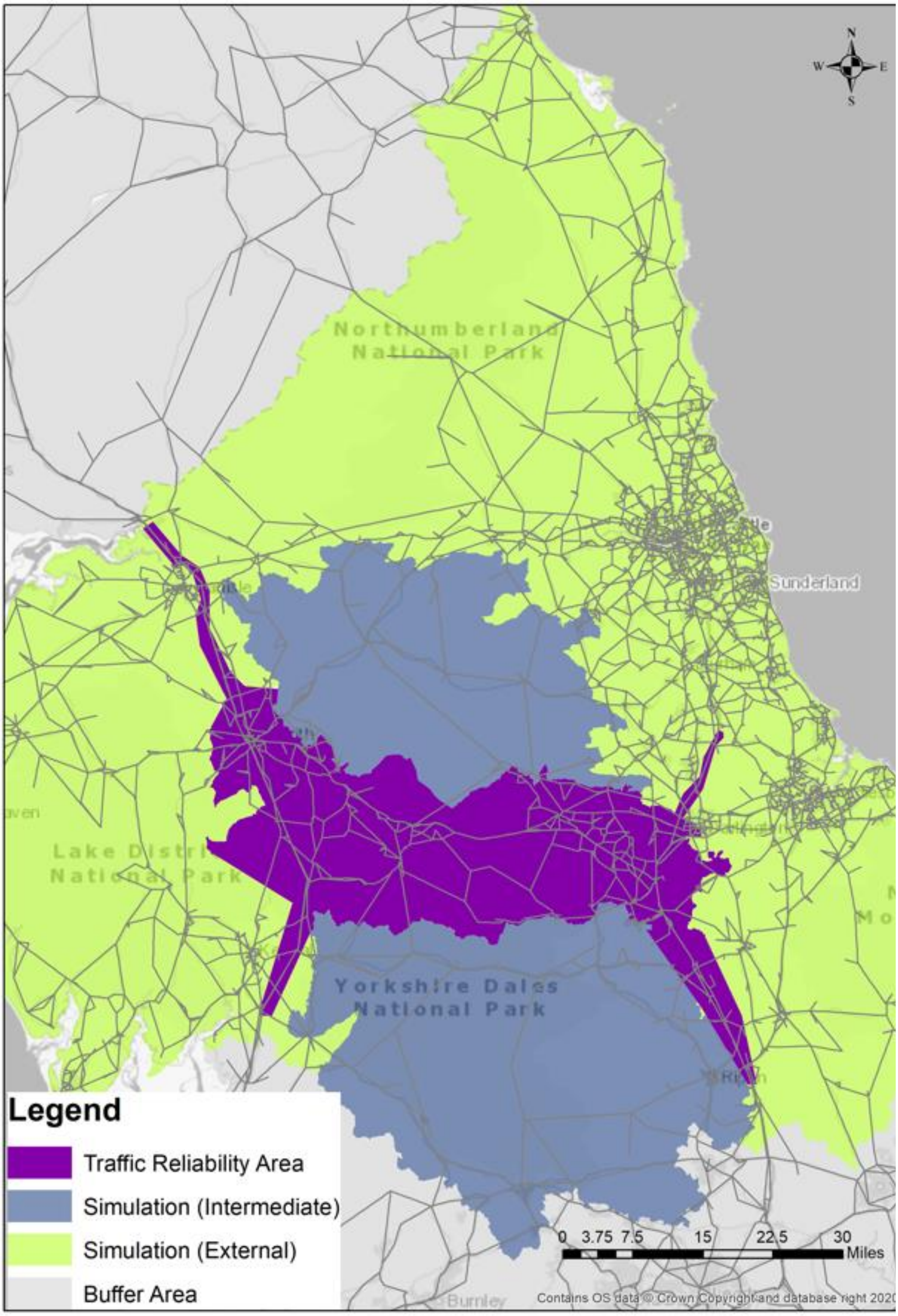

Figure 4-1: Stage 3 A66TM Modelled Area

4.6 Model details

Modelled base year and month

4.6.1 The PCF Stage 1 and 2 model has been updated to March 2019. An average weekday (Monday to Friday) is used in line with the NRTM.

Modelled time periods

4.6.2 The NRTM (upon which the A66TM is based) is comprised of 2 three-hour periods covering the AM and PM peaks together with a 6-hour interpeak. The suitability of these time periods was investigated at the start of PCF Stage 3 to ensure they were representative of traffic conditions on the A66. To do this, the journey time taken to complete the whole route from Penrith to Scotch Corner throughout the day was plotted against average temporal flow distributions form WebTRIS count data along the A66.

4.6.3 From the analysis, the following points were concluded:

- The AM peak lasts for only 1 hour, peaking sharply between 08:00-09:00. The flow during this hour is 20% higher at this location than the average flow contained in the NRTM peak period between 07:00 and 10:00.
- The NRTM PM peak period covers 16:00 to 19:00. The analysis suggested a more appropriate PM period would cover 16:00-18:00. The average flow during this two-hour period is 14% greater than in the 3-hour period used within NRTM.

4.6.4 As a result of the analysis, the modelled time periods were set to:

- AM Peak Hour (08:00-09:00)
- Inter-Peak Period (10:00-16:00)
- PM Peak Average Hour (16:00-18:00)
- Off-Peak Period (19:00-07:00).

4.6.5 The selected time periods leaves two unmodelled hours within the AM period, namely 07:00-08:00 and 09:00-10:00, and a single hour in the PM period (namely 18:00-19:00). For TUBA purposes, and to maintain the correct journey purpose proportions, shoulder peaks were developed using the correct proportion of the AM/PM matrices for the particular hour be used, together with the skims from these models. These shoulder peaks have also been used in the demand model.

Demand segmentation

4.6.6 The base year model represents a representative March weekday in 2019. Vehicle class definitions are from the COBA manual, with OGV1 (Other Goods Vehicles 1) and OGV2 (Other Goods Vehicles 2) combined together and referred to as HGVs, and the car user class split into Car Commute, Car Employers Business and Car Other trips to allow for variations in the perceived costs of travel between different journey purposes. LGVs have all been assumed to be employer’s business trips, and other goods vehicles (OGV1 and OGV2) along with Passenger Service Vehicles (PSV) have been combined with HGVs. As the number of PSVs picked up in the manual counts were so low it was assumed they would have a negligible effect combined with the HGV movements.

4.6.7 The highway assignment model user classes are as follows:

- User class 1 – Car, Employers Business
- User class 2 – Car, Commute
- User class 3 – Car, Other
- User class 4 – Light Goods Vehicles
- User class 5 – Heavy Goods Vehicles

4.6.8 The demand model also includes the following rail purposes:

- Rail – Commuting
- Rail – Other
- Rail – Employers Business

4.6.9 In line with expectations within TAG Goods vehicles are excluded from the demand model. TAG Unit M1[20] states that as Freight movements are often part of a complex logistic chain, it is often not appropriate to assume that each trip can be modelled individually as part of a choice (demand) model. Therefore, simple factoring methods are often used for freight movements.

4.7 Matrix development

Car matrix development

4.7.1 The process to develop the matrices for the A66TM is summarised in Figure 4-2 below. Further details around the construction of the 2015 NRTM matrices can be found in the NRTM Model Validation Report[21], with development of the 2015 A66TM matrices detailed in the Stage 2 Transport Model Package[22].

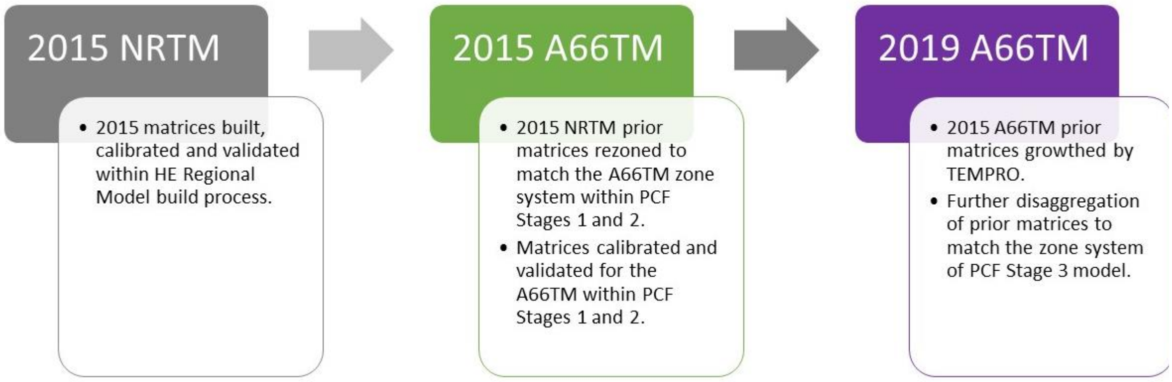

Figure 4-2: Matrix Development Process

[20] DfT TAG Unit M1 Principles of Modelling and Forecasting January 2014
[21] Highways England 'Northern Regional Transport Model – Model Development Report – March 2017
[22] Highways England - A66 Northern Trans-Pennine Project, Transport Model Package, Stage 2 - May 2019

4.7.2 To update the model to a contemporary base year, during PCF Stage 3, the matrices have been updated from a base year of 2015 to a base year of 2019 and further refined to reflect further zone disaggregation.

4.7.3 TEMPRO trip end data by area, and journey type were downloaded for 2015 and 2019. Data for the A66TM simulation area (namely the Fully Modelled Area and Intermediate areas) was downloaded at detailed sub local authority district level to allow trip end growth factors to be applied. Within the buffer area, growth was applied using county factors. The matrices were then growthed using these factors and balanced using a Furness procedure. The resultant matrix total growth is shown by model segment in Table 4-1. Growth has been applied to the PA (Production – Attraction)[23] and OD (Origin-Destination)[24] matrix segments in line with the disaggregation between home based and non-home based information within TEMPRO.

Table 4-1: Car Matrix resultant matrix growth

			2015 Stage 2 Model	2019 Stage 3 Model	Resultant Matrix Growth	NTM TEMPRO Growth (GB)	A66 Corridor Growth
PA	24 Hour	Business	1,993,192	2,076,976	4.20%	4.08%	N/A
		Commute [25]	12,858,781	13,112,844	1.98%	1.80%	
		Other	14,196,856	14,706,085	3.59%	3.68%	
OD	AM	Business	188,496	193,324	2.56%	2.85%	9.8%
		Other	332,637	342,895	3.08%	3.10%	
	IP	Business	209,685	215,061	2.56%	2.62%	9.5%
		Other	589,889	608,825	3.21%	3.22%	
	PM	Business	204,906	210,422	2.69%	2.64%	3.8%
		Other	469,386	484,586	3.24%	3.26%	
	OP	Business	60,102	61,642	2.56%	2.68%	4.7%
		Other	169,064	174,862	3.43%	3.48%	

4.7.4 The resultant matrix growth is closely equivalent to that observed at Great Britain (GB) level within TEMPro. Overall growth within TEMPro is lower than that observed on the A66, particularly during the AM and Inter peak. This difference will be accounted for within the remainder of the model revalidation.

4.7.5 Further matrix manipulation was undertaken to split the matrices to account for Zone disaggregation within Penrith. The matrices were then

[23] The Production / Attraction (or P/A) definition is used to represent the various trips that form a tour (whether outbound from home, return to home) in such a way that relates them most closely to the available demographic data. As the strongest and most relevant demographic data generally relates to resident population, it is useful to distinguish trip ends that relate to "home" from those that relate to "non-home" activities. Home-based trip ends are therefore split by production (home) and attraction (the reason for travel).
[24] Non home based trips are described more simply by Origin (O) and Destination (D).
[25] By definition, a commute trip is always expressed in PA form as one end of a commute trip is always "home".

subjected to factoring at a sector level to balance flows across screenlines prior to matrix estimation.

LGV matrix development

4.7.6 The LGV matrix has been developed using 2019 Teletrac Navman data. The following steps were applied to the original Teletrac Navman source data to create the initial LGV assignment matrices:

- Rezone Lower Super Output Area (LSOA) zone data to A66 zoning system.
- Apply filtering and factors to convert input data from all time periods into average-hour AM, IP, and PM peak data.

4.7.7 Upon creation of the initial matrices, the Teletrac Navman data was found to have significantly different trip length distributions to those found in the PCF Stage 2 2015 prior matrices, which themselves had been calibrated to National Travel Survey data. To bring the matrices into alignment, the following steps were undertaken to improve the trip length distribution:

- define distance bands (0-10km, 10-20km, 20-30km, 30-40km, 40-50km, 50-75km, 75-100km, 100-150km, >150km);
- scale up the trips in each distance band to equal the total number of trips in the corresponding distance band in the prior matrices.

4.7.8 This improved the relative fit of the 2015 and 2019 matrices in terms of the numbers of trips between the study area and the external areas.

4.7.9 The 2019 prior matrix was factored at a screenline level during calibration and validation, prior to matrix estimation. This further scaling was necessary to account for growth in LGV traffic between 2015 and 2019, and for the changes in the modelled periods between the PCF2 and PCF3 matrices. The factors were developed through comparison of assigned flows to traffic counts on the model screenlines.

Freight matrix development

4.7.10 Prior freight matrices based in 2018 were provided by TfN based on data supplied by MDS Transmodal, provided in the A66TM zone system. The matrices matched the A66TM model time periods, and as they had been developed for a pan northern highway assignment model, little further processing was required.

4.7.11 Upon receipt of these matrices within the A66 project they were checked to ensure:

- they were symmetrical at a 24-hour level;
- the average trip length was compared against the DfT domestic and inter-nation road freight statistics;
- that the largest freight generators within the matrices were allocated to appropriate industrial zones.

4.7.12 The matrices were factored at screenline level to provide a better fit to the observed flow data at an aggregate level, before matrix estimation was applied.

4.8 Network development

Network development in PCF1 and PCF2

4.8.1 The model network is based on the NRTM network. The NRTM network includes an area of simulation network, where junction modelling is included, and buffer network, where the network representation is link based.

4.8.2 In the NRTM, a tiered approach to network coding was used. In the core modelled area, detailed simulation coding was generally reserved for the SRN, roads connected to the SRN and running parallel. In the rural and urban areas away from the SRN relatively simplistic 'template' simulation coding was adopted. Outside of the core modelled area the NRTM covers the remainder in less detail in the form of a buffer network with fixed speed links and no junction coding.

4.8.3 The approach to network coding in the NRTM, particularly along the A66 corridor was not appropriate for A66 Project assessment, as there was insufficient network detail to accurately capture all of the anticipated impacts, and was therefore enhanced at PCF Stage 1. At PCF Stage 2 only minor changes were made to further refine network representation.

4.8.4 For the A66TM, the geographical extent of the network is based on the NRTM. The modelling undertaken during Stage 0 provided a good understanding of the potential demand and reassignment impacts of an improved A66. Initial modelling of the full A66 dualling option provided an indication of the extent of reassignment and hence a basis for determining the extent of the network.

4.8.5 The extent of both the simulation area and buffer area have been retained from NRTM; however, the simulation area has been further subdivided to include fully modelled, intermediate and external areas containing different levels of simulation coding. This reflects the need to enhance the network detail included in the NRTM, particularly along the A66 corridor and competing corridors.

Network development in PCF3

4.8.6 The majority of the A66 model network remains unchanged from PCF Stage 2, however, several updates were required to develop the PCF Stage 3 model. These include:

- additional coding to include RIS1 National Highways and local highway schemes built since 2015
- additional coding in Penrith to better reflect route choice and improve the accuracy of traffic flows
- additional coding north of Kirkby Thore
- additional coding east of Scotch Corner between Middleton Tyas, Scorton and Croft-on-Tees to capture local traffic which could route via the Scotch Corner junction
- additional coding and updated zone loadings to improve convergence in Durham, Middlesbrough and Carnforth.

Network coverage and approach to network representation

4.8.7 At PCF Stage 1 the NRTM network was reviewed, and a revised hierarchy was developed for the A66TM model. The model area was sub-divided, and in each area a different level of network and zone system detail implemented based on the level of impact the Project was expected to have. The areas are as follows, and were shown in Figure 4-1.

- Simulation Fully Modelled Area: Core Project area, centred on A66 between A1 (M) and M6;
- Simulation Intermediate Area: bounded by the A1, A69, M6 and A65/A59, provides an area of transition between the fully modelled area and the remainder of the simulation area;
- Simulation External Area: Covers the remainder of the NRTM simulation area;
- Buffer Area: This covers the rest of England, Scotland and Wales.

4.8.8 The extent of the network, together with the boundaries of the simulation and buffer areas is shown in Figure 4-1.

Simulation network link coding

4.8.9 For each link in the simulation area the following information is required:

- Link length;
- Speed flow curve index; and
- Link length for each link was obtained from the Ordnance Survey Integrated Transport Network (OS ITN) layer.

4.8.10 Speed flow curves were allocated based on the characteristics of each link. This includes:

- The speed limits;
- The number of lanes;
- The road standard;
- Road quality;
- Location of road (urban/suburban/rural).

4.8.11 The speed flow curves adopted have been inherited from the NRTM which were based on the Regional Traffic Models network coding manual. The characteristics of the links which determine the speed flow curves have been reviewed and if necessary, the speed flow curves allocated to links amended.

4.8.12 At PCF Stage 1, the speed limits were reviewed in the simulation fully modelled and the simulation intermediate area. Within the simulation fully modelled area the network was modelled in further detail with regards to junctions and changes in carriageway type, particularly along the A66. Link speeds were adjusted where appropriate, particularly along the A66.

4.8.13 Information on speed limits for the modelled road network (fully modelled, intermediate and external areas) was collected and applied to the model links, using Google Maps street view and supplemented by site visits. Where deemed appropriate, link speed adjustments were made.

4.8.14 Link capacities are based on the Regional Traffic Models Network Coding Manual. These were checked for each link in the simulation fully modelled area and adjusted where appropriate.

Buffer area link coding

4.8.15 The buffer area network links are "fixed speed", comprising link length and link observed speed by modelled time period. Link length originates from the OS ITN layer mapped to model links using a correspondence table. Observed speeds by time period are based on Teletrac Navman data. The RTM Data Consistency Group provided an agreed method of processing the speed data from Teletrac Navman and allocating it to the network[26].

4.8.16 The buffer area link coding was inherited from the NRTM.

4.9 Model zoning

4.9.1 The model zone system is based on the NRTM zoning system, with some adjustments made to reflect the anticipated Project impact.

4.9.2 The NRTM zone system uses LSOA as a basis, aggregating up to larger zones at Middle Super Output Area (MSOA) level where appropriate. In the external area, zones are based on MSOAs aggregated to county levels.

4.9.3 At Stage 1, the NRTM model zones were adjusted in accordance with the A66TM defined model areas as follows:

- Simulation Fully Modelled Area: Zones were disaggregated (split) to fit with the more detailed network in and around the A66. All disaggregated zones adhere to the Census boundaries.
- Simulation Intermediate Area: NRTM zones were largely retained, but with some disaggregation close to the simulation fully modelled area.
- Simulation External Area: Zone aggregation in the urban areas, most notably the North East area to simplify the model and to fit with a less detailed model network in these areas.
- Buffer Area: NRTM zone system retained.

4.9.4 Table 4-2 and Table 4-3 show the number of NRTM zones and number of A66TM model zones, categorised by the type of zone change applied (split or merged) and model area (simulation or external area).

Table 4-2: A66TM Zone Numbers

Zone change	NRTM – Number of zones	A66TM Stage 2 – Number of zones	A66TM Stage 3 – Number of zones
Split Zones	65	181	185
Merged Zones	403	143	143
No Change – Zones Retained	1,082	1,082	1,082
Total	1,550	1,406	1,410

[26] Mouchel: TN26 - TrafficMaster JT Data Process, November 2015

4.9.5 The difference in the total number of zones between the A66TM Stage 2 and Stage 3 model is due to:

- Zone disaggregation in Penrith;
- Two new zones representing future developments in Cumbria (Eden 41 Business Park) and in North Yorkshire (Scotch Corner Designer Village).

Table 4-3: A66TM Zone Detail

Model Area	NRTM – Number of zones	A66TM Stage 2 – Number of zones	A66TM Stage 2 – Number of zones
Simulation	1,431	1,287	1,291
External	119	119	119
Total	1,550	1,406	1,410

4.9.6 The A66TM model zone system is shown in Figure 4-3, Figure 4-4 and Figure 4-5.

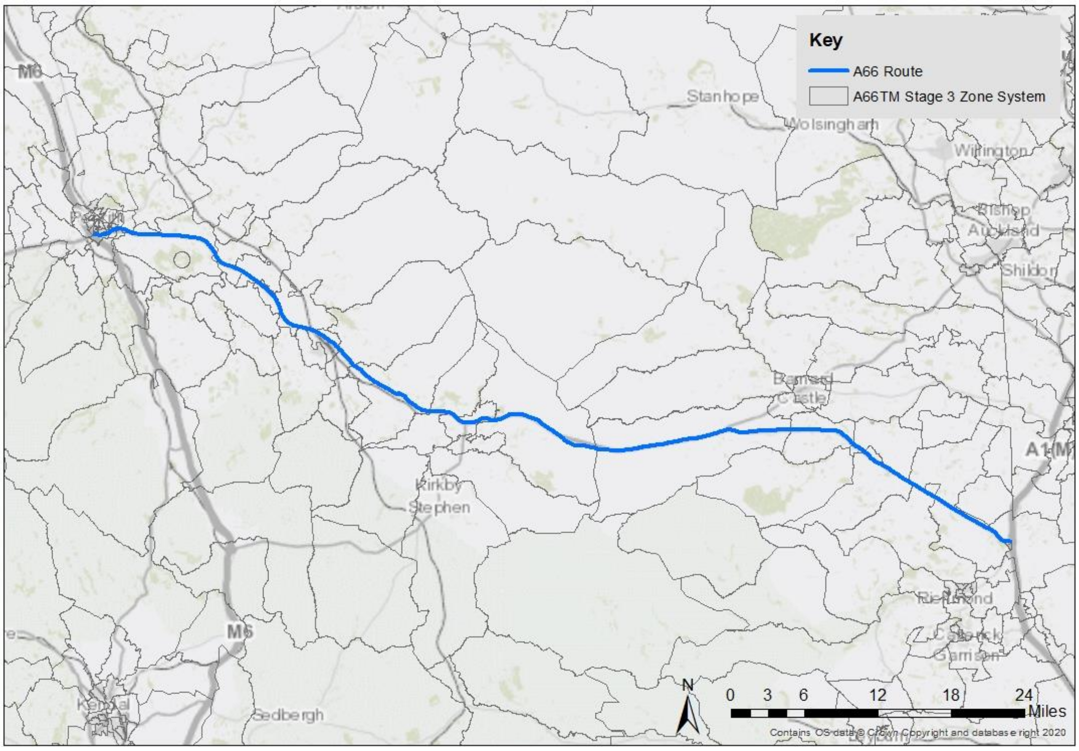

Figure 4-3: Zones around the A66

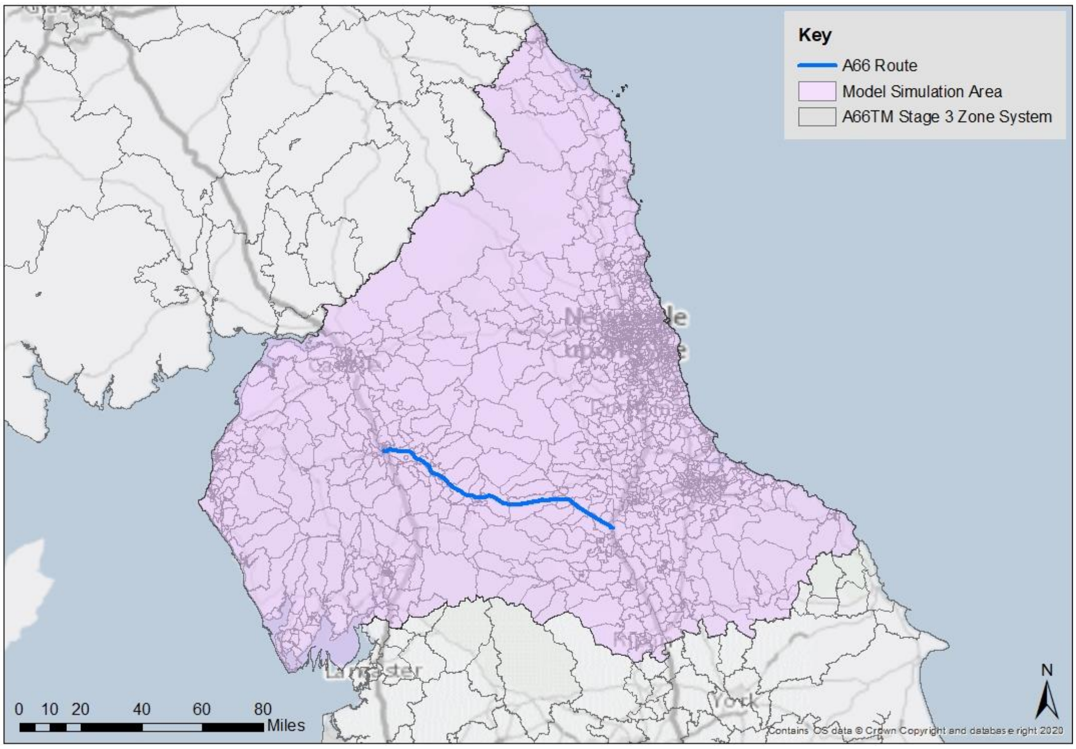

Figure 4-4: Zone system within Model Simulation Area

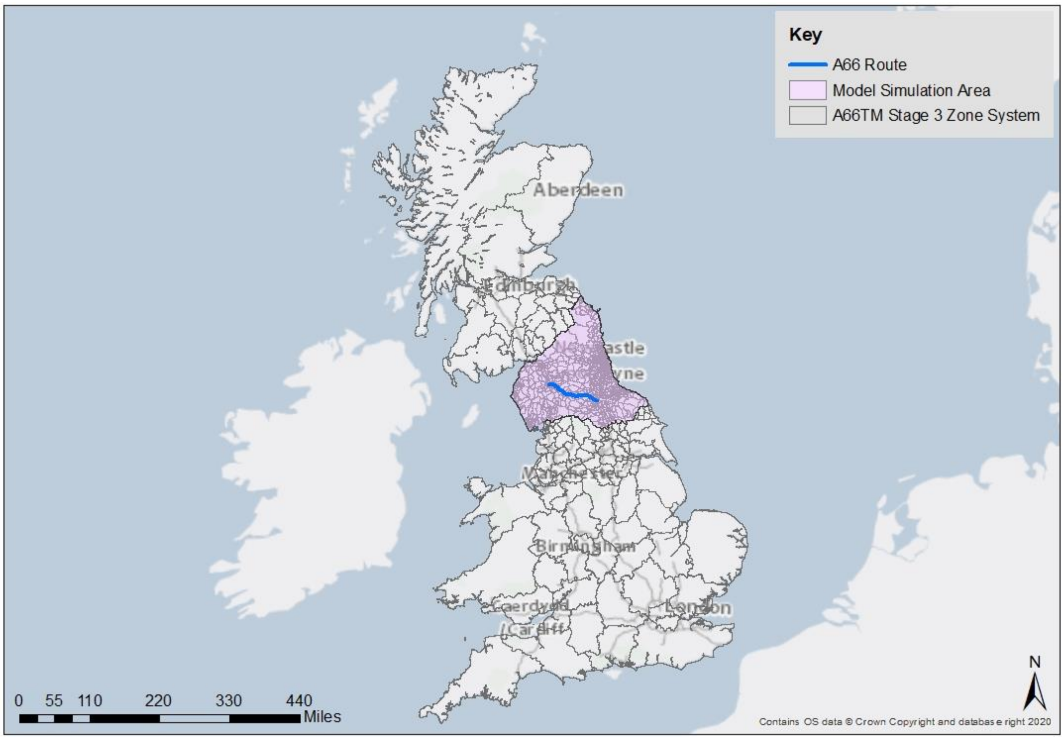

Figure 4-5: National Zone System

4.10 Model validation

Overview

4.10.1 Model validation is the process of comparing model outputs with independent data.

4.10.2 The validation of the model is divided into two main elements:

- Validation of demand matrices – based on comparison of observed and modelled traffic flow across screenlines and cordons; and
- Assignment validation – based on a comparison of observed and modelled traffic flows at individual sites and observed and modelled journey times along defined routes.

4.10.3 Acceptability guidelines on both demand and assignment validation are included in TAG unit M3-1 and reproduced in Chapter 3.

4.10.4 This chapter describes the Stage 3 highway model validation.

Assignment model convergence

Before the results of any traffic assignment are used to influence decisions, the stability (degree of convergence) of an assignment must be confirmed. The criteria set out in TAG Unit M3.1 (detailed in Table 4-4) were used to assess the assignment convergence of the SATURN models for the AM, inter-peak and PM average time period hours.

Table 4-4: Assignment Convergence Acceptability Guidelines

Criteria	Acceptability Guidelines
Delta and %GAP	Less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with **flow change (P) <1%**	Four consecutive iterations greater than 98%
Percentage of links with **cost change (P2) <1%**	Four consecutive iterations greater than 98%

Source: TAG – Unit M3-1

4.10.5 A summary of the SATURN convergence for the AM, interpeak and PM average time period hours is shown in Table 4-5 where:

- %Flows – Link flows differing by <1% between assignment-simulation loops
- %GAP – Wardrop equilibrium gap function post simulation

Table 4-5: Calibrated Assignment Statistics

AM Peak			Inter Peak			PM Peak		
Loop	% Flow	% GAP	Loop	% Flow	% GAP	Loop	% Flow	% GAP
22	98.7	0.0006	14	98.6	0.0011	20	98.6	0.0013
23	98.6	0.0004	15	99.0	0.0008	21	98.6	0.0019
24	98.7	0.0004	16	98.7	0.0011	22	98.9	0.0013
25	98.8	0.0004	17	98.9	0.0005	23	98.8	0.0017

4.10.6 The convergence statistics show that the model is stable and converges in a reasonable number of loops. Among these statistics, of particular importance is the % GAP parameter, which TAG recommends is less than 0.1%. As the tables show this is achieved in all three models indicating that they have converged to satisfactory levels.

Trip matrix and link flow validation

4.10.7 According to TAG unit M3-1 guidance, the model validation is measured by assessing the goodness of fit between the assigned hourly flows and journey times and the corresponding independent observed data.

4.10.8 For trip matrix validation, the measure which should be used is the percentage differences between modelled flows and counts. Comparisons at screenline level provide information on the quality of the trip matrices.

4.10.9 For link flow validation, two criteria are presented:

- the absolute and percentage differences between modelled flows and counts; and
- the GEH statistic.

4.10.10 the traffic flow data used within the validation is collected at different locations on the highway network than those used for calibration. The two sets of data are therefore independent.

4.10.11 The validation criterion and acceptability guideline for screenline flows and link flows are presented in Table 4-6.

Table 4-6: Link Flow Validation and Acceptability Guidelines

Criteria	Description	Acceptability Guidelines
Screenline flow validation criterion and acceptability guidelines		
Difference between modelled flows and counts should be less than 5% of the counts		All or nearly all screenlines
Link flow and turning movements validation criterion and acceptability guidelines		
1	Individual flows within 100 vph for flows <700 vph	>85% of cases
	Individual flows within 15% for flows 700-2,700 vph	
	Individual flows within 400vph for flows >2,700 vph	
2	GEH <5 for individual flows	>85% of cases

Source: TAG – Unit M3-1

4.10.12 A summary of the screenline performance for total vehicles after matrix calibration is shown in Table 4-7.

Table 4-7: Matrix Validation – All Vehicles

Performance Measure	AM Peak		Inter-Peak		PM Peak	
	No.	%	No.	%	No.	%
All screenlines or cordons within 5% of observed flows	17	94%	17	94%	18	100%
All screenlines or cordons within 10% of observed flows	18	94%	18	100%	18	100%
All screenlines or cordons within GEH <4	18	94%	18	100%	18	100%
All screenlines and cordons with GEH <7.5	18	100%	18	100%	18	100%

4.10.13 The matrix screenline validation performance is high. This is good performance is due to factoring of prior matrices and the changes made at Penrith to improve network coverage and zoning.

4.10.14 Table 4-8 and Table 4-9 shows the summary of the link flow validation in each of the three peak time periods, detailing the proportion of cases that pass the criteria. In accordance with TAG the validation is presented for cars and all vehicles together.

Table 4-8: Link Flow Validation Summary – Calibrated Matrices (All Vehicles)

Performance Measure	AM Peak	Inter-Peak	PM Peak
All Links (494)			
- within GEH of 5.0	84%	89%	87%
- within GEH of 7.5	95%	97%	95%
- pass cal/val guidance link criterion	85%	85%	85%
By Calibration/Validation			
Calibration Counts (341)			
- within GEH of 5.0	89%	93%	91%

Performance Measure	AM Peak	Inter-Peak	PM Peak
- within GEH of 7.5	96%	98%	96%
- pass cal/val guidance link criterion	85%	85%	85%
Validation Counts (153)			
- within GEH of 5.0	71%	81%	78%
- within GEH of 7.5	91%	93%	91%
- pass cal/val guidance link criterion	85%	85%	85%
By Road Type			
SRN link Counts (230)			
- within GEH of 5.0	84%	92%	88%
- within GEH of 7.5	96%	96%	95%
- pass cal/val guidance link criterion	85%	85%	85%
Non-SRN link Counts (264)			
- within GEH of 5.0	83%	87%	86%
- within GEH of 7.5	94%	97%	94%
- pass cal/val guidance link criterion	85%	85%	85%

Table 4-9: Link Flow Validation Summary – Calibrated Matrices (Cars)

Performance Measure	AM Peak	Inter-Peak	PM Peak
All Links (449)			
- within GEH of 5.0	84%	89%	87%
- within GEH of 7.5	95%	97%	95%
- pass cal/val guidance link criterion	85%	85%	85%
By Calibration/Validation			
Calibration Counts (324)			
- within GEH of 5.0	89%	93%	91%
- within GEH of 7.5	96%	98%	96%
- pass cal/val guidance link criterion	85%	85%	85%
Validation Counts (125)			
- within GEH of 5.0	71%	81%	78%
- within GEH of 7.5	91%	93%	91%
- pass cal/val guidance link criterion	85%	85%	85%

4.10.15 The results indicated that for all vehicles, when considering both calibration and validation counts, the validation exceeds the TAG criteria in all time periods. When considering the independent validation counts the model is just short of TAG criteria. This outcome is the same when considering cars only.

Journey time validation

4.10.16 For journey time validation, the measure which should be used is the percentage difference between modelled and observed journey times, subject to an absolute maximum difference. The validation criterion and acceptability guideline for journey times are defined in Table 4-10.

Table 4-10: Journey Time Validation and Acceptability Guidelines

Criteria	Acceptability Guidelines
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%)	>85% of cases

Source: TAG – Unit M3-1

4.10.17 In addition to the validation of link flows, the model has been also validated against observed journey times by direction along a series of fourteen routes. The routes used are shown graphically in Figure 3-11. A summary of the number and proportion of journey time routes passing the journey time validation criteria and acceptability guideline for each time period is shown in Table 4-11.

Table 4-11: Journey Time Validation Summary

Route Class	No. of Routes	AM Peak		Inter Peak		PM Peak	
		No.	%	No.	%	No.	%
SRN	14	14	100%	14	100%	14	100%
Non-SRN	20	20	100%	20	100%	20	100%
Total	34	34	100%	34	100%	34	100%

4.10.18 TAG acceptance criteria states that greater than 85% of routes should meet the individual route acceptance criteria. The overall percentage of routes meeting the TAG criteria exceeds 85% in all time periods. All routes achieve TAG criteria in all modelled time periods.

4.11 Variable demand modelling

Introduction

4.11.1 TAG Unit M2-1 provides guidance on the need for variable demand modelling. The modelled approach was undertaken according to this guidance. It was recognised at PCF Stage 0 that given the scale of the interventions being considered by the study, in terms of estimated cost of options, and scale of travel time savings estimated, that variable demand modelling would be necessary to undertake an accurate appraisal of the Project. Therefore, a variable demand modelling approach was undertaken in the subsequent PCF stages (PCF Stage 1 and 2) and continues to be undertaken within this appraisal.

Model Characteristics

4.11.2 The variable demand modelling system developed for the A66TM is largely unchanged from that developed for the NRTM. Changes are limited to updating it and recalibrating it to reflect the enhanced A66TM networks and zonings systems and recalibrated demand. The reasoning behind the specification of the structure of the Variable Demand Model (VDM) are contained in the NRTM model development report and remain valid for the A66TM.

4.11.3 The key characteristics of the VDM are as follows:

- Incremental pivot point approach

- Pivot point between base and test
- Home Based Production / Attraction
- Non-Home-Based Origin / Destination
- Goods Fixed
- Special Generators Fixed

4.11.4 The VDM model applies to the entire modelled area (simulation and buffer area) and predicts the key traveller responses of:

- Mode Choice (between Car Available Car Users and Rail);
- Destination Choice (a change of origin and\or destination);
- Macro Time of Day Choice (MTOD) (a change of time period in which travel is made).

4.11.5 Within the NRTM the model the time slices were based on average hour models across each time period, namely:

- AM Average Hour representing the AM period of 07:00-10:00
- Inter-Peak Average Hour representing the IP 10:00-16:00
- PM Average Hour representing the PM period of 16:00-19:00

4.11.6 The A66TM was adapted to model the congestion effects during the morning and evening peak hours. As such the AM and PM periods have each been split into two time slices comprising:

- the calibrated and validated peak hour(s)
- uncalibrated shoulder hour(s)

4.11.7 The shoulder period is derived by applying a simple factor to the calibrated peak hour matrix to reduce the quantum of demand assigned during the peak shoulder hours. The skim time for each i-j movement within the demand model within either the AM or PM period would therefore be derived from a demand weighted average of the skim time generated from assignments of the peak and shoulder matrices.

4.11.8 Public Transport supply and demand are represented as inter-urban rail travel only. It is considered the main competitor to the car when the RTMs were developed. This assumption and its representation in the model have been retained for the A66TM.

4.11.9 A land use transport interaction model has not been used after considering the Project's location, surrounding development, current network conditions, and the likely impacts with the Project in place.

Realism tests

4.11.10 As described in TAG unit M2-1, it is essential to ensure that a variable demand model behaves realistically once it has been constructed, by changing various components of the travel costs and time and checking that the overall demand response accords with general experience. The acceptability of the model response is determined by its demand elasticities, calculated by amending a cost or time component by a small global proportionate amount and calculating the proportionate change in travel made.

4.11.11 Car fuel cost elasticity tests were undertaken with the fuel costs adjusted by +10%. Adjustments were made to the median illustrative destination choice parameters within the model in order to match the outturn elasticity expected within TAG. The values adopted were:

- Home-based work: 0.113
- Home-based employers' business: 0.038
- Home-based other: 0.125
- Non-home-based employers' business: 0.069
- Non-home-based other: 0.091

4.11.12 All values are within the illustrative range suggested by TAG Unit M2-1. Matrix-based, and network-based elasticity have been calculated in accordance with the change in car vehicle kilometres. The results of the fuel cost elasticity test are shown in Table 4-12 and Table 4-13 respectively.

Table 4-12: Car Cost Fuel Elasticities – Matrix Calculation (Any trip with an Internal Origin)

Elasticity	Business	Work (Commute)	Other	Total
AM Shoulder	-0.13	-0.29	-0.38	-0.25
AM Peak	-0.13	-0.27	-0.37	-0.25
Inter Peak	-0.15	-0.28	-0.41	-0.30
PM Peak	-0.12	-0.27	-0.39	-0.28
PM Shoulder	-0.12	-0.28	-0.39	-0.28
Off Peak	-0.16	-0.29	-0.41	-0.31
24 Hour	-0.14	-0.28	-0.40	-0.29

Table 4-13 Car Fuel Cost Elasticities – Network Calculation (Simulation Area only)

Elasticity	Car Business	Work (Commute)	Car Other	Car Total
AM Shoulder	-0.13	-0.26	-0.34	-0.24
AM Peak	-0.11	-0.27	-0.35	-0.18
Inter Peak	-0.15	-0.26	-0.36	-0.28
PM Peak	-0.08	-0.26	-0.36	-0.20
PM Shoulder	-0.13	-0.25	-0.35	-0.25
Off Peak	-0.17	-0.27	-0.38	-0.29
24 Hour	-0.09	-0.26	-0.37	-0.25

4.11.13 The following is noted:

- Similar range of values across both sets of elasticity calculations. The matrix-based calculations show slightly more elastic results than the network-based calculations. This is to be expected as TAG Unit M2-1 notes; *the network calculation is likely to underestimate the fuel cost elasticity if the change in car-kms includes fixed elements, such as external to external.*
- The overall fuel cost elasticity is -0.29 (matrix based) which is within the range of -0.25 to -0.35 specified by TAG Unit M2-1.
- The pattern of average elasticities shows values for employers' business trips as -0.14, for other trips -0.4, and for commuting as -0.28, which broadly aligns with the expectations of TAG.
- The pattern of all-purpose elasticities shows peak period elasticities which are lower than interpeak elasticities which are lower than off-peak elasticities.

4.12 Summary

4.12.1 The modelling used throughout the Project is based on the NRTM. The base year model represents a representative March weekday in 2019. To update the model to a contemporary base year, during PCF Stage 3, the matrices have been updated from a base year of 2015 to a base year of 2019 and further refined to reflect further zone disaggregation.

4.12.2 To update the model to a contemporary base year, during PCF Stage 3, the car matrices have been updated from a base year of 2015 to a base year of 2019 using TEMPRO trip end data, and further refined to reflect further zone disaggregation.

4.12.3 The LGV matrix has been developed using 2019 Teletrac Navman data

4.12.4 Prior freight matrices based in 2018 were provided by TfN based on data supplied by MDS Transmodal,

4.12.5 The majority of the A66 model network remains unchanged from PCF Stage 2, however, several updates were required to develop the PCF Stage 3 model, to better represent conditions in the area around the Project. To complement these network changes, some additional zones were added to better represent network conditions.

4.12.6 The resultant model is stable and converges in a reasonable number of loops. A % GAP of less than 0.1% is achieved in all three models indicating that they have converged to satisfactory levels.

4.12.7 The assignment model meets TAG criteria in terms of screenline flow and journey time criteria. In terms of the demand model, the overall fuel cost elasticity is -0.29 which is within the range of -0.25 to -0.35 specified by TAG.

4.13 References

4.13.1 For further details on the information provided in Section 4.10, please see Appendix C: Transport Model Package.

5 Traffic Forecasts

5.1 Introduction

5.1.1 TAG Unit M4 – Forecasting and Uncertainty provides guidance for forecasting the impact of transport projects including option testing and appraisal. In transport scheme appraisal, modelling is used to establish the difference between two forecasts, without scheme and with scheme scenarios. In order to do this an understanding of errors and associated uncertainty and what impact this may have on the analysis is required.

5.1.2 This section of the report describes the following aspects:

- Model forecast years – which will be used to forecast economic benefits.
- Uncertainty log and core scenario – input assumptions of developments and infrastructure schemes, and selection for the core scenario.

5.2 Forecast years

5.2.1 The following forecast traffic model years have been defined based on information provided for scheme construction and data availability for predicting future demand:

- 2029 – scheme opening year
- 2044 –15 years post opening
- 2051 – additional model year

5.2.2 For economic appraisal TAG Unit M4 recommends that the final forecast years is as far into the future as possible. 2051 was chosen as this is the current horizon year to which DfT currently provide trip end forecasts.

5.3 Future year travel demand

DfT Traffic growth forecasts (National Trip End Model)

5.3.1 The DfT NTEM provides growth figures for trip origin and destination (or production/attraction[27]). The forecasts consider population, employment, housing, car ownership and trip rates.

5.3.2 Growth in demand is expressed by the number of trip ends providing an estimate of the total number of trips to or from a zone, split by trip purpose, mode and time period. Spatially they are disaggregated across an NTEM zoning system, covering the whole of Great Britain. NTEM zones for England and Wales are consistent with MSOAs, whilst for Scotland, NTEM zones are an aggregation of Data Zones (DZs).

5.3.3 NTEM v7.2 has been used for the Stage 3 model forecasting to calculate growth factors for both car and rail uses.

[27] Home-based trip ends are split by production (home) and attraction (the reason for travel). Across a suitably large geographical area, it is usually best to scale the attractions to match the productions, as the productions are based on the most relevant and reliable data (resident population) and the fit of production trip ends to planning assumptions is usually better.

5.3.4 Table 5-1 up to and including Table 5-3 show NTEM car growth for the forecast model years by the following trip purposes:

- Home-based work (HBW)
- Home-based employer's business (HBEB)
- Home-based other (HBO)
- All Purposes

5.3.5 The tables show increases by Production (P) and Attraction (A).

Table 5-1: 2019 – 2029 NTEM v7.2 Car Trip Growth

Region	HBW		HBEB		HBO		All Purposes	
	P	A	P	A	P	A	P	A
North East	6.9%	6.9%	8.2%	8.2%	8.8%	8.8%	8.0%	8.0%
North West	6.2%	6.2%	7.1%	7.1%	8.5%	8.5%	7.5%	7.5%
Other Regions	5.8%	5.8%	6.9%	6.9%	10.9%	10.9%	8.8%	8.8%
All Regions	5.9%	5.9%	7.0%	7.0%	10.6%	10.6%	8.6%	8.6%

Table 5-2: 2019 – 2044 NTEM v7.2 Car Trip Growth

Region	HBW		HBEB		HBO		All Purposes	
	P	A	P	A	P	A	P	A
North East	17.0%	17.0%	20.3%	20.3%	21.5%	21.5%	19.6%	19.6%
North West	15.2%	15.2%	17.6%	17.6%	20.6%	20.6%	18.3%	18.3%
Other Regions	14.1%	14.1%	16.9%	16.9%	24.3%	24.3%	20.0%	20.0%
All Regions	14.4%	14.4%	17.1%	17.1%	23.8%	23.8%	19.8%	19.8%

Table 5-3: 2019 – 2051 NTEM v7.2 Car Trip Growth

Region	HBW		HBEB		HBO		All Purposes	
	P	A	P	A	P	A	P	A
North East	21.7%	21.7%	26.2%	26.2%	28.3%	28.3%	25.6%	25.6%
North West	19.6%	19.6%	22.9%	22.9%	26.9%	26.9%	23.7%	23.7%
Other Regions	18.2%	18.2%	22.0%	22.0%	30.1%	30.1%	25.1%	25.1%
All Regions	18.5%	18.5%	22.3%	22.3%	29.6%	29.6%	24.9%	24.9%

Uncertainty log

5.3.6 An uncertainty log is required for transport model forecasting. The purpose of an uncertainty log is to record the central forecasting assumptions that underpin the core scenario, as well as uncertainty around those central assumptions. The uncertainty log should summarise all known uncertainties in the modelling and forecasting, listing each source of uncertainty together with the following information:

- The core scenario assumptions, describing development and infrastructure assumptions for the Central Case.
- The likelihood that the Project or development will go ahead.
- The range of assumptions around each input or parameter.

5.3.7 The initial data collection concentrated on interrogation of the planning portals to obtain submitted planning applications in all nearby Local Authority Districts for all live applications, applications approved in the last three years and potential developments up to local plan horizon years, or 2035 in the case of the TfN list of developments. Any built schemes along the A66 corridor since 2019 were identified and also included. Table 5-4 shows the information sources used to collect the uncertainty log data.

Table 5-4: Information Sources for Developments

Local Authority	Sources
Cumbria County Council	Strategic Economic Plan, Cumbria LEP Infrastructure Plan. Additional input from Eden District Council Local Plan, Carlisle District Local Plan, Copeland Borough Council Local Plan, Barrow in Furness Draft Local Plan, Allerdale District Local Plan, South Lakeland Local Plan, Lake District National Park Development Plan.
North Yorkshire County Council	Online planning portals, submitted planning applications, live and approved in the last three years. Additional input from Richmondshire District Council, Yorkshire Dales National Park Local Plan
Durham County Council	County Durham Plan – preferred options document, SHLAA
Darlington Borough Council	Darlington Employment Land Review, LDF Core Strategy, SHLAA
Hartlepool Council	Hartlepool Employment Land Review
Stockton Borough Council	Stockton Local Plan
Redcar and Cleveland Borough Council	South Tees Regeneration Masterplan
Middlesbrough Council	Middlesbrough Local Plan
Tees Valley Combined Authority	Strategic Infrastructure Plan
South Lakeland District Council	South Lakeland Local Plan
Gateshead Borough Council	Core Strategy and Urban Core Plan, Making Spaces for Growing Places
North Tyneside Council	North Tyneside Local Plan
Sunderland City Council	Sunderland Local Plan
Newcastle City Council	Core Strategy and Urban Core Plan, Newcastle Employment Land Review, SHLAA, Benwell Scotswood Area Action Plan
Transport for the North (TfN)	Draft Strategic Transport Plan, TfN Development Log

5.3.8 Updates were then applied using the latest information from the following sources:

- Local Development Plans and Planning portals,
- Council and National Highways websites,
- TfN development and infrastructure interventions Logs.

5.3.9 To ensure accuracy the uncertainty log was issued to Cumbria County Council (incorporating feedback from the district councils within Cumbria), Durham County Council, North Yorkshire County Council, Richmondshire District Council and Tees Valley Combined Authority (representing the councils within the Tees Valley) for their review and to update with any additional strategic sites not yet included. Responses were received from all and updates incorporated as appropriate.

5.3.10 All development data was entered with details provided of the data source, development location, planning reference, size, planning status and predicted trip generation where available.

5.3.11 An estimation of the number of jobs at each development type was required so that development sites could be filtered by size when identifying sites for inclusion in the core scenario and for the subsequent calculation of trip generation during the demand modelling process. Information collected on employment sites recorded in the uncertainty log generally covered development type and development size, (based on floor space size), but not necessarily the number of jobs. Therefore, a consistent approach was applied across all employment sites based on the site area and employment type categories

5.3.12 For each employment site job numbers were derived by taking the gross external area and converting to gross internal area, and then net floor area using factors developed from TRICs[28] (Trip Rate Information Computer System) data. The net floor area per employment type was then used to calculate the total number of jobs of that type using data from the “Homes & Communities Agency – Employment Density Guide – 3rd Edition – November 2015”.

5.3.13 For developments within the Core Area (see 5.3.16 below), Transport Assessments were found, and their trip generation data recorded to incorporate more accurate trip data.

Core scenario

5.3.14 The complete uncertainty log contains all the sites identified in the data collection process regardless of certainty level, geographical location or size. In selecting development sites for inclusion in the core scenario, filters were applied as follows:

- Level of Certainty – Filter applied in line with TAG (Near Certain or More than Likely).
- Geographical Location – Filters were applied to sites geographically to select those within the core boundary, noting that for development sites remote from the Project there would be little difference in traffic impact if these schemes were explicitly represented in the model or included as part of the overall TEMPRO growth.
- Size of Development – Similarly filters were applied based on the size of individual development and whether it was ‘big enough’, noting that for developments that did not generate much traffic there would be little difference in traffic impact if these schemes were explicitly

28 http://www.trics.org/system.html

represented in the model or included as part of the overall TEMPRO growth.

5.3.15 In summary only those developments that were considered ‘near certain’ or ‘more than likely’, within the core area and considered ‘big enough’ were included in the future year modelling. All developments classed as ‘reasonably foreseeable’ and ‘hypothetical’, have been excluded.

5.3.16 For selection of core scenario developments, a boundary was drawn up based on a combination of development density, Local Authority Districts and geographical proximity to the A66. The core and wider area can be described as:

- Core area – the A66 corridor largely including the south-west part of County Durham comprising Barnard Castle and the Borough of Darlington, Richmondshire District Council and the Eden District of Cumbria.
- Wider area – area outside of the core area (largely including Cumbria, County Durham, Northumberland and Local Authorities in Tyne & Wear and the Tees Valley).

5.3.17 Size criteria for developments based on number of households for residential developments or jobs for employment developments were established. In developing the criteria, consideration was given to the level of trip generation that might impact on the A66 corridor traffic, given that background trip end growth is contained within NTEM, which is used to account for traffic growth from smaller developments.

5.3.18 The size criteria for the inclusion of developments in the core scenario was based on the following thresholds:

Core area:

- over 200 jobs for employment sites
- over 100 dwellings for residential sites

Wider area:

- over 500 jobs for employment sites
- over 250 dwellings for residential sites

Developments

5.3.19 Figure 5-1 shows both the core scenario developments and other developments included in the uncertainty log, the core boundary. Those that are included within the core scenario are both large enough to be considered and are likely enough to come forward. Figure 5-2 and Figure 5-3 show all core area employment and residential developments.

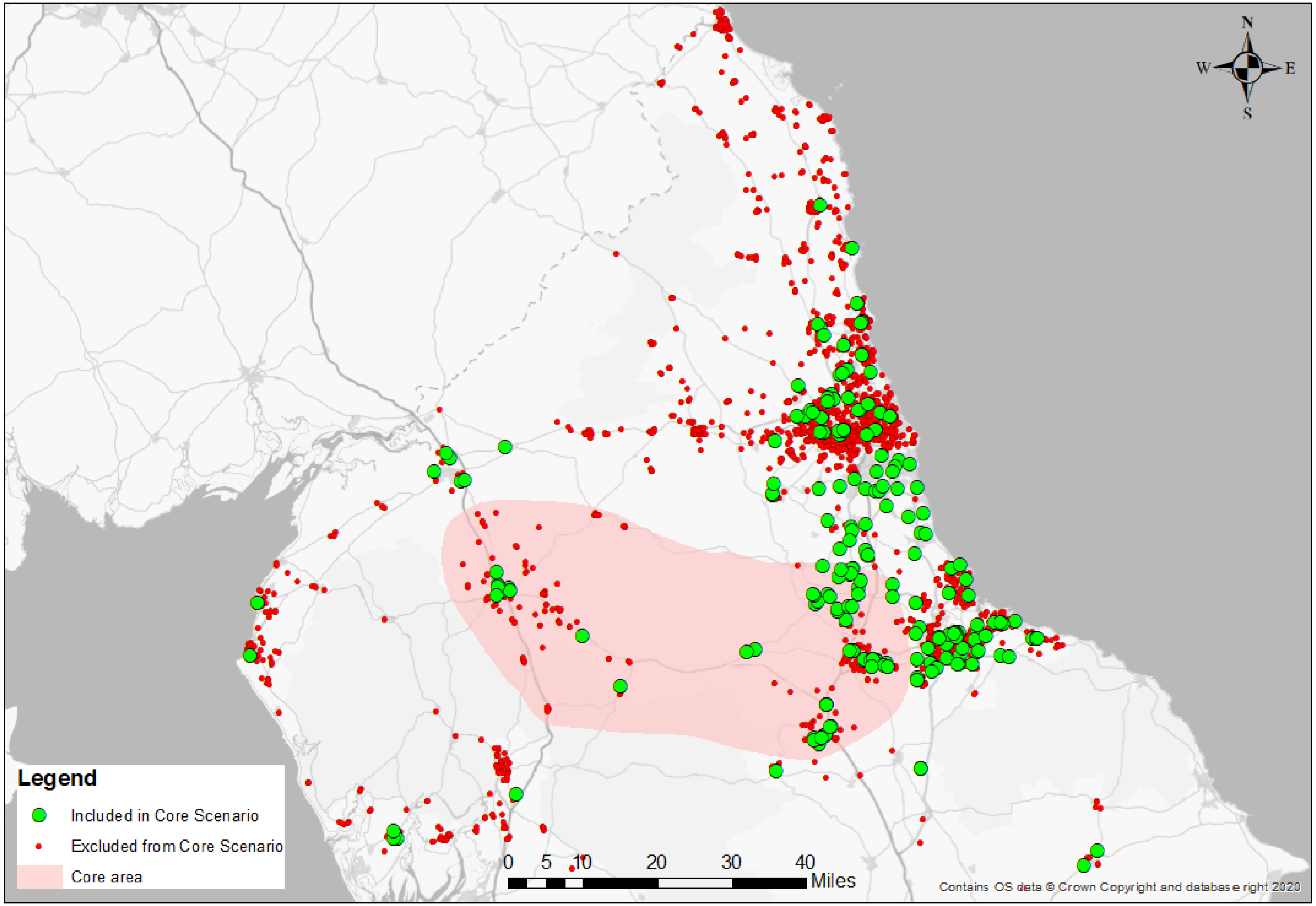

Figure 5-1: All Uncertainty Log Developments

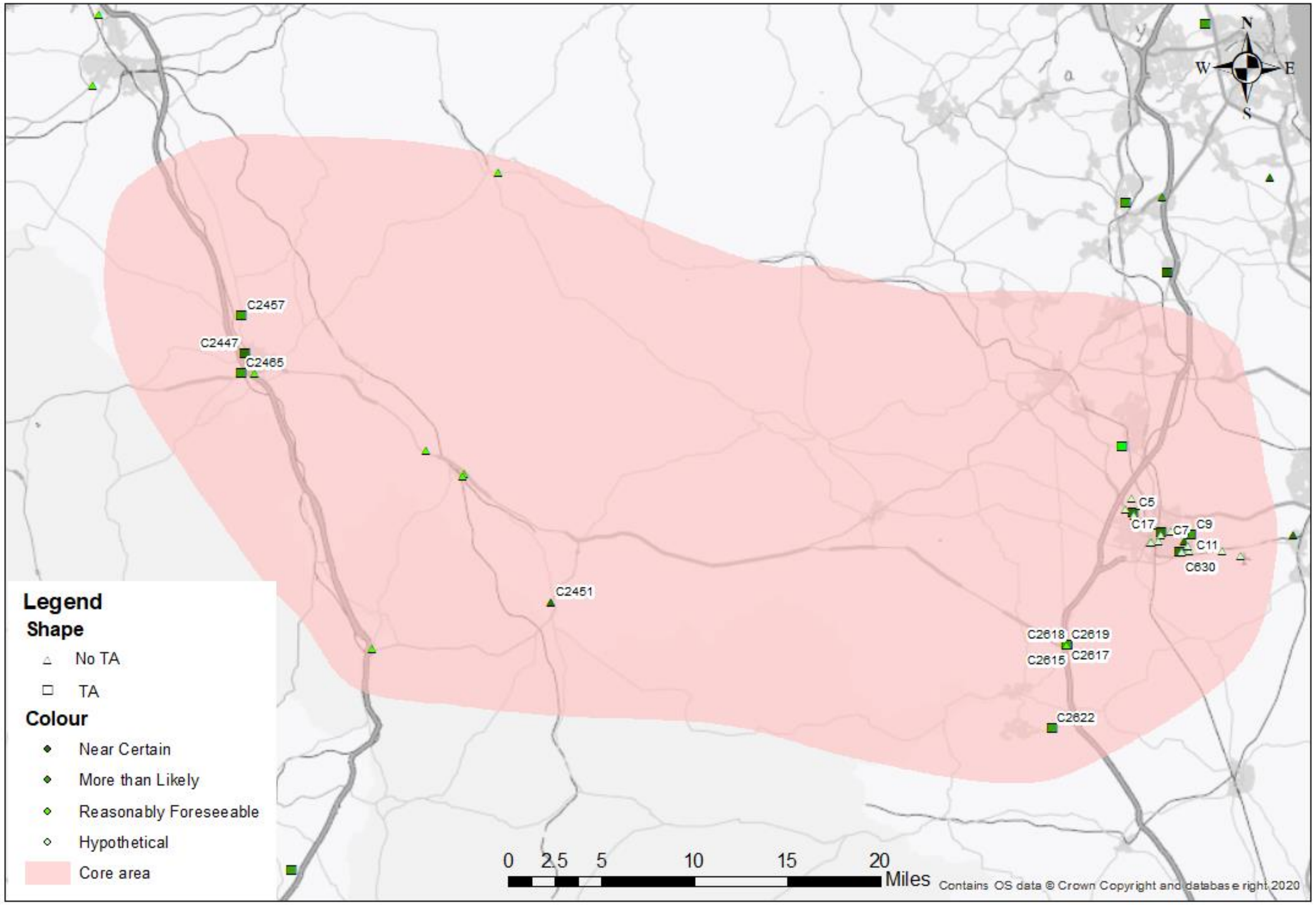

Figure 5-2: Core Area Employment Sites

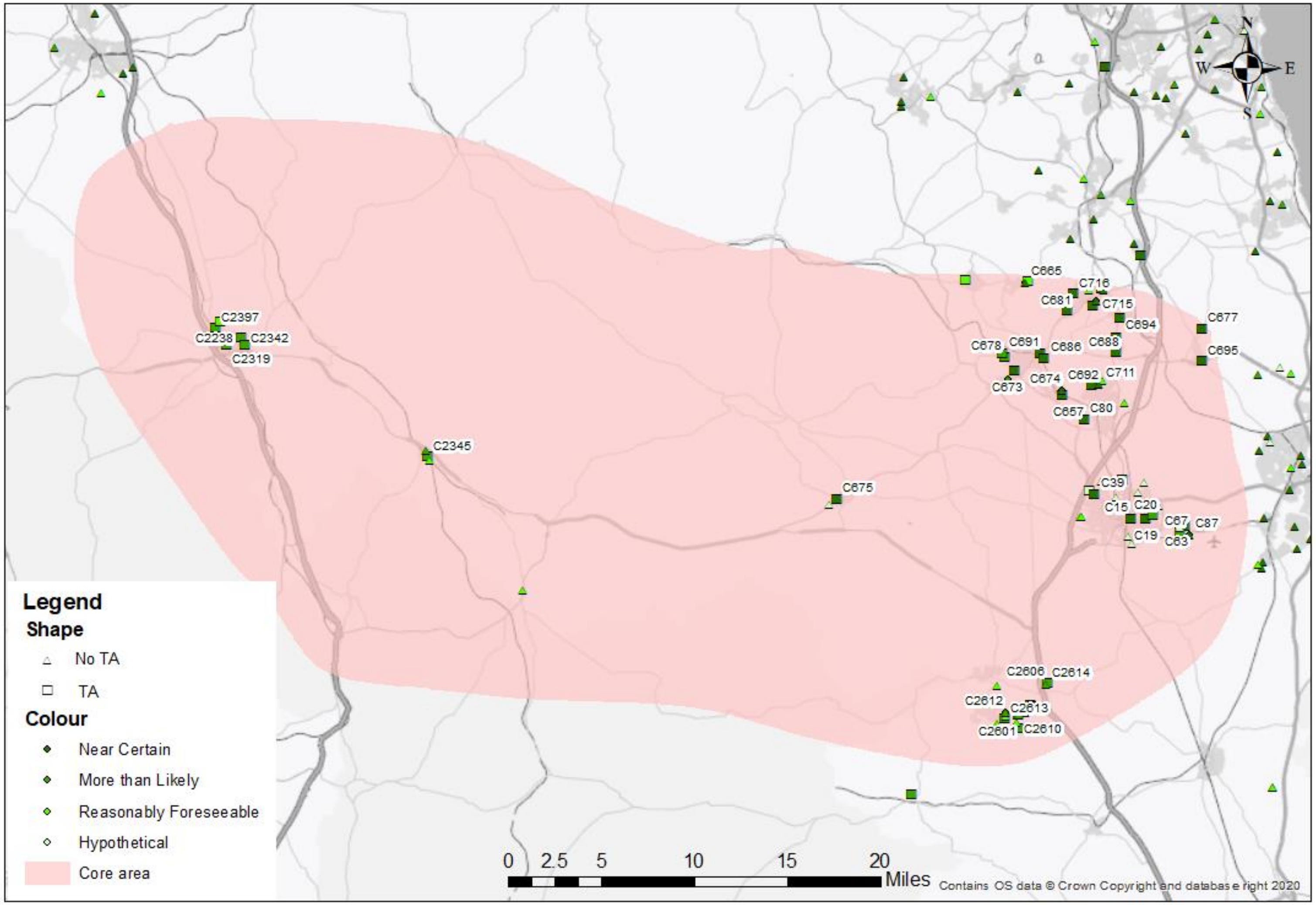

Figure 5-3: Core Area Residential Developments

5.3.20 The following sites are of particular interest in terms of their size and location in the A66 corridor area, all of which are included in the core scenario:

- A66 route:
  - C2615 – Scotch Corner Designer Outlet – 822 estimated jobs.
  - C2618 – Scotch Corner Garden Centre – 822 estimated jobs.
  - C2238 – Residential Development at Carleton Fields, Carleton Heights, Penrith – 505 houses.
- North Penrith:
  - C2397 – Residential Development at Raiselands Farm, Penrith – 299 houses.
  - C2457– Eden 41 Business Park – 420 estimated jobs.
- County Durham:
  - C716 – Residential Development Whitworth Park – 726 houses.
  - C686 – Land South of Douglas Crescenthouses – 500 houses.
- Catterick Garrison:
  - C69 – DIO Catterick Service Family Accommodation (Breckenbrough Lane) – 155 houses.
  - C2631 – Residential Development at Catterick Garrison – 160 houses.
- Darlington:
  - C630 – Employment development at Ingenium Parc – 1,536 estimated jobs.
  - C39 – West Park Garden Village – 1,200 houses.
  - C175 – Lingfield Point – 1,140 estimated jobs.

5.3.21 The uncertainty log identifies a large area of residential development at Carleton, Penrith, and significant development anticipated in Darlington, as this is identified in the core scenario it indicates that it is not dependent on the A66 corridor scheme.

5.4 Goods vehicles

5.4.1 Freight growth factors for goods vehicles are based on Road Traffic Forecasts (RTF) 2018 Scenario 1 which uses central projections of GDP, fuel price, and population. RTF data is provided on a five yearly basis from 2015 to 2050. Factors for the modelled years were calculated by interpolating the RTF data.

5.4.2 LGV and HGV growth from the RTF data used for forecasting are provided in Table 5-5 and Table 5-6.

Table 5-5: RTF Growth vs 2019 - LGVs

Region	2029	2044	2051
North East	12%	34%	42%
North West	11%	33%	41%
Yorkshire and Humber	15%	37%	45%
East Midlands	13%	35%	43%
Eastern England	11%	33%	41%
South East	12%	34%	42%
London	11%	33%	40%
South West	13%	36%	44%
West Midlands	12%	34%	42%
Wales	11%	34%	41%
All Regions	12%	34%	42%

Table 5-6: RTF Growth vs 2019 - HGVs

Region	2029	2044	2051
North East	-1%	3%	5%
North West	4%	13%	17%
Yorkshire and Humber	1%	4%	5%
East Midlands	-1%	2%	3%
Eastern England	0%	3%	5%
South East	4%	14%	19%
London	0%	2%	3%
South West	0%	5%	7%
West Midlands	0%	5%	7%
Wales	0%	3%	5%
All Regions	1%	7%	9%

5.4.3 Growth for Scotland was assumed the same as that for England and Wales in line with the assumption made within the development of RTM2.

VDM generalised costs

5.4.4 The methodology for using generalised costs in the forecast models align with the NRTM development methodology. The growth between 2019 and future year generalised costs in the v1.17 November Databook has been applied to the 2019 v1.15 data book values to calculate forecast VoT and VoC parameters for the forecast years 2029, 2044 and 2051 (see Table 5-7 up to and including Table 5-12).

Table 5-7: Value of Time Costs 2029 Parameters – PPM

Element	User Class	AM Peak	Inter Peak	PM Peak
Car	Employers Business	34.34	35.19	34.84
	Commute	23.03	23.41	23.11
	Other	15.89	16.93	16.64
LGV		24.89	24.89	24.89
HGV		49.78	49.78	49.78

Table 5-8: Vehicle Operating Cost 2029 Parameters – PPK

Element	User Class	AM Peak	Inter Peak	PM Peak
Car	Employers Business	10.97	10.97	10.97
	Commute	5.28	5.28	5.28
	Other	5.28	5.28	5.28
LGV		13.20	13.20	13.20
HGV		41.27	41.27	41.27

Table 5-9: Value of Time Costs 2044 Parameters – PPM

Element	User Class	AM Peak	Inter Peak	PM Peak
Car	Employers Business	42.34	43.39	42.95
	Commute	28.39	28.86	28.49
	Other	19.59	20.87	20.51
LGV		30.68	30.68	30.68
HGV		61.37	61.37	61.37

Table 5-10: Vehicle Operating Cost 2044 Parameters – PPK

Element	User Class	AM Peak	Inter Peak	PM Peak
Car	Employers Business	8.59	8.59	8.59
	Commute	4.01	4.01	4.01
	Other	4.01	4.01	4.01
LGV		11.56	11.56	11.56
HGV		38.81	38.81	38.81

Table 5-11: Value of Time Costs 2051 Parameters – PPM

Element	User Class	AM Peak	Inter Peak	PM Peak
Car	Employers Business	46.34	47.48	47.01
	Commute	31.08	31.58	31.18
	Other	21.21	22.84	22.45
LGV		33.58	33.58	33.58
HGV		67.16	67.16	67.16

Table 5-12: Vehicle Operating Cost 2051 Parameters – PPK

Element	User Class	AM Peak	Inter Peak	PM Peak
Car	Employers Business	8.31	8.31	8.31
	Commute	3.86	3.86	3.86
	Other	3.86	3.86	3.86
LGV		11.13	11.13	11.13
HGV		39.22	39.22	39.22

5.5 Forecast matrix development

Development trips

5.5.1 Trips for developments selected to be explicitly represented in the model forecast demand have been included as follows:

- Trip generation – establish the number of trips produced or attracted to a development sites based on quantum of households or jobs;
- Trip distribution – distribute the development trips across the model zone system, based on existing distributions within the model;
- Constraining to Balancing Areas – controlling overall trip growth so that the development and background trips comply with NTEM growth forecasts. The NTEM control is applied using designated balancing areas.

5.5.2 With the Uncertainty log providing numbers of dwellings and jobs per site, trip ends were established for each development as follows:

- Car – trip rates taken from NTEM v7.2, establishing trip rates per dwelling of job for each model demand segment.
- Goods vehicles – the proportion of goods vehicles per car trip ends were calculated using the TRICS 7.6.2 database, selecting a comprehensive set of sites across England, Wales and Scotland to derive different proportions for the development types used in the uncertainty log. Proportions were calculated by comparing TRICS goods trips rates against the TRICS car trip rates.

5.5.3 With using the TRICS database for goods trips, very few, if any, sites existed with matching geographical and employment profiles as our developments. Therefore, data from the whole of England, Wales and Scotland was used to give a good sample of representative sites.

5.5.4 Employment sites from the uncertainty log were classified into the different TRICS employment type categories, with sites of a mixed nature being allocated across more than one employment type. Using TRICS data in this way provides a suitable representation of goods vehicle development trips in the absence of NTEM goods vehicle trip rates.

5.5.5 Rather than apply the goods trip rates directly to the uncertainly log developments, the proportion of goods trips to car trips was calculated and subsequently applied to the NTEM car trip rates. The proportion system was used due to the discrepancy in NTEM car trip rates to that of TRICS. Forecasting the goods trips as a proportion of car trips ensures the relative trip rates per land use type are respected whilst also retaining a proportionate ratio of trips between cars and goods vehicles.

5.5.6 Car trip rates used are summarised below in Table 5-13 for Local Authorities situated in the Core model area.

Table 5-13: Car vehicle trip rates from NTEM

Local Authority	HBEB		HBW		HBO		NHBEB		NHBO	
	Prod	Attr	*Prod*	*Attr*	Prod	Attr	Orig	Dest	Orig	Dest
24-hour trip rates per job										
Cleveland	0.00	0.05	0.00	0.35	0.00	0.54	0.07	0.07	0.23	0.23
Durham	0.00	0.05	0.00	0.35	0.00	0.51	0.07	0.07	0.23	0.22
Cumbria	0.00	0.05	0.00	0.34	0.00	0.53	0.07	0.07	0.22	0.23
North Yorkshire	0.00	0.05	0.00	0.34	0.00	0.52	0.07	0.07	0.23	0.22
24-hour trip rates per dwelling										
Cleveland	0.05	0.00	0.33	0.00	0.60	0.09	0.00	0.00	0.00	0.00
Durham	0.05	0.00	0.36	0.00	0.62	0.09	0.00	0.00	0.00	0.00
Cumbria	0.06	0.00	0.38	0.00	0.68	0.09	0.00	0.00	0.00	0.00
North Yorkshire	0.06	0.00	0.40	0.00	0.71	0.10	0.00	0.00	0.00	0.00

5.5.7 The proportion of goods vehicles forecast per development type are shown below in Table 5-14 at a 24 hour level.

Table 5-14: Goods vehicle trip rate proportions calculated from TRICS

Local Authority	LGV	HGV
Office	5%	1%
Business Park	5%	1%
Industrial Unit	5%	1%
Industrial Estate	6%	1%
Warehousing	13%	9%
Hotels	23%	8%
Residential	40%	3%

5.5.8 In addition to trip rates being developed and applied, an extensive data collection exercise was undertaken to collate the Transport Assessments (TA) developed for each of the developments listed in the uncertainty log. Where available, forecast trip levels were generally only provided for the peak hours. Therefore, where TAs were available, NTEM trip rates for the respective developments were scaled to align with those forecast by the detailed assessments.

5.5.9 To distribute the generated trips, developments were assigned to model zones primarily based on their location. Where a site area covered multiple zones, a single zone was chosen based on land usage composition being most like the development. The distribution from these assigned zones was then used to distribute the trips using a

SATURN based approach taking distribution proportions from the base matrix.

5.5.10 The Eden 41 Business Park and Scotch Corner Designer Outlet were deemed too large and close to the Project to load onto an existing zone, and without the supporting existing network connectivity. Two new zones were therefore created specifically for these developments. The trip distributions for these new zones were sourced from multiple nearby zones providing distribution compositions considered similar in land usage to the respective developments.

5.5.11 For the Scotch Corner Retail Park trip the distribution is based on multiple donor zones selected nearby to the site covering a mix of rural and urban locations, including Darlington town centre, to reflect the different trip patterns that would be expected at the site.

Balancing areas

5.5.12 Balancing areas were used to control the background growth to a level which results in an overall growth, including the development trips, in line with NTEM. Balancing areas are collections of zones, in this case representing grouped District areas, where the demand will be constrained to an overall growth level for each forecast year.

5.5.13 The balancing areas used are shown in Figure 5-4. The ‘External Model Areas’ balancing area represents areas where there are no explicitly modelled developments. The balancing areas were used in HEIDI as part of its standard approach to forecast demand development process.

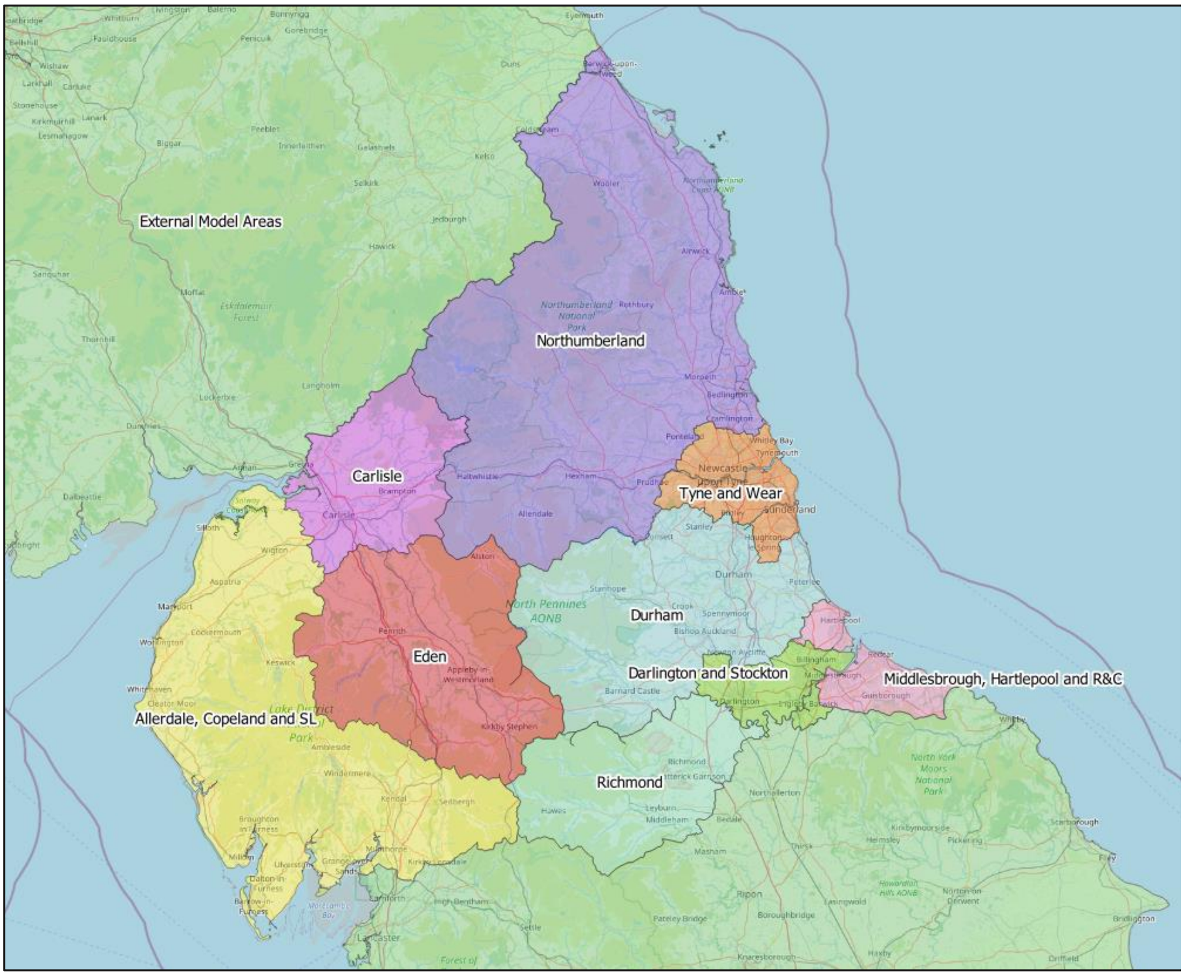

Figure 5-4: Balancing Areas

Combined reference forecast demand

5.5.14 The reference forecast refers to the forecast demand growth factors being applied to the base demand but without taking account of changes in cost which are later included through VDM. These matrix totals are presented for Employer's Business (EB), Commute, Other, LGV and HGV user classes in Table 5-15, Table 5-16Table 5-15 Table 5-16 and Table 5-17Table 5-17 below.

Table 5-15: Highway Reference Forecast Demand - AM Peak (pcu/hr)

Vehicle type/ purpose	2019 Base	2029 Ref	Growth %	2044 Ref	Growth %	2051 Ref	Growth %
EB	579,018	618,377	6.80%	675,028	16.58%	703,389	21.48%
Commute	3,302,016	3,500,883	6.02%	3,785,833	14.65%	3,924,863	18.86%
Other	1,646,480	1,815,335	10.26%	2,029,278	23.25%	2,125,006	29.06%
LGV	751,106	842,229	12.13%	1,009,005	34.34%	1,065,760	41.89%
HGV	284,138	283,591	-0.19%	294,772	3.74%	300,131	5.63%
Total	6,562,758	7,060,415	7.58%	7,793,917	18.76%	8,119,149	23.72%

Table 5-16: Highway Reference Forecast Demand - IP Peak (pcu/hr)

Vehicle type/ purpose	2019 Base	2029 Ref	Growth %	2044 Ref	Growth %	2051 Ref	Growth %
EB	508,367	542,564	6.73%	591,676	16.39%	616,210	21.21%
Commute	1,300,580	1,379,132	6.04%	1,491,595	14.69%	1,546,497	18.91%
Other	2,918,620	3,219,595	10.31%	3,599,782	23.34%	3,769,546	29.16%
LGV	561,879	630,230	12.16%	755,024	34.37%	797,483	41.93%
HGV	267,153	266,621	-0.20%	277,128	3.73%	282,166	5.62%
Total	5,556,599	6,038,142	8.67%	6,715,204	20.85%	7,011,902	26.19%

Table 5-17: Highway Reference Forecast Demand - PM Peak (pcu/hr)

Vehicle type/ purpose	2019 Base	2029 Ref	Growth %	2044 Ref	Growth %	2051 Ref	Growth %
EB	605,848	646,883	6.77%	705,853	16.51%	735,365	21.38%
Commute	2,716,123	2,880,057	6.04%	3,114,865	14.68%	3,229,375	18.90%
Other	3,225,905	3,561,127	10.39%	3,984,065	23.50%	4,172,809	29.35%
LGV	546,359	612,634	12.13%	733,940	34.33%	775,217	41.89%
HGV	199,293	198,917	-0.19%	206,783	3.76%	210,551	5.65%
Total	7,293,528	7,899,617	8.31%	8,745,506	19.91%	9,123,317	25.09%

5.5.15 Input and output model growth by vehicle type/ purpose for each forecast year is shown below in Table 5-18, comparing trip growth from NTEM or RTF (input trip growth) and the trip growth from the SATURN reference matrices (output trip growth), across the full model. The table shows the growth in the reference case matrices align with that in the respective forecast at a national level.

Table 5-18: Input and Model Vehicle Trip Growth

Vehicle type/ purpose	2029		2044		2051	
	NTEM/ RTF	Model	NTEM/ RTF	Model	NTEM/ RTF	Model
Car – EB	6%	7%	15%	16%	20%	21%
Car – Commute	5%	6%	14%	15%	18%	19%
Car – Other	9%	10%	22%	23%	28%	29%
LGV	12%	12%	34%	34%	42%	42%
HGV	1%	0%	7%	4%	9%	6%

Dependent development

5.5.16 Dependent development refers to new development that is dependent on the provision of a transport scheme and for which, with the new development but in the absence of the transport scheme, the existing transport network would not provide a reasonable level of service to existing and/or new users. This has the implication that the development would not be delivered in the absence of the transport scheme.

5.5.17 Based on the information listed in uncertainty log no dependant supply or land use developments were identified. Accordingly, dependency testing has not been undertaken.

5.6 Impact of variable demand modelling

5.6.1 Two scenarios have been developed:

- The Do Minimum (DM) forecasts reflects forecast conditions in the assessment year with all of the committed development and forecast year population in place, subject to the correct forecast year travel costs.
- The Do Something (DS) network reflects the Do Minimum (DM) forecast but with the addition of the A66 Northern Trans-Pennine Route Project.

Highway assignment model convergence

5.6.2 TAG Unit M3.1 provides guidance on assignment model convergence and stability, which is set out below in Table 5-19, and has been used as the acceptability convergence criteria for the model.

Table 5-19: Convergence Criteria – TAG Unit M3.1

Measure	Criteria
Convergence Gap	Adopt TAG criteria 0.1%
Percentage of links with flow change (P)<1%	Adopt TAG criteria – 4 iterations >98%
Percentage of links with cost change (P2)<1%	Adopt TAG criteria – 4 iterations >98%

5.6.3 Highway assignment model convergence for each forecast scenario is presented in tables Table 5-20 to

5.6.4 Table 5-25. Convergence has been assessed for the final four loops of the following scenarios:

- DM (Do Minimum) 2029 (Table 5-20)
- DM 2044 (Table 5-21)
- DM 2051(Table 5-22)
- DS (Do Something) 2029 (Table 5-23)
- DS 2044 (Table 5-24)
- DS 2051 (Table 5-25)

Table 5-20: DM Convergence Statistics (2029)

AM Peak			Inter Peak			PM Peak		
Loop	% Flow	% GAP	Loop	% Flow	% GAP	Loop	% Flow	% GAP
18	98.7	0.000	18	98.6	0.000	35	98.5	0.001
19	98.6	0.001	19	98.8	0.000	36	99.1	0.001
20	98.7	0.000	20	98.5	0.000	37	98.8	0.001
21	99.0	0.000	21	99.2	0.000	38	99.1	0.001

Table 5-21: DM Convergence Statistics (2044)

AM Peak			Inter Peak			PM Peak		
Loop	% Flow	% GAP	Loop	% Flow	% GAP	Loop	% Flow	% GAP
29	98.7	0.001	25	98.7	0.000	28	98.8	0.002
30	98.6	0.001	26	98.8	0.000	29	98.8	0.001

AM Peak			Inter Peak			PM Peak		
31	98.8	0.001	27	98.9	0.000	30	98.9	0.001
32	98.5	0.001	28	98.9	0.000	31	98.6	0.001

Table 5-22: DM Convergence Statistics (2051)

AM Peak			Inter Peak			PM Peak		
Loop	% Flow	% GAP	Loop	% Flow	% GAP	Loop	% Flow	% GAP
42	98.8	0.001	27	98.7	0.000	35	98.8	0.002
43	98.8	0.001	28	98.8	0.000	36	98.7	0.002
44	99	0.001	29	99	0.000	37	98.8	0.002
45	99.1	0.001	30	99.0	0.000	38	98.7	0.002

Table 5-23: DS Convergence Statistics (2029)

AM Peak			Inter Peak			PM Peak		
Loop	% Flow	% GAP	Loop	% Flow	% GAP	Loop	% Flow	% GAP
19	98.5	0.000	18	98.8	0.000	29	98.6	0.001
20	98.8	0.000	19	98.5	0.000	30	98.9	0.001
21	98.8	0.001	20	99.1	0.000	31	98.8	0.002
22	98.7	0.000	21	98.9	0.000	32	98.7	0.001

Table 5-24: DS Convergence Statistics (2044)

AM Peak			Inter Peak			PM Peak		
Loop	% Flow	% GAP	Loop	% Flow	% GAP	Loop	% Flow	% GAP
31	98.9	0.001	21	98.8	0.000	28	98.6	0.002
32	98.9	0.001	22	98.9	0.000	29	98.7	0.002
33	99.2	0.001	23	99.1	0.000	30	98.6	0.002
34	98.9	0.001	24	98.5	0.000	31	98.8	0.001

Table 5-25: DS Convergence Statistics (2051)

AM Peak			Inter Peak			PM Peak		
Loop	% Flow	% GAP	Loop	% Flow	% GAP	Loop	% Flow	% GAP
46	98.8	0.001	26	98.6	0.001	34	98.6	0.003
47	99	0.001	27	98.8	0.000	35	98.7	0.002
48	98.6	0.001	28	98.7	0.001	36	98.8	0.002
49	99.1	0.001	29	99.0	0.000	37	98.7	0.002

5.6.5 The assignment convergence statistics provided in Table 5-20 to

5.6.6 Table 5-25 show that all models converge within a reasonable number of iterations, such that the rate of improvement of the convergence statistics is uniform and does not slow significantly or bottom out as the stopping criterion are approached.

Forecast network performance

5.6.7 The network performance statistics are based on assigned traffic in the SATURN assignment model. The tables below show the network statistic scenario values and differences between scenarios as follows:

- Table 5-26 – Network Statistics, Values – 2029
- Table 5-27 – Network Statistics, Differences – 2029
- Table 5-28 – Network Statistics, Values 2044
- Table 5-29– Network Statistics, Differences – 2044
- Table 5-30 – Network Statistics, Values – 2051
- Table 5-31 – Network Statistics, Differences – 2051.

5.6.8 Values in the tables represent the following:

- Time – Total Travel Time, pcu hours (000)
- Distance – Total Distance Travelled, pcu kms (000)
- Speed – Total Average Speed, kph
- Trips – Total Trip, (pcu/hr)

Table 5-26: Network Statistics – Values 2029

Scenario	Time Period	Time	Distance	Speed	Trips
Base 2019	AM	1,701	120,229	71	1,545,821
	IP	1,189	86,941	73	1,161,397
	PM	1,629	115,082	71	1,555,659
Reference Forecast	AM	1,845	128,636	70	1,657,070
	IP	1,291	93,093	72	1,248,207
	PM	1,768	123,303	70	1,671,213
DM Post VDM	AM	1,948	135,917	70	1,723,445
	IP	1,361	98,234	72	1,297,441
	PM	1,872	130,646	70	1,739,898
DS Post VDM	AM	1,948	135,952	70	1,723,432
	IP	1,361	98,286	72	1,297,536
	PM	1,872	130,701	70	1,739,929

Table 5-27: Network Statistics – Differences 2029

Scenario	Time Period	Time	Distance	Speed	Trips
Reference vs. Base	AM	144 (8%)	8,408 (7%)	-1 (-1%)	111,250 (7%)
	IP	102 (9%)	6,152 (7%)	-1 (-1%)	86,810 (7%)
	PM	139 (9%)	8,221 (7%)	-1 (-1%)	115,554 (7%)

DM Post VDM vs Reference	AM	103 (6%)	7,281 (6%)	0 (0%)	66,374 (4%)
	IP	70 (5%)	5,141 (6%)	0 (0%)	49,235 (4%)
	PM	104 (6%)	7,343 (6%)	0 (0%)	68,686 (4%)
DS Post VDM vs DM Post VDM	AM	0 (0%)	35 (0%)	0 (0%)	-13 (0%)
	IP	0 (0%)	52 (0%)	0 (0%)	94 (0%)
	PM	0 (0%)	55 (0%)	0 (0%)	31 (0%)

Table 5-28: Network Statistics – Values 2044

Scenario	Time Period	Time	Distance	Speed	Trips
Base 2019	AM	1,701	120,229	71	1,545,821
	IP	1,189	86,941	73	1,161,397
	PM	1,629	115,082	71	1,555,659
Reference Forecast	AM	2,070	141,981	69	1,830,005
	IP	1,449	102,845	71	1,382,029
	PM	1,982	135,927	69	1,845,210
DM Post VDM	AM	2,348	161,311	69	2,004,630
	IP	1,641	116,577	71	1,513,876
	PM	2,263	155,486	69	2,026,913
DS Post VDM	AM	2,348	161,357	69	2,004,627
	IP	1,641	116,653	71	1,513,999
	PM	2,264	155,555	69	2,026,906

Table 5-29: Network Statistics – Differences 2044

Scenario	Time Period	Time	Distance	Speed	Trips
Reference vs. Base	AM	369 (22%)	21,752 (18%)	-2 (-3%)	284,184 (18%)
	IP	260 (22%)	15,903 (18%)	-2 (-3%)	220,632 (19%)
	PM	353 (22%)	20,846 (18%)	-2 (-3%)	289,551 (19%)
DM Post VDM vs Reference	AM	279 (13%)	19,331 (14%)	0 (0%)	174,625 (10%)
	IP	192 (13%)	13,733 (13%)	0 (0%)	131,848 (10%)
	PM	281 (14%)	19,559 (14%)	0 (0%)	181,703 (10%)
DS Post VDM vs DM Post VDM	AM	0 (0%)	46 (0%)	0 (0%)	-3 (0%)
	IP	0 (0%)	76 (0%)	0 (0%)	123 (0%)

Scenario	Time Period	Time	Distance	Speed	Trips
	PM	0 (0%)	69 (0%)	0 (0%)	-7 (0%)

Table 5-30: Network Statistics – Values 2051

Scenario	Time Period	Time	Distance	Speed	Trips
Base 2019	AM	1,701	120,229	71	1,545,821
	IP	1,189	86,941	73	1,161,397
	PM	1,629	115,082	71	1,555,659
Reference Forecast	AM	2,168	147,994	68	1,908,303
	IP	1,519	107,282	71	1,443,365
	PM	2,078	141,764	68	1,926,326
DM Post VDM	AM	2,490	170,241	68	2,108,685
	IP	1,742	123,151	71	1,595,396
	PM	2,403	164,265	68	2,134,907
DS Post VDM	AM	2,490	170,290	68	2,108,687
	IP	1,742	123,232	71	1,595,534
	PM	2,403	164,342	68	2,134,951

Table 5-31: Network Statistics – Differences 2051

Scenario	Time Period	Time	Distance	Speed	Trips
Reference vs. Base	AM	467 (27%)	27,765 (23%)	-2 (-3%)	362,482 (23%)
	IP	330 (28%)	20,341 (23%)	-3 (-3%)	281,968 (24%)
	PM	449 (28%)	26,682 (23%)	-2 (-3%)	370,667 (24%)
DM Post VDM vs Reference	AM	322 (15%)	22,247 (15%)	0 (0%)	200,382 (11%)
	IP	223 (15%)	15,868 (15%)	0 (0%)	152,031 (11%)
	PM	325 (16%)	22,501 (16%)	0 (0%)	208,582 (11%)
DS Post VDM vs DM Post VDM	AM	0 (0%)	50 (0%)	0 (0%)	3 (0%)
	IP	0 (0%)	82 (0%)	0 (0%)	138 (0%)
	PM	0 (0%)	78 (0%)	0 (0%)	43 (0%)

5.6.9 The network performance statistics show that the main changes occur between the base and reference forecast, as a result of the assigned trip growth, and then to a lesser extent between reference forecast and DM as a result of the VDM response to change in costs. The differences between the DM and DS are minor in comparison, as would be expected considering the only model input change is the A66 Project network. This pattern is consistent across the time periods and years.

5.7 Forecast results

Forecast traffic flows

5.7.1 Forecast traffic flows for each forecast year are shown below for the A66 corridor, and mainline M6 eitherside of J40 and likewise for A1(M) Scotch Corner:

- Table 5-32 _bookmark108- 12-Hour Traffic Flows (vehicles, two-way) – 2029
- Table 5-33 - 12-Hour Traffic Flows (vehicles, two-way) – 2044
- Table 5-34 _bookmark110- 12-Hour Traffic Flows (vehicles, two-way) – 2051

5.7.2 A map showing the link locations where traffic flows have been extracted from the model is provided in Figure 5-5.

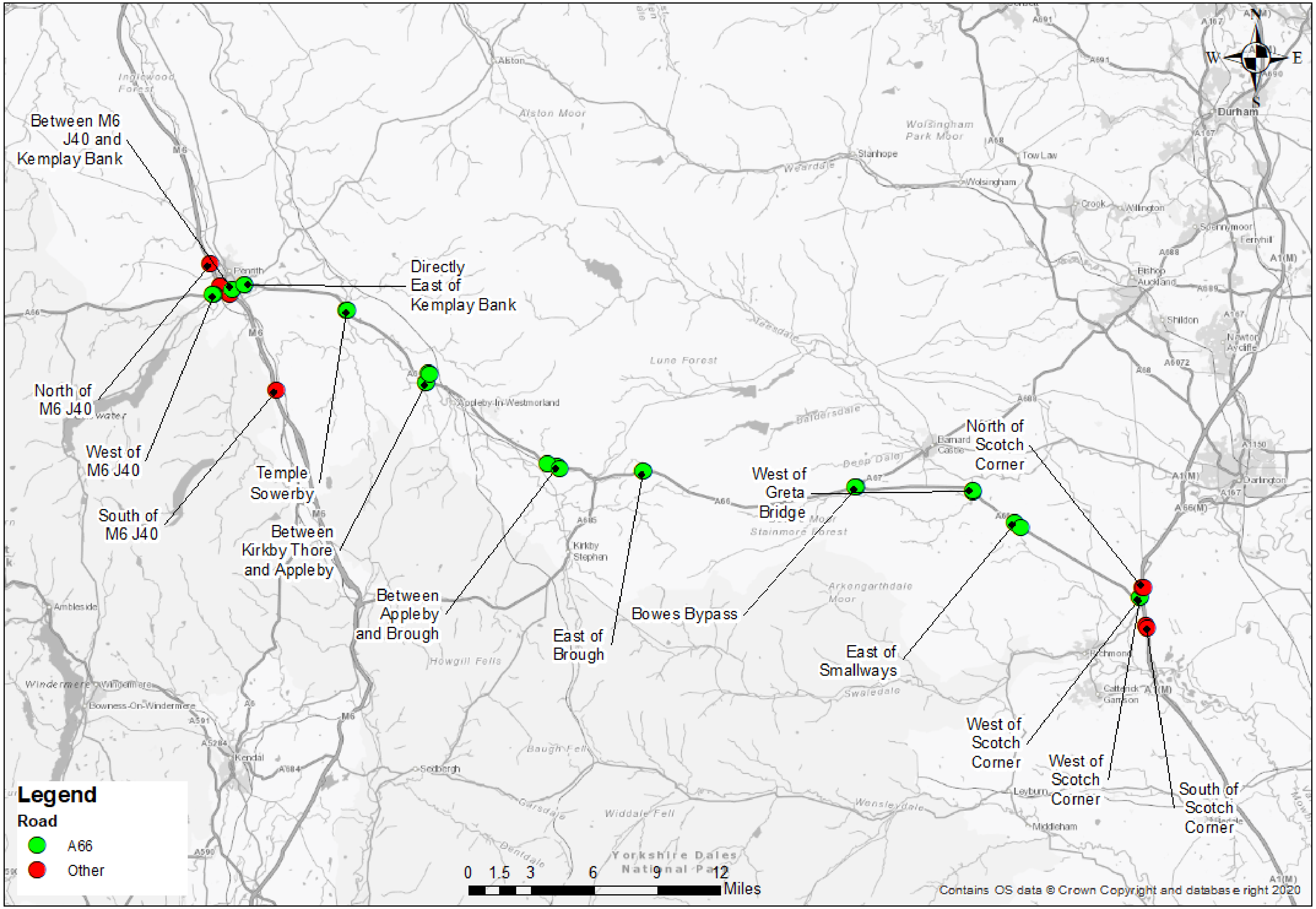

Figure 5-5: A66 Traffic Flow Locations

Table 5-32: 12-Hour Traffic Flows (vehicles, two-way) - 2029

Road	Location	Base 2019	Reference	DM Post VDM	DS Post VDM	DM Ref vs. Base	DM Post VDMvs. Ref	DS Post VDM vs. DM Post VDM
A66	West of M6 J40	16,584	17,687	18,644	19,307	**1,103 (7%)**	**957 (5%)**	**663 (4%)**
A66	Between M6 J40 and Kemplay Bank	25,699	27,502	29,319	33,508	**1,802 (7%)**	**1,818 (7%)**	**4,189 (14%)**
A66	Directly East of Kemplay Bank	17,598	19,073	19,968	25,354	**1,476 (8%)**	**894 (5%)**	**5,386 (27%)**
A66	Temple Sowerby	14,459	15,589	16,459	22,590	**1,130 (8%)**	**870 (6%)**	**6,131 (37%)**
A66	Between Kirkby Thore and Appleby	15,629	16,767	17,693	20,889	**1,138 (7%)**	**927 (6%)**	**3,196 (18%)**
A66	Between Appleby and Brough	13,038	13,790	14,660	20,280	**752 (6%)**	**871 (6%)**	**5,620 (38%)**
A66	East of Brough	14,793	16,020	17,227	22,555	**1,227 (8%)**	**1,207 (8%)**	**5,328 (31%)**
A66	Bowes Bypass	12,701	14,119	15,075	20,697	**1,418 (11%)**	**955 (7%)**	**5,623 (37%)**
A66	West of Greta Bridge	15,422	17,004	18,094	24,111	**1,582 (10%)**	**1,089 (6%)**	**6,018 (33%)**
A66	East of Smallways	15,196	16,769	17,798	24,408	**1,573 (10%)**	**1,029 (6%)**	**6,609 (37%)**
A66	West of Scotch Corner	15,652	17,595	18,597	25,145	**1,943 (12%)**	**1,002 (6%)**	**6,548 (35%)**
A1(M)	North of Scotch Corner	49,043	56,097	61,094	62,968	**7,054 (14%)**	**4,998 (9%)**	**1,873 (3%)**
A1(M)	South of Scotch Corner	51,079	56,245	61,312	64,156	**5,165 (10%)**	**5,068 (9%)**	**2,844 (5%)**
M6	North of M6 J40	42,658	46,550	51,330	52,597	**3,891 (9%)**	**4,781 (10%)**	**1,267 (2%)**
M6	South of M6 J40	31,472	33,993	37,037	35,465	**2,521 (8%)**	**3,043 (9%)**	**-1,572 (-4%)**

Table 5-33: 12-Hour Traffic Flows (vehicles, two-way) - 2044

Road	Location	Base 2019	Reference	DM Post VDM	DS Post VDM	DM Ref vs. Base	DM Post VDM vs. Ref	DS Post VDM vs. DM Post VDM
A66	West of M6 J40	16,584	19,499	21,972	23,001	2,915 (18%)	2,473 (13%)	1,030 (5%)
A66	Between M6 J40 and Kemplay Bank	25,699	29,610	33,367	38,319	3,911 (15%)	3,757 (13%)	4,952 (15%)
A66	Directly East of Kemplay Bank	17,598	20,973	22,903	29,910	3,375 (19%)	1,931 (9%)	7,007 (31%)
A66	Temple Sowerby	14,459	17,030	18,866	26,748	2,571 (18%)	1,836 (11%)	7,882 (42%)
A66	Between Kirkby Thore and Appleby	15,629	18,254	20,181	24,854	2,625 (17%)	1,927 (11%)	4,674 (23%)
A66	Between Appleby and Brough	13,038	15,105	16,979	24,164	2,067 (16%)	1,874 (12%)	7,185 (42%)
A66	East of Brough	14,793	17,945	20,958	27,822	3,152 (21%)	3,012 (17%)	6,865 (33%)
A66	Bowes Bypass	12,701	16,050	18,301	25,385	3,349 (26%)	2,251 (14%)	7,085 (39%)
A66	West of Greta Bridge	15,422	19,058	21,404	29,474	3,636 (24%)	2,346 (12%)	8,070 (38%)
A66	East of Smallways	15,196	18,752	20,553	29,776	3,556 (23%)	1,801 (10%)	9,223 (45%)
A66	West of Scotch Corner	15,652	19,814	22,014	30,252	4,162 (27%)	2,200 (11%)	8,239 (37%)
A1(M)	North of Scotch Corner	49,043	62,382	73,079	75,069	13,338 (27%)	10,697 (17%)	1,991 (3%)
A1(M)	South of Scotch Corner	51,079	62,531	73,604	76,407	11,451 (22%)	11,074 (18%)	2,803 (4%)
M6	North of M6 J40	42,658	52,165	62,613	64,520	9,507 (22%)	10,448 (20%)	1,906 (3%)
M6	South of M6 J40	31,472	38,474	46,266	45,006	7,001 (22%)	7,792 (20%)	-1,260 (-3%)

Table 5-34: 12-Hour Traffic Flows (vehicles, two-way) - 2051

Road	Location	Base 2019	Reference	DM Post VDM	DS Post VDM	DM Ref vs. Base	DM Post VDMvs. Ref	DS Post VDM vs. DM Post VDM
A66	West of M6 J40	16,584	20,558	23,190	24,336	**3,974 (24%)**	**2,631 (13%)**	**1,147 (5%)**
A66	Between M6 J40 and Kemplay Bank	25,699	30,574	34,343	39,891	**4,875 (19%)**	**3,768 (12%)**	**5,548 (16%)**
A66	Directly East of Kemplay Bank	17,598	21,850	23,678	31,477	**4,252 (24%)**	**1,828 (8%)**	**7,799 (33%)**
A66	Temple Sowerby	14,459	17,652	19,431	28,108	**3,193 (22%)**	**1,779 (10%)**	**8,677 (45%)**
A66	Between Kirkby Thore and Appleby	15,629	18,918	20,839	26,160	**3,289 (21%)**	**1,921 (10%)**	**5,321 (26%)**
A66	Between Appleby and Brough	13,038	15,664	17,555	25,484	**2,626 (20%)**	**1,891 (12%)**	**7,929 (45%)**
A66	East of Brough	14,793	18,785	22,033	29,479	**3,992 (27%)**	**3,248 (17%)**	**7,446 (34%)**
A66	Bowes Bypass	12,701	16,822	19,218	26,902	**4,120 (32%)**	**2,397 (14%)**	**7,684 (40%)**
A66	West of Greta Bridge	15,422	19,812	22,386	31,246	**4,390 (28%)**	**2,573 (13%)**	**8,861 (40%)**
A66	East of Smallways	15,196	19,427	21,168	31,448	**4,231 (28%)**	**1,741 (9%)**	**10,280 (49%)**
A66	West of Scotch Corner	15,652	20,689	22,917	31,862	**5,037 (32%)**	**2,229 (11%)**	**8,945 (39%)**
A1(M)	North of Scotch Corner	49,043	64,829	76,113	78,143	**15,785 (32%)**	**11,284 (17%)**	**2,030 (3%)**
A1(M)	South of Scotch Corner	51,079	65,227	77,019	80,131	**14,148 (28%)**	**11,792 (18%)**	**3,111 (4%)**
M6	North of M6 J40	42,658	54,623	66,191	68,139	**11,965 (28%)**	**11,568 (21%)**	**1,949 (3%)**
M6	South of M6 J40	31,472	40,690	49,541	48,138	**9,218 (29%)**	**8,850 (22%)**	**-1,403 (-3%)**

5.7.3 The traffic flows above show the following:

- Reference forecast growth is generally similar to NTEM background growth on the West side of the A66 corridor, but less so on the east side where it is slightly higher. Reference forecast growth along the A66 corridor is as follows:
  - 6% - 12% (2029)
  - 15% - 27% (2044)
  - 19% - 32% (2051)
- The impact of VDM on traffic flows on the A66 in the DM are significant with an increase in traffic compared to the reference forecast of;
  - 5% - 8% (2029)
  - 9% - 13% (2044)
  - 9% - 17% (2051)
- This reflects the response to change in costs between Base and future years, and the resulting impact of an increase in longer car journeys which use the A66 and other strategic roads.
- The DS vs. DM results show traffic flows increase by at least 30%-40% at most locations along theA66 with the Project in place due to re-routing and VDM response. Traffic growth on the A66 corridor due to the Project ranges between;
  - 14% - 38% (2029)
  - 15% - 45% (2044)
  - 16% - 49% (2051)
- The lowest percentage increases are associated with the section of A66 between M6 junction 40 and Kemplay Bank close to Penrith, where the base traffic flows are highest, with most other locations much closer to the higher end of the range between 30%-40%.

5.7.4 The following tables show traffic flows by vehicle types along the A66 corridor

- Table 5-35 **–** Vehicle Flows by Vehicle Type (Two-way) – 2029
- Table 5-36 **–** Vehicle Flows by Vehicle Type (Two-way) – 2044
- Table 5-37 **–** Vehicle Flows by Vehicle Type (Two-way) – 2051

5.7.5 Lights represent cars and LGVs; and Heavies HGVs.

Table 5-35: Vehicle Flows by Vehicle Type (two-way) 2029

Road	Location	Scenario	AM (veh/hr)		IP (veh/hr)		PM (veh/hr)	
			Lights	Heavies	Lights	Heavies	Lights	Heavies
A66	East of M6 J40	Base	1,926 (82%)	415 (18%)	1,702 (81%)	407 (19%)	2,010 (85%)	363 (15%)
		DM	2,197 (84%)	421 (16%)	2,000 (83%)	407 (17%)	2,396 (87%)	361 (13%)
		DS	2,514 (85%)	438 (15%)	2,313 (84%)	425 (16%)	2,837 (88%)	386 (12%)
A66	East of Brough	Base	939 (78%)	264 (22%)	1,019 (78%)	281 (22%)	1,073 (80%)	276 (20%)
		DM	1,134 (81%)	267 (19%)	1,238 (81%)	283 (19%)	1,275 (82%)	278 (18%)
		DS	1,489 (84%)	290 (16%)	1,656 (85%)	299 (15%)	1,864 (86%)	300 (14%)
A66	West of Scotch Corner	Base	1,026 (79%)	269 (21%)	1,008 (76%)	319 (24%)	1,180 (79%)	305 (21%)
		DM	1,261 (82%)	273 (18%)	1,254 (80%)	321 (20%)	1,464 (83%)	308 (17%)
		DS	1,708 (85%)	297 (15%)	1,762 (84%)	337 (16%)	2,206 (87%)	331 (13%)

Table 5-36: Vehicle Flows by Vehicle Type (two-way) 2044

Road	Location	Scenario	AM (veh/hr)		IP (veh/hr)		PM (veh/hr)	
			Lights	Heavies	Lights	Heavies	Lights	Heavies
A66	East of M6 J40	Base	1,926 (82%)	415 (18%)	1,702 (81%)	407 (19%)	2,010 (85%)	363 (15%)
		DM	2,524 (85%)	442 (15%)	2,331 (85%)	425 (15%)	2,740 (88%)	375 (12%)
		DS	2,925 (86%)	458 (14%)	2,699 (86%)	441 (14%)	3,263 (89%)	393 (11%)
A66	East of Brough	Base	939 (78%)	264 (22%)	1,019 (78%)	281 (22%)	1,073 (80%)	276 (20%)
		DM	1,416 (83%)	280 (17%)	1,547 (84%)	297 (16%)	1,618 (85%)	291 (15%)
		DS	1,882 (86%)	304 (14%)	2,107 (87%)	312 (13%)	2,349 (88%)	309 (12%)
A66	West of Scotch Corner	Base	1,026 (79%)	269 (21%)	1,008 (76%)	319 (24%)	1,180 (79%)	305 (21%)
		DM	1,512 (84%)	290 (16%)	1,539 (82%)	338 (18%)	1,780 (85%)	304 (15%)
		DS	2,115 (87%)	315 (13%)	2,222 (86%)	354 (14%)	2,584 (88%)	337 (12%)

Table 5-37: Vehicle Flows by Vehicle Type (two-way) 2051

Road	Location	Scenario	AM (veh/hr)		IP (veh/hr)		PM (veh/hr)	
			Lights	Heavies	Lights	Heavies	Lights	Heavies
A66	East of M6 J40	Base	1,926 (82%)	415 (18%)	1,702 (81%)	407 (19%)	2,010 (85%)	363 (15%)
		DM	2,596 (85%)	452 (15%)	2,407 (85%)	433 (15%)	2,831 (88%)	372 (12%)

Road	Location	Scenario	AM (veh/hr)		IP (veh/hr)		PM (veh/hr)	
			Lights	Heavies	Lights	Heavies	Lights	Heavies
		DS	3,098 (87%)	464 (13%)	2,794 (86%)	442 (14%)	3,436 (89%)	403 (11%)
A66	East of Brough	Base	939 (78%)	264 (22%)	1,019 (78%)	281 (22%)	1,073 (80%)	276 (20%)
		DM	1,499 (84%)	286 (16%)	1,636 (84%)	303 (16%)	1,705 (85%)	297 (15%)
		DS	2,027 (87%)	310 (13%)	2,235 (88%)	319 (12%)	2,498 (89%)	316 (11%)
A66	West of Scotch Corner	Base	1,026 (79%)	269 (21%)	1,008 (76%)	319 (24%)	1,180 (79%)	305 (21%)
		DM	1,597 (85%)	290 (15%)	1,612 (82%)	343 (18%)	1,851 (86%)	307 (14%)
		DS	2,271 (88%)	322 (12%)	2,352 (87%)	362 (13%)	2,695 (89%)	345 (11%)

5.7.6 The tables for light and heavy vehicles show the following:

- A high proportion of Heavies along the A66 at Bowes Bypass and West of Scotch Corner (approx.20-25%).
- A reduction in the proportion of Heavies in the future as RTF HGV growth is not forecast to be as significant as Car NTEM growth and RTF LGV growth.
- A higher proportion of light vehicles in the DS compared to the DM due to assignment re-routing and HGVdemand being fixed.

Forecast traffic delay

5.7.7 Forecast traffic delays have been assessed on approaches to major junctions along the A66 including;

- M6 Junction 40
- Kemplay Bank
- Scotch Corner

5.7.8 Delay information in this section relates to the base, DM 2044 and DS 2044 scenarios for AM, IP (Inter Peak) and PM peak periods. Whilst the delay information from the SATURN A66 traffic model provides an indication of operational performance, each junction has been assessed separately within VISSIM (microsimulation modelling software) which is considered more appropriate when focussing on a much smaller and localised area. Full information on these operational forecast models can be found separately within the **3.7 Transport Assessment Chapter 8.2 Major junction performance.**

M6 Junction 40

5.7.9 The following figure and tables show the junction approaches and forecast delays on the M6 junction 40;

- Figure 5-6 – M6 Junction 40 approaches
- Table 5-38 – M6 Junction 40 AM Delays
- Table 5-39 – M6 Junction 40 IP Delays

- Table 5-40 – M6 Junction 40 PM Delays

Figure 5-6: Junction 40 approaches

Table 5-38: Delay (seconds) Junction 40 – AM

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A592	30	71	21	41 (139%)	-50 (-70%)
A66 East	18	20	21	2 (13%)	1 (5%)
M6 South	38	67	23	30 (79%)	-45 (-67%)
A66 West	24	58	22	34 (141%)	-36 (-62%)
M6 North	17	30	32	13 (76%)	2 (7%)

Table 5-39: Delay (seconds) Junction 40 - IP

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A592	24	62	14	38 (157%)	-48 (-77%)
A66 East	14	18	12	4 (31%)	-6 (-32%)
M6 South	42	96	26	54 (130%)	-69 (-72%)
A66 West	22	45	23	24 (109%)	-22 (-49%)
M6 North	15	19	31	3 (22%)	12 (66%)

Table 5-40: Delay (seconds) Junction 40 PM

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A592	28	106	15	78 (279%)	-91 (-86%)
A66 East	14	20	14	5 (37%)	-6 (-31%)

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
M6 South	47	133	27	86 (183%)	-106 (-80%)
A66 West	22	82	24	60 (271%)	-57 (-70%)
M6 North	16	19	43	4 (24%)	24 (125%)

5.7.10 Forecast delays at M6 Junction 40 exceed one minute for the design year DM scenario, particularly on the A592 and M6 South junction approaches where delays are in the region of two minutes during the PM peak period. Whilst the percentage change in delay between the base and DM is high on these approaches, the DS scenario reveals a reduction of 70-80% in delay from the DM. Delays on the A66 East and M6 North remain relatively low across the base, DM and DS scenarios and are generally within 30 seconds. All forecast delays are comfortably within a minute on all approaches in all time periods.

Kemplay Bank

5.7.11 The following figure and tables show the junction approaches and forecast delays on Kemplay Bank;

- Figure 5-7 – Kemplay Bank approaches
- Table 5-41Table 5-41 – Kemplay Bank AM Delays
- Table 5-42Table 5-42 - Kemplay Bank IP Delays
- Table 5-43Table 5-43 - Kemplay Bank PM Delays

Figure 5-7: Kemplay Bank junction approaches

Table 5-41: Delay (seconds) Kemplay Bank - AM

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A686 (Carleton Avenue)	61	97	29	36 (58%)	-68 (-70%)
A66 East	21	26	18	5 (23%)	-8 (-32%)
A6 South (Kemplay Bank)	20	20	21	0 (0%)	1 (6%)
A66 West	14	22	41	8 (57%)	19 (85%)
A6 North (Bridge Lane)	18	26	26	8 (42%)	0 (1%)

Table 5-42: Delay (seconds) Kemplay Bank IP

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A686 (Carleton Avenue)	44	60	29	16 (37%)	-31 (-51%)
A66 East	20	45	21	24 (118%)	-23 (-52%)
A6 South (Kemplay Bank)	24	31	31	8 (33%)	0 (-1%)
A66 West	11	14	16	4 (36%)	2 (13%)
A6 North (Bridge Lane)	18	25	26	7 (42%)	1 (2%)

Table 5-43: Delay (seconds) Kemplay Bank - PM

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A686 (Carleton Avenue)	59	89	34	31 (53%)	-56 (-62%)
A66 East	21	63	22	42 (201%)	-40 (-64%)
A6 South (Kemplay Bank)	25	42	39	17 (68%)	-4 (-9%)
A66 West	11	15	17	4 (38%)	2 (12%)
A6 North (Bridge Lane)	19	28	28	9 (49%)	0 (0%)

5.7.12 Forecast delays at Kemplay Bank are generally within one minute on all approaches across AM, IP and PM periods during the design year. The highest delay is seen on the A686 (Carleton Avenue) which exceeds one minute in the base and DM scenario but this reduces to around 30 seconds across all time periods in the DS. The DS scenario shows a generous reduction in delay on the A686 (Carleton Avenue), A66 East and A66 West compared with the DM.

Scotch Corner

5.7.13 The following figure and tables show the junction approaches and forecast delays on Scotch Corner;

- Figure 5-8 – Scotch Corner approaches
- Table 5-44 – Scotch Corner AM Delays
- Table 5-45 – Scotch Corner IP Delays
- Table 5-46 – Scotch Corner PM Delays

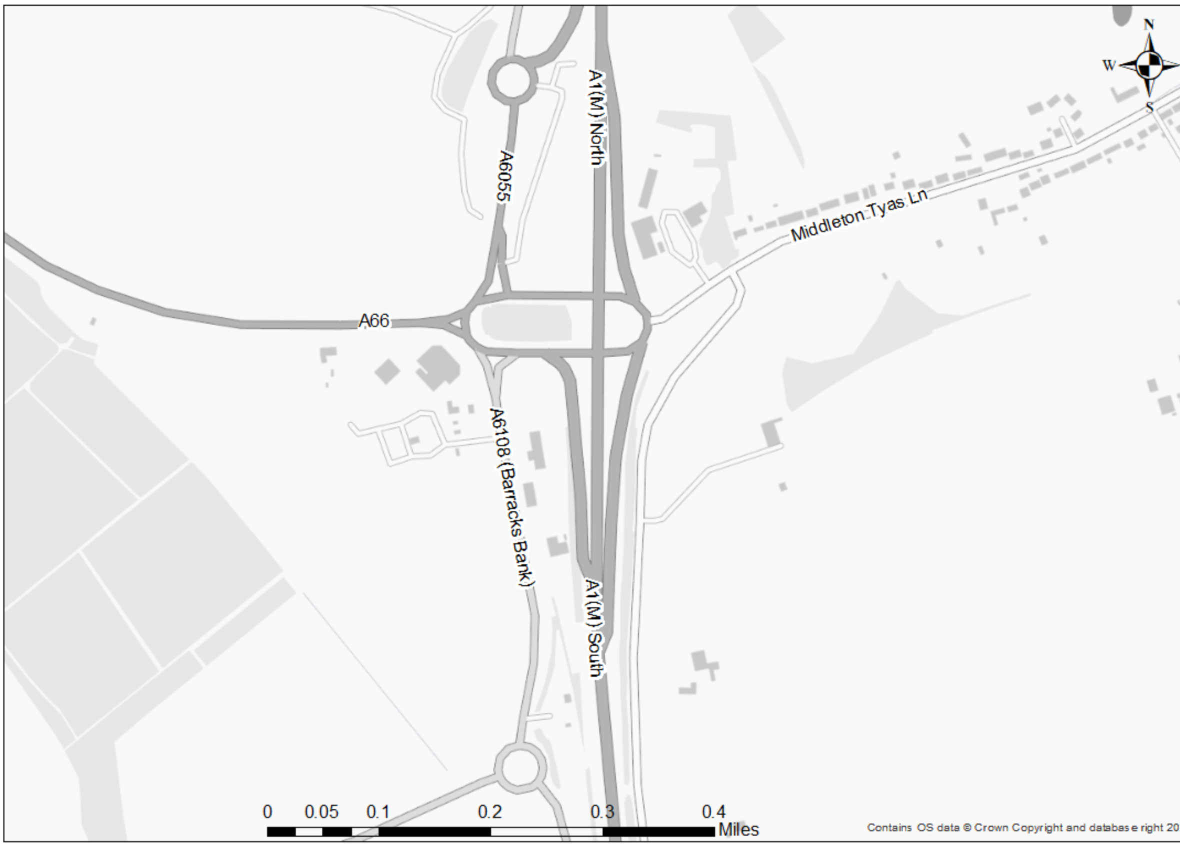

Figure 5-8: Scotch Corner junction approaches

Table 5-44: Delay (seconds) Scotch Corner - AM

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A1(M) North	15	17	18	2 (10%)	1 (6%)
Middleton Tyas Ln	7	10	11	2 (32%)	1 (14%)
A1(M) South	21	22	23	1 (6%)	1 (5%)
A6108 (Barracks Bank)	19	21	20	1 (7%)	0 (0%)
A66	12	13	15	1 (7%)	1 (11%)
A6055	6	6	6	0 (4%)	0 (7%)

Table 5-45: Delay (seconds) Scotch Corner - IP

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A1(M) North	18	21	24	3 (17%)	3 (12%)
Middleton Tyas Ln	7	10	11	3 (38%)	1 (14%)
A1(M) South	14	15	16	1 (6%)	1 (5%)
A6108 (Barracks Bank)	15	16	16	1 (9%)	0 (0%)
A66	14	15	17	1 (8%)	2 (13%)
A6055	6	6	6	0 (5%)	0 (7%)

Table 5-46: Delay (seconds) PM Scotch Corner

Time Period	Base 2019	DM 2044	DS 2044	DM vs. Base	DS vs. DM
A1(M) North	19	24	26	5 (26%)	2 (8%)
Middleton Tyas Ln	8	13	14	5 (71%)	1 (8%)
A1(M) South	14	15	17	1 (7%)	2 (11%)
A6108 (Barracks Bank)	16	19	20	4 (23%)	0 (2%)
A66	14	16	18	1 (9%)	3 (18%)
A6055	6	6	7	1 (10%)	1 (13%)

5.7.14 Forecast delays at Scotch are low across all scenarios and time periods with only small increases between the DM vs. Base and DS vs. DM. All delays remain within 30 seconds for the design year DS scenario.

Forecast journey times

5.7.15 Journey times for the A66 corridor between Scotch Corner and M6 Junction 40 are shown below:

- Table 5-47 – A66 Corridor Journey times (mm:ss) – 2029
- Table 5-48 – A66 Corridor Journey times (mm:ss) – 2044
- Table 5-49 – A66 Corridor Journey times (mm:ss) – 2051

5.7.16 The routes capture delay through the Kemplay Bank junction and stop line delay on the approaches tothe M6 J40 and Scotch Corner.

Table 5-47: A66 Corridor Journey Times (mm:ss) - 2029

Time Period	Direction	Base 2019	2029 DM	2029 DS	DM vs. Base	DS vs. DM
AM	A66 - Eastbound	53:20	54:36	44:47	01:16 (2%)	-09:49 (-18%)
	A66 - Westbound	54:11	55:25	45:04	01:14 (2%)	-10:21 (-19%)
IP	A66 - Eastbound	54:11	55:36	45:04	01:25 (3%)	-10:32 (-19%)
	A66 - Westbound	54:05	55:46	44:56	01:41 (3%)	-10:50 (-19%)
PM	A66 - Eastbound	54:49	56:22	45:12	01:33 (3%)	-11:10 (-20%)
	A66 - Westbound	54:26	56:04	45:20	01:38 (3%)	-10:44 (-19%)
OP	A66 - Eastbound	49:25	49:32	44:07	00:07 (0%)	-05:25 (-11%)
	A66 - Westbound	49:24	49:39	44:10	00:15 (0%)	-05:29 (-11%)

Table 5-48: A66 Corridor Journey Times (mm:ss) - 2044

Time Period	Direction	Base 2019	2044 DM	2044 DS	DM vs. Base	DS vs. DM
AM	A66 - Eastbound	53:20	56:34	45:11	03:13 (6%)	-11:23 (-20%)
	A66 - Westbound	54:11	57:29	45:26	03:17 (6%)	-12:02 (-21%)
IP	A66 - Eastbound	54:11	57:54	45:27	03:43 (7%)	-12:27 (-22%)
	A66 - Westbound	54:05	58:21	45:29	04:15 (8%)	-12:51 (-22%)
PM	A66 - Eastbound	54:49	58:58	45:45	04:09 (8%)	-13:13 (-22%)
	A66 - Westbound	54:26	58:49	45:55	04:23 (8%)	-12:54 (-22%)
OP	A66 - Eastbound	49:25	49:43	44:09	00:18 (1%)	-05:34 (-11%)
	A66 - Westbound	49:24	49:55	44:11	00:31 (1%)	-05:44 (-11%)

Table 5-49: A66 Corridor Journey Times (mm:ss) - 2051

Time Period	Direction	Base 2019	2051 DM	2051 DS	DM vs. Base	DS vs. DM
AM	A66 - Eastbound	53:20	57:07	45:20	03:46 (7%)	-11:46 (-21%)
	A66 - Westbound	54:11	58:22	45:39	04:11 (8%)	-12:43 (-22%)
IP	A66 - Eastbound	54:11	58:39	45:36	04:28 (8%)	-13:03 (-22%)
	A66 - Westbound	54:05	59:17	45:41	05:11 (10%)	-13:35 (-23%)
PM	A66 - Eastbound	54:49	59:55	45:56	05:06 (9%)	-13:58 (-23%)
	A66 - Westbound	54:26	59:55	46:10	05:30 (10%)	-13:45 (-23%)

Time Period	Direction	Base 2019	2051 DM	2051 DS	DM vs. Base	DS vs. DM
OP	A66 - Eastbound	49:25	49:48	44:10	00:23 (1%)	-05:38 (-11%)
	A66 - Westbound	49:24	50:01	44:12	00:37 (1%)	-05:49 (-12%)

5.7.17 These results show the following:

- Journey time increases between the base and DM, with travel times increasing in the future years during AM/IP/PM as follows:
  - One to two minutes (2029)
  - Three to five minutes (2044)
  - Four to six minutes (2051)
- A journey time decrease between the DM and DS scenarios, with time saving increasing in the later forecast years. Time savings for AM/IP/PM are as follows:
  - 10 – 11 minutes (2029)
  - 11 – 13 minutes (2044)
  - 12 – 14 minutes (2051)

5.7.18 The travel times and scale of time saving with the Project in place is very similar to Stage 2 where journey time savings were in the order of 10 – 15 minutes.

5.8 References

5.8.1 For further details on the information provided in Section 5, please see Appendix D: Transport Forecasting Package.

6 Economic Appraisal

6.1 Methodology

Introduction

6.1.1 Economic appraisal is the determination of the benefits of a transport scheme using information on travel demand, traffic flows, journey times and other data derived from a transport model. In addition to this consideration of environmental and other economic impacts are also made. The benefits calculated from the appraisal are compared to the Project costs to produce a benefit to cost ratio (BCR).

6.1.2 The A66 assessment compares outcomes without the A66 NTP improvement (DM) against outcomes with the improvement (DS), to determine the net effect of intervention.

6.1.3 Economic impacts are mainly determined using principles of monetised cost-benefit analysis, since most aspects of transport and travel incur a monetary cost in terms of infrastructure provision and expenditure, vehicle use, time spent by transport users, accident injuries and damage, environment damage and mitigation, and 'externalities' (or costs not wholly born by the instigator).

6.1.4 In cost-benefit analysis, all monetised outcomes are assessed over a 60-year appraisal period from scheme opening[29]. For A66, this means the appraisal period is from 2029 to 2088, inclusive. Monetised costs and benefits are also converted back to 2010 present year real market prices and values, and by discounting[30] from the year of occurrence back to 2010 at a rate of 3.5% per annum for the first 30 years from current year (from 2022 to 2051 inclusive), and 3% per annum for the remaining 37 years of the 60-year appraisal period (from 2052 to 2088 inclusive) as stated in Tag Unit A1.1.

6.1.5 A lower discount rate of 1.5% per annum is applied to certain 'human health' impacts where monetary valuation is based on 'willingness to pay', specifically air quality, noise, physical activity and human costs of accidents.

6.1.6 Model parameters, which are used in the SATURN traffic model (A66TM) to control the traffic patterns and network performance in the scenarios for appraisal, and appraisal parameters, which are used in the assessment calculations to determine monetised outcomes, are derived from the latest best practice guidance and DfT specifications in TAG Data Book v1.17 (November 2021).

6.1.7 Social and distributional impacts are mainly determined using quantitative and qualitative, non-monetised, assessments.

[29] In line with the Principles of Cost Benefit Analysis as set out in *TAG Unit A1.1 Cost Benefit Analysis (Dft July 2021).*

[30] There is significant evidence to show that people prefer to consume goods and services now, rather than in the future. In general, even after adjusting for inflation, people would prefer to have £1 now, rather than £1 in 60 years' time. All monetised costs and benefits arising in the future need to be adjusted to take account of this phenomenon, known as 'social time preference'. The technique used to perform this adjustment is known as 'discounting'

6.1.8 Environmental impacts are examined primarily in the **3.2 Environmental Statement**. However, the findings are also fed into TAG-consistent worksheets for the EAP and the AST.

6.1.9 Most impacts are predicted using travel patterns and road network performance measurements from the A66TM. These direct impacts on road users and providers are quantified and monetised. The appraisal method here is recognised and reliable. The 'initial' BCR, is then calculated as the ratio of Present Value of Benefits (PVB) to Present Value of Cost (PVC). The following impacts are included within the initial BCR

- Transport economic efficiency (TEE)
- Other transport user impacts including wider public finance / indirect fuel tax revenue & public sector operator revenue
- Scheme construction impacts
- Environment impacts of noise, air quality & greenhouse gases
- Accident impacts
- Public expenditure

6.1.10 Other impacts are also quantified and monetised. They are assessed using A66TM outputs as above, but the outcomes are handled separately to the initial BCR and are only used to produce an 'adjusted' BCR, as there is more uncertainty around the appraisal methods.

- Journey Time Reliability
- Wider Economic Impacts

Core Scenario for Appraisal

6.1.11 A Core scenario outlook is assessed for the A66 project, which represents the most likely project outcomes, and which entails using the following assumptions and parameters in the A66 SATURN traffic model (v11.4.07H) and in the various impact appraisal tools and mechanisms:

- Most likely number and spatial distribution of people, homes and jobs.
- Central case levels of income for individuals and the economy.
- Inclusion of land use developments from the project 'Uncertainty Log' which are either 'Near certain' or 'More Than Likely'.
- Most likely forecast of travel demand trip ends and wider area growth constraints from TEMPro v7.2b database for both DM and DS.
- Central case monetary valuation of travel costs and transport impacts.
- Central case valuation of greenhouse gases (carbon) impacts, and Carbon Dioxide equivalent (CO2e) emissions factors (DfBEIS and DfT 2021).
- Central case appraisal period (60 years) and discount rate (HM Treasury).
- Central case TAG Data Book V1.17 parameters (DfT).

Annualisation of User Benefits

6.1.12 Traffic model March 2019 weekday and weekend day assignment outputs, for DM and DS scenarios, at forecast years 2029, 2044 and 2051, are used in the DfT's Transport Users Benefit Appraisal (TUBA) program to undertake economic calculations. The model outputs are expanded to a 365-day (8,760-hour) equivalent using annualisation factors appropriate for converting modelled hourly traffic flows at selected times of day and week to a whole year of annual average weekdays, including school holidays, and weekend days plus bank holidays.

6.1.13 In the A66TM, in every forecast year, Project scenario and time period, road users are categorised into vehicle types (Cars, Light Goods Vehicles, and Heavy Goods Vehicles) and into 'User Classes' (UC), which represent permutations of vehicle types and trip purposes (Business, Commute and Other).

6.1.14 Annualisation factors for 2019 are applied in TUBA to expand the daily time period outputs from the SATURN A66TM to all hours and all days in the whole year. Factors are derived from 12-month directional traffic counts on the A66 analysed from the WebTRIS database.

6.1.15 Annualisation factors used to convert TUBA inputs (from SATURN) to a whole year of annual average days (365-days, or 8,760-hours) are summarised in Table 6-1. The table shows:

- Conversion from six weekday model 1-hour periods, which represent March 2019, to all-year weekday and school holiday 24-hour periods in 2019.
- Conversion from two weekend model 1-hour periods, which represent an average month in 2019, to all-year weekend and bank holiday 24-hour periods in 2019.

Table 6-1: A66 NTP TUBA Annualisation

Vehicle Type	Period Name	TUBA 2019 All-Year Time Slice	SATURN 2019 Modelled Hour	2019 Traffic Flow Ratio: All-Months Avg 1hr / Model 1hr [A]	No. Daily Hours per Time Slice [B]	No. Annual Days per Time Slice [C]	Proposed PCF S3 Annualising Factors [A]*[B]*[C] for TUBA
Weekdays (Including School Holidays)							
All Vehicles	**AMS**	TS1 week day 07-08 & 09-10	March week day Avg 07-08 & 09-10	0.97	2	253	492
	AM	TS2 week day 08-09	March week day 08-09	0.95	1	253	241
	IP	TS3 week day 10-16	March week day Avg 10-16	1.03	6	253	1565
	PM	TS4 week day 16-18	March week day Avg 16-18	0.98	2	253	493
	PMS	TS5 week day 18-19	March week day 18-19	1.00	1	253	253
	OP	TS6 week day 19-07	March week day Avg 07-08 & 09-10	1.01	12	253	3055
Weekend Days & Bank Holidays							
All Vehicles	**WE Day**	TS7 weekend day 10-18	All Year weekend day Avg 10-18	1.00	8	112	896
	WE Night	TS8 weekend day 18-10	All Year weekend day Avg 18-10	1.00	16	112	1792

6.1.16 The rationale for how various SATURN traffic models are created and their outputs are used in TUBA is summarised below.

6.1.17 Weekday models are included are:

- AM Peak hour (8am-9am)
- Inter Peak average hour (10am-4pm)
- PM Peak average hour (4pm-6pm)
- The weekday model for an Off-Peak average hour (7pm-7am) is derived from the 24-hour

6.1.18 The weekend models for Day time average hour (10am-6pm) and Night-time average hour (6pm-10am) are derived from the weekday Inter Peak and Off Peak average hour models respectively, for car, LGV and HGV, and then factored using A66 March weekday and all-year weekend 2019 counts to convert from weekday Inter Peak 6 hours to weekend Day time 8 hours and from weekday Off Peak 12 hours to weekend Night time 16 hours.

6.1.19 These assignment outputs are converted to appropriate units and are then input to TUBA, where factors are applied to adjust the split of UC1, 2 and 3 car trips amongst business, commute and other purposes, split UC4 LGV trips into other and business purposes, and to split HGV trips into OGV1 and OGV2 categories, in line with TAG Data Book v1.17.

Masking of User Benefits

6.1.20 As explained in paragraph tests of model convergence identified some areas of instability in the wider model area, which are typically in the urban areas within Tyne and Wear which are remote from the Project. Accordingly, a masking system was developed for the assessment of transport user benefits excluding local trips within these areas from the TUBA assessment, while retaining movements to, from, within and through the Area of Detailed Modelling (AoDM) and adjacent area.

6.1.21 Movements which are not masked in the assessment are reasonably expected to experience changes in travel time or distance, and therefore cost, as a result of the Project. These changes could either be as a direct result of the Project, for example reductions in travel time for trips travelling along it, or knock-on effects from wider re-routeing into the corridor. The benefits and disbenefits arising for these movements are therefore included in the final assessment of transport user benefits.

6.1.22 In addition to appraising transport user benefits, including those arising due to reductions in accidents and delays during construction, an assessment of the environmental impacts of the Project, quantifying and monetising air quality, greenhouse gas and noise benefits where there are large forecast changes in traffic flows has been undertaken in line with TAG Unit A3 ‘Environmental Impact Appraisal’.

Wider Economic Impacts

6.1.23 Wider Economic Impact (WEI) appraisal quantifies the impact on the local, regional and national economy caused by changes in accessibility generated by the A66 Project improvement. WEIs are not captured by the conventional transport user benefits appraisal undertaken using TUBA. They are not captured in TUBA if there are ‘distortions’ or market failures that mean the economy is not functioning efficiently, then the additional benefits (or disbenefits) will arise as the impact of transport improvements is transmitted into the wider economy. Positive WEI arise when there are market failures caused by difficulties for businesses in accessing employees, suppliers and other professional services, and when these market failures are addressed by the proposed transport scheme.

- Increased output in imperfectly competitive markets. An increase in the production of goods or services due to companies benefiting from time savings due to the A66 NTP Project. This is effectively a reduction in their production costs which leads to an incentive to increase the output while still keeping their profit margins. Businesses and consumers would therefore be jointly better off if firms were to increase production.
- Labour Supply Impacts from More People Working. Transport is most likely to be a barrier to employment when an area has poor connections to employment centres and/or high transport costs relative to incomes. In deciding if they can access suitable employment, and whether (or not) to work, people will weigh travel costs against the wage rate of available jobs. A change in transport costs is therefore likely to incentivise people to work, and to find employment in a sector most suited to their skills. As a result of the A66 NTP scheme, businesses based in Durham, Darlington, Middlesbrough and Stockton will have access to a widened pool of skilled labour, and inactive workers who travel on the A66 will be able to access appropriate and viable employment.

Journey Time Reliability

6.1.24 The journey time reliability aspect of the A66 NTP improvement comprises the following elements of unpredictable journey time impacts for road users,

- Travel time variability on the A66 during normal operating conditions (daily congestion).
- Travel time variability on the A66 during carriageway incident constrictions.
- Travel time delay on the A66 during carriageway incident constrictions shorter than 6 hours, with some traffic diverting.

6.1.25 The journey time reliability assessment uses MyRIAD 2021 to compare performance of the A66 scenarios, DS and DM, in terms of:

- Travel time variability (TTV) –
  - MyRIAD determines day to day TTV as the variance and standard deviation (SD) of travel times during congestion, by assessing road type, carriageway speed / flow / capacity characteristics (and hence SD of travel time), route length, link speed (and hence travel time), forecast traffic flows, and proportion of HGV.
  - MyRIAD determines incident TTV as the variance and SD of travel times during incidents, using the same parameters as for daily

variability, but additionally MyRIAD assesses incident types, durations, rates (per million vehicle kilometres), likelihood, (and hence queue probabilities), and reduced carriageway capacity (lanes closed).

- In terms of incident delays (ID)
  - MyRIAD determines incident delays using the same parameters as for incident TTV, but additionally MyRIAD assesses mean and maximum queuing delay per vehicle, and hence proportion of diverting traffic.

Journey Time Resilience

6.1.26 Resilience refers to the ability of the road network to recover after a major incident. The 'resilience' impact of the A66 NTP improvement comprises the following elements of unpredictable journey time impacts for road users:

- Travel time delay on the A66 route during incidents and closures longer than 6[31] hours, with all traffic diverting.
- Travel time delays on the strategic road network, during carriageway incident closures longer than 6 hours, with some traffic diverting to the improved A66.
- Travel time delays on the local road network, during carriageway incident closures longer than 6 hours, with some traffic diverting to the improved A66.

6.1.27 As advised in TAG Unit A1.3 'User and Provider Impacts' (July 2021), neither journey time reliability nor resilience are assessed as established monetised impacts within the initial BCR. However, the evolving approach for assessing journey time reliability is accepted and so this impact is included in the adjusted BCR. By contrast, resilience is assessed only as an indicative monetised impact, as the method of appraisal is still emerging. Resilience is therefore excluded from both the initial and adjusted BCR but is included as an indicative impact.

Road Safety

6.1.28 The safety appraisal assesses the likely change in the number of road accidents within the area of focus and influence of the A66 route, as a result of the Project improvements. It also predicts the consequent change in the number and severity of casualties (individuals who are killed or injured), and the change in associated costs to people and organisations.

6.1.29 A monetary value is attached to accidents, casualties and associated impacts, so quantifying the change in impacts gives a valuation of the prevention of casualties with the Project in place. Accidents are quantified and monetised using COBALT V2.1 (July 2021).

[31] The dataset behind MyRIAD, removed extreme outlier events to avoid bias within its calculations. The threshold for exclusion was chosen to be 6 hours. Therefore incidents that last for shorter than 6 hours are considered under 'reliability' and those major incidents that impact the network for more than 6 hours are considered under 'resilience'.

Noise, Air Quality and Greenhouse Gases

6.1.30 Environmental impacts of the A66 improvements on noise, air quality and greenhouse gases are monetised in accordance with TAG advice in Unit A3 Environmental Impact Appraisal (July 2021) and TAG impact-specific workbooks. The appraisal takes inputs from the project's environment team, using their quantified and monetised assessments of the forecast traffic-related impacts of the A66 improvements. Further details can be found in the **Environmental Statement, Chapter 05 Air Quality, Chapter 07 Climate, and Chapter 12 Noise and Vibration (document reference 3.2).**

6.1.31 Each aspect is assessed using assigned network flows from the A66TM. Noise, air quality and greenhouse gases outcomes are calculated during normal scheme operation only.

Comparison of Costs and Benefits

6.1.32 Costs and benefits occur in different years throughout the appraisal period. Benefits are realised in the sixty years following the implementation of the Project. Up-front costs associated with construction of the Project are appraised together with regular operational and maintenance expenditure which is assumed to occur throughout the appraisal period.

6.1.33 Benefits and costs were deflated and discounted to a 2010 price base and 2010 present value using the standard DfT discount rates of 3.5% per year for the first thirty years following 2018 (appraisal date) and then 3.0% per year for the remainder of the appraisal period.

6.2 Project Benefits

Transport Users

6.2.1 Transport economic efficiency outcomes for road users, during normal operation of the A66 route, in the Core Scenario, are calculated in TUBA. The net impact, (equivalent to DS user costs subtracted from DM user costs), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted.

6.2.2 The 60-year core scenario TEE outcomes for road users are summarised in Table 6-2, sub-divided by travel cost aspects and trip purposes. Of the overall masked total travel cost savings for road users, which amount to £521.621m, 83% are gained by business users, 7% by commuters, and 10% by other users.

Table 6-2: Transport User Impacts by purpose during Normal Operation (£m at 2010 Market Prices Discounted)

	Travel Time	Vehicle Operation	User Charges	Total
Business Users	476.275	1.345	-0.031	477.589
Commuter Users	49.426	-24.773	-0.014	24.638
Other Users	93.830	-74.844	-0.117	18.870

	Travel Time	Vehicle Operation	User Charges	Total
All Users	619.531	-98.272	-0.162	521.097

6.2.3 The TUBA results for road users are analysed further in Table 6-3, split by travel cost aspects and vehicle sub-modes. Of the total masked travel cost savings, 75% are gained by car users, 8% by LGV users, and 17% by HGV users.

Table 6-3: Transport User Impacts by vehicle Type during Normal Operation (£m at 2010 Market Prices Discounted)

Road User Category	Travel Time	Vehicle Operation	User Charges	Total
Car Users	488.238	-99.254	-0.161	388.823
LGV Users	52.938	-11.343	-0.002	41.592
HGV Users	78.355	12.326	-0.001	90.681
All Users	619.531	-98.272	-0.162	521.097

6.2.4 The masking of movements in the assessment of transport user benefits reduced the travel time benefits from £657.4million to £619.5million in 2010 prices, discounted to 2010 present values. This represents a decrease of 5.8%; a small change representing the uncertainty within the transport model and which shows that the masking has no material impact on the appraisal.

Delays During Construction

6.2.5 Effects of the A66 improvement upon road users during Project construction and route maintenance, in the Core Scenario, are assessed by undertaking further A66TM assignments. Temporary Traffic Management (TTM) arrangements during roadworks for each scenario have been modelled in the opening year 2029. These are scenarios described in detail in **3.7 Transport Assessment Chapter 11 Construction Impact Assessment.** Impacts of TTM upon travel costs are then calculated in TUBA, in the same way as for TTE and public finance impacts during normal operation.

6.2.6 The net impact, (equivalent to DS user costs subtracted from DM costs during construction), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted.

6.2.7 The share of road user impacts between Construction and Maintenance roadworks scenarios is shown in Table 6-4, split by travel cost aspects.

Table 6-4: Transport User Impacts by Construction Scenario (£m at 2010 Market Prices Discounted)

	Travel Time	Vehicle Operation	User Charges	Total
Scenario A	-9.250	-0.440	-0.007	-9.697
Scenario B	-9.349	-0.446	-0.007	-9.802
Scenario C	-22.169	-0.736	-0.015	-22.920
Scenario D	-19.147	-0.475	-0.014	-19.636

	Travel Time	Vehicle Operation	User Charges	Total
Scenario E	-3.505	-0.241	-0.004	-3.750
Scenario F	-0.902	-0.429	-0.001	-1.332
Scenario G	7.607	-1.533	-0.004	6.070
Total All Construction Scenarios	-56.715	-4.300	-0.052	-61.067

Indirect Tax Benefits

6.2.8 Other transport economic efficiency impacts in the Core Scenario are also assessed in the masked TUBA appraisal, namely:

- Indirect tax revenue (the effect on Central Government wider public finances, in respect of fuel tax revenue).
- Operator revenue (the effect on Central Government funding, in respect of revenue from road tolls).

6.2.9 The 60-year core scenario TEE outcomes for road users are summarised in Table 6-5, sub-divided by travel cost aspects and trip purposes.

Table 6-5: Indirect Tax and Operator Revenue by purpose during Normal Operation (£m at 2010 Market Prices Discounted)

Journey Purpose	Operator Revenue	Indirect Tax Revenue	Total
Business Users	0.000	32.345	32.345
Commuter Users	0.004	11.344	11.348
Other Users	0.108	35.440	35.548
All Users	0.112	79.129	79.241

Road safety

6.2.10 Implications for the social welfare of users, in terms of road safety and accidents, are appraised using COBALT for the project's area of focus and influence in the Core Scenario. The net impact, (equivalent to DS with-scheme accident costs subtracted from DM without-scheme accident costs), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted.

6.2.11 Table 6-6 shows the number of accidents (PIA (Personal Injury Accident)) saved by introducing the A66 improvements. Over the 60-year appraisal period, the project saves 281 personal injury accidents, of which 3% are fatal, 21% are serious, and 76% are slight. Overall, the project saves 6,975 accidents, of which 4% involve personal injury and 96% are damage-only.

Table 6-6: Number of Accidents Saved

Accident Severity	Without Scheme (DM)	With Scheme (DS)	No. Accidents Saved
Fatal PIA	619	612	7
Serious PIA	4,912	4,854	58
Slight PIA	73,727	73,511	216
Sub-Total All PIA	79,258	78,977	281
Damage-Only	999,484	992,790	6,694
All Accidents	1,078,742	1,071,767	6,975

6.2.12 Each PIA could have multiple casualties. Therefore, Table 6-7 shows the number of casualties saved over the 60-year period. There is an overall reduction of 530 casualties, of which 3% are fatal, 28% are serious, and 69% are slight.

Table 6-7: Number of Casualties Saved

Casualty Severity	Without Scheme (DM)	With Scheme (DS)	No. Casualties Saved
Fatal Casualties	1,251	1,237	14
Serious Casualties	11,381	11,233	148
Slight Casualties	100,234	99,866	368
All Casualties	112,866	112,336	530

6.2.13 The monetised valuation of accidents saved by the Project is shown in Table 6-8, split by casualty, insurance, Police and property damage costs. Over the 60-year appraisal period, the total accident savings are £29.646m. These savings are derived in the following proportions: 85% from casualty savings (36% fatal, 41% serious, and 8% slight), and 15% from associated cost savings (1% insurance, 13% Police, and 1% property damage).

Table 6-8: Safety Valuation (£m at 2010 Market Prices Discounted)

	Without Scheme (DM)	With Scheme (DS)	No. Accidents Saved
Fatal Casualties	927.861	917.180	10.681
Serious Casualties	926.902	914.805	12.097
Slight Casualties	624.161	621.810	2.351
Sub-Total All Casualties	2,478.924	2,453.795	25.129
Insurance	23.550	23.401	0.149
Property Damage	872.287	868.151	4.136
Police	35.806	35.574	0.232
Total Cost	3,410.567	3,380.921	29.646

Noise, greenhouse gases and air quality

6.2.14 The environmental impacts of the Project which are quantified and monetised are:

- noise – changes in noise levels on sensitive receptors (residential properties)
- air quality – changes in the exposure of people to air pollutants
- greenhouse gases – the overall change in emissions of greenhouse gases including carbon dioxide, including an assessment of construction, road user (tailpipe), renewal/maintenance, and corporate/operational emissions.

6.2.15 Each aspect is assessed using assigned network flows from the A66TM, for the whole-route, in each modelled time period by vehicle type, at base year 2019 and at forecast years 2029, 2044 and 2051, The modelled network hourly traffic flows are annualised to equivalent 18-hour AAWT, for noise, and to 24-hour AADT, for air quality and greenhouse gases.

6.2.16 Noise, air quality and greenhouse gases outcomes are calculated during normal Project operation, for the Core appraisal scenario only.

6.2.17 Details of the noise assessment are contained in **3.2 Environmental Statement Chapter 12 Noise and Vibration.** For noise, a monetary value was calculated using the TAG noise workbook and the method set out in TAG Unit A3. The monetary value for noise impacts includes the effect on sleep disturbance, amenity, acute myocardial infarction, stroke and dementia.

6.2.18 The total value of noise impacts for the core growth scenario is an overall benefit of £1.24 million. This figure is also included in the low and high traffic growth appraisal scenarios

6.2.19 Details of the air quality assessment are contained in **3.2 Environmental Statement Chapter 5 Air Quality.** Air quality impacts are determined in respect of Oxides of Nitrogen (NOx) & Particulate matter with an aerodynamic diameter of less than 10 micrometres (PM10) emissions damage. NOx emissions are quantified for 'areas not in exceedance', whereas PM10 emissions are predicted across the affected road network. Both impacts are based on modelled vehicle flows, composition and speeds.

6.2.20 The air quality appraisal uses the procedures set out in 'Air quality appraisal: damage cost' guidance (DEFRA March 2021), and the 'Air quality appraisal: impact pathways approach (DEFRA March 2021) with 'Damage Costs Appraisal Toolkit' (DEFRA March 2021).

6.2.21 Monetised air quality impacts are summarised in the TAG 'Air Quality Valuation Workbook' (November 2021). The TAG 'Local Air Quality Assessment Workbook' (May 2019) is used to assess Nitrogen Dioxide (NO2) and Particulate matter with an aerodynamic diameter of less than 2.5 micrometres (PM2.5) concentrations around properties affected by the A66 improvements.

6.2.22 The air quality assessment over 60 years, within the area of focus, shows a net increase in NOx emissions of 608.79 tonnes and a net increase in PM2.5 emissions of 278.43 tonnes. The present year 2010 valuation of the NOx damage and abatement costs is -£2.744m, and the valuation of the PM2.5 damage costs is -£6.995m, which gives an overall air quality cost of -£9.740m.

6.2.23 Details of the greenhouse gas assessment are contained in **3.2 Environmental Statement Chapter 7 Climate.**

6.2.24 Changes in end-user (tail pipe) emissions of greenhouse gases, as a result of the project, are assessed by comparing tonnes of carbon dioxide equivalent (tCO_2e) across the traffic reliability area, with and without the A66 Project, based on modelled vehicle flows, composition and speed bands.

6.2.25 The monetised greenhouse gas impact is calculated in terms of traded and non-traded carbon (tCO_2e) using the following guidance and tools:

- 'Carbon Valuation' (BEIS September 2021).
- 'Valuation of greenhouse gas emissions: for policy appraisal and evaluation' (BEIS September 2021),
- 'Valuation of energy use and greenhouse gas' (BEIS October 2021).
- 'IAG spreadsheet tool for valuing changes in greenhouse gas emissions' (2019).
- 'Data tables 1-19' (BEIS June2021).
- 'Template reporting emissions savings' (BEIS September 2021).
- Emissions Factors Toolkit (EFT) version 11 (DEFRA, November 2021)

6.2.26 Greenhouse gas (GHG) calculations have been undertaken, to quantify and value the Project's traded GHG impacts as well as the non-traded GHG impacts, using latest DfT guidance and tools (February 2021). The latest guidance reflects changes in the proportion of electric vehicles (EV) and the impetus for zero emissions.

6.2.27 Construction emissions are calculated for the following lifecycle stages (aligning with PAS 2080):

- Materials used on works site (A1-3) - The extraction and manufacturing of materials used in the construction of the works site.
- Transport to works site (A4) - The transport of materials to the works site.
- Energy Use (A5) - Fuel usage, electricity and water usage during the construction process.
- Business and employee transport (A5) – Number of construction staff and estimated commute frequency and distances.
- Waste and waste transport (A5) – The transport and disposal of waste generated through the construction process.
- Land use change (D) – Type and area of land subject to change in usage.

6.2.28 The assessment of operational emissions includes road users, the need to maintain/replace certain elements of the Project periodically; and land use change benefits arising from planting.

6.2.29 Quantified and monetised non-traded and traded GHG impacts are summarised in the TAG 'Greenhouse Gases Workbook'. The results of the appraisal are shown in Table 6-9. The valuation of traded carbon is based on the difference between the social cost of carbon and the traded carbon price, to avoid double-counting with carbon permit costs.

Table 6-9: Summary of carbon impacts – value of emissions over 60 Years (£m 2010 present values positive value represents a cost)

	Tailpipe	Construction & Maintenance	Operating	Total
Non-Traded emissions	£147.89m	£9.19m	£16.84m	£173.91m
Traded emissions	£1.79m	£26.34m	£0.00m	£9.28m
Total value of emissions	£149.68m	£35.53m	£16.84m	£202.05m

6.2.30 A summary of these environmental impacts are included in Table 6-10 below.

Table 6-10: Summary of monetised environmental impacts - value of emissions over 60 Years (£m 2010 present values positive value represents a cost)

Impact	Monetised Value
Noise	-£1.24m
Air Quality	-£9.74m
Greenhouse Gases	£202.05m

Journey Time Reliability

6.2.31 Reliability effects on the A66 associated with the NTP improvement are assessed in MyRIAD in terms of TTV and travel time delays during incidents shorter than 6 hours. The net impact, (equivalent to DS reliability costs subtracted from DM reliability costs), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted.

6.2.32 TTV impact is calculated in two respects:

- During normal operating conditions, or daily congestion.
- During incidents (accidents, breakdowns and other events).

6.2.33 Travel time delays shorter than 6 hours, during incidents, are calculated for two parts of the road network:

- On the A66 route between Penrith and Scotch Corner.
- On adjacent diversion routes.

6.2.34 The spread of user reliability savings between trip purposes is shown in Table 6-11. The overall 60-year total benefit of £272.204m is proportioned between trip purposes as follows: 46% amongst business users, and 54% amongst commuter and other users.

Table 6-11: Reliability Benefits by Trip Purpose (£m, at 2010 Market Prices Discounted)

	Business Users	Commuter & Other Users	All Users
TTV (Daily Congestion & Incidents)	71.811	79.348	151.159
Incident Delays (A66 Route)	52.697	67.816	120.513
Incident Delays (Diversion Routes)	0.231	0.301	0.532

	Business Users	Commuter & Other Users	All Users
All Reliability Aspects	124.739	147.465	272.204

Route Resilience

6.2.35 Route resilience assessment for the A66 represents the potential for the road to recover to normal operating conditions and travel times, after an incident blockage and carriageway closure longer than 6 hours. The route resilience effects of the A66 improvement are assessed by testing carriageway closure scenarios in the SATURN traffic model (A66TM) and by monetising the resulting road user economic impacts in TUBA v1.9.17.

6.2.36 The carriageway incident closure scenarios are determined from recorded incident characteristics on the A66, over a 6-year period from 2014 to 2019, inclusive.

6.2.37 The net overall economic impact of the project on route resilience (DS scenario), compared with the existing situation (DM scenario), is calculated in terms of travel cost savings by comparing the cost of carriageway closures in the DS scenario against the costs in the DM scenario.

6.2.38 The spread of travel cost savings amongst route sections during A66 carriageway incident closures is shown in Table 6-12.

Table 6-12: A66 Route Resilience Valuation (£m, at 2010 Market Prices Discounted)

No.	Description	With Project (DS)	Without Project (DM)	Net Travel Cost Saving (DS – DM)
04	Penrith to Temple Sowerby	-0.189	-0.360	0.171
06	Temple Sowerby to Appleby	-0.086	-0.188	0.102
08	Appleby to Brough	-0.480	-1.685	1.206
09	Brough to Bowes	-9.627	-5.215	-4.413
10	Bowes Bypass	-0.378	-0.689	0.312
13	Rokeby to Stephen Bank	-0.122	-0.055	-0.067
14	Stephen Bank to Carkin Moor	-0.631	-1.481	0.850
15	Carkin Moor to Scotch Corner	-0.201	-0.101	-0.100
Total All Route Sections		**-9.774**	**-11.714**	**-1.939**

6.2.39 The overall route resilience outcome is -£1.939m over 60 years. The assessment clearly shows a positive travel cost saving, with the A66 improvement, on link sections 04, 06, 08, 10, and 14, associated with upgrading the existing single carriageway to dual carriageway and thereby mitigating, in future, the impact of historic road closures (mostly 2-way closures). On these existing single carriageways, the route resilience benefit amounts to £2.640m.

6.2.40 However, the overall outcome is significantly affected by future incident closures on the unchanged dual carriageway link sections 09, 13 and 15, especially between Brough and Bowes, which handle increased traffic flow in the DS compared with the DM. These unchanged route sections therefore experience a greater incident closure cost in the DS compared with the DM, amounting to -£4.580m.

6.2.41 The National Highways approach to assessing A66 route resilience appraisal is thought to underestimate likely travel cost savings with the improvement, because the method unrealistically assumes that all traffic can re-route away from the A66 during accidents and breakdowns, and that no vehicles are trapped and delayed in a queue behind a single carriageway 2-way closure. This queue delay effect cannot be replicated in the SATURN traffic model. In reality, the route resilience effect of the A66 project on travel costs associated with carriageway incident closures longer than 6 hours could be a positive benefit, similar to (but less than) the journey time reliability outcome shown in MyRIAD for incidents shorter than 6 hours.

Network Resilience

6.2.42 Wider network resilience assessment for the A66 Project represents the potential for other routes on the adjacent strategic and local road network to recover to normal operating conditions and travel times, after an incident blockage and carriageway closure longer than 6 hours. These routes could benefit from improvement of the A66, if the upgraded A66 provides a more dependable diversion route than it does now. The strategic and local network resilience effects of the A66 improvement are assessed separately by testing carriageway closure scenarios in the SATURN traffic model (A66TM) and by monetising the resulting road user economic impacts in TUBA v1.9.17.

6.2.43 The carriageway incident closure scenarios on the strategic road network are determined from recorded incident characteristics, over a 6-year period from 2014 to 2019, inclusive. Since no recorded incident data are available on local roads from the relevant highway authorities, the local network incident closure characteristics are derived from the MyRIAD 2021 incident database for typical road types.

6.2.44 Preliminary testing of road closures in the SATURN traffic model show that there are two roads on the strategic network where the A66 improvement could have a quantifiable impact (more than negligible), namely:

- M6 between J31 Preston (A59) and J39 Shap (B6261).
- M62 between J21 Milnrow (A640) and J27 Gildersome (M621).

6.2.45 Similarly, there are four roads on the local network where the A66 improvement could have a quantifiable impact, namely:

- A688 east of Barnard Castle.
- A67 east of Barnard Castle.
- A67 west of Barnard Castle.
- A685 south of Brough (5 road sections).

6.2.46 The overall strategic network resilience outcome is £17.513m over 60 years. Benefits are split evenly between the M6 route sections (47.7%) and the M62 route sections (52.3%). The assessment shows positive travel cost savings, with the A66 improvement, on all M6 and M62 modelled link sections, associated with making the A66 a more efficient and dependable diversion route.

6.2.47 The overall local network resilience outcome is £3.911m over 60 years. Benefits are split amongst local roads as follows:

- A688 east of Barnard Castle 21.9%.
- A67 east of Barnard Castle 14.7%
- A67 west of Barnard Castle 6.0%
- A685 south of Brough 57.4%.

6.2.48 The assessment shows small positive travel cost savings, with the A66 improvement, on all local road modelled link sections, associated with making the A66 an easier and more dependable diversion route.

6.2.49 The resilience assessment is summarised in Table 6-13.

Table 6-13: Network Resilience Impacts (£m, at 2010 Market Prices, Discounted)

Resilience Category	Value
Strategic Network Impacts	£17.513
Local Network Impacts	£3.911
A66 Route Impact	-£1.939
Total Impact	**£19.49**

Wider Economic Impacts

6.2.50 The implications of improving the A66 for the wider economy are captured using WITA. Wider economic impacts (WEI) are likely to arise under the static land use assumptions, which underpin the A66TM DM and DS traffic forecast scenarios, under improved transport connectivity, and under conditions of market failure where businesses and workers may be constrained, owing to spatial, environmental, political, technological, economic, demographic, social or distributional factors.

6.2.51 The net wider economic impact, (equivalent to DM welfare and GDP outcomes subtracted from DS outcomes), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted.

6.2.52 Monetised impacts assessed using WITA comprise the following:

- Business output change under imperfect market competition, (whereby reduced travel costs lead to market value of output greater than cost of production).

- Labour supply change, (whereby better transport access releases inactive workers into the labour market and provides tax revenue).

6.2.53 Wider economy agglomeration effects are assessed, whereby better transport connectivity, closer proximity and easier interaction improves economic productivity and GDP. Agglomeration impacts are analysed robustly, using WITA, and proportionately, by masking out impacts in peripheral areas where predicted changes in the generalised costs of travel are less reliable. However, further evidence is needed to demonstrate the presence of market failures and distortions within the area of influence of the A66 improvement, and to show that a significant number of journeys occur in areas where agglomeration benefits are found, before the monetised impacts can be included in the adjusted BCR.

6.2.54 Table 6-14 shows the overall WEI results, split be type of impact.

Table 6-14: Wider Economic Impact (£m, at 2010 Market Prices, Discounted)

	Road User Cost Item	Net Valuation
Business Output under Imperfect Market Competition	10% Uplift to business user benefit	47.759
	10% uplift to business reliability	12.474
Labour Supply Change (Income Tax Revenue)		1.227
All Wider Economic Impacts		61.460

6.2.55 The total A66 WEI benefit is £61.460m, This is chiefly associated with the increased value of business output under imperfect competition, through travel efficiency and reliability cost savings. The remainder of benefits, is derived through tax revenue from releasing inactive labour supply.

6.3 Other Impacts

6.3.1 The (Appraisal Summary Table) AST[32] presents evidence from the analysis that is undertaken to inform the economic case of an intervention. Applying the principles of HMT Green Book, the AST has been designed to record all impacts, beyond just those of the Economic and public accounts. It therefore includes Environmental, Social, and Distributional impacts – at the national level. This section describes the results of the Social, Environmental and Distributional appraisals.

6.3.2 TAG Unit A3[33] describes how (Social and) Environmental Impact Appraisal is undertaken as part of the transport appraisal process. This is distinct from the statutory requirement to provide an Environmental Statement for the Project in accordance with the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the EIA Regulations). Social and environmental impact appraisal is the process

[32] The purpose of the AST is described in described in: TAG, advice for the Technical Project Manager, May 2018, Department for Transport
[33] TAG UNIT A3 Environmental Impact Appraisal July 2021 Department for Transport

of developing social and environmental impact information for inclusion in a transport appraisal.

6.3.3 The social and environmental appraisal builds on the baseline data and impact assessment work carried out as part of the **3.2 Environmental Statement**. The methodologies set out in TAG differ from those that apply to the Environmental Statement, so there may be differences in the appraisals reported in the AST and the Environmental Statement. The outcomes reported here do not affect the environmental assessment of the project and should be considered in isolation as part of the transport appraisal process.

Social Impacts

6.3.4 The Project would have some positive and negative impacts on people within proximity to the Project. A qualitative assessment of these impacts has been undertaken following the methods set out in TAG. A summary of the impacts is given in Table 6-15 using the following 7-point scale set out in TAG Unit A3 Environmental Impact Appraisal:

- Large beneficial (positive)
- Moderate beneficial (positive)
- Slight beneficial (positive)
- Neutral
- Slight adverse (negative)
- Moderate adverse (negative)
- Large adverse (negative)

6.3.5 Further information on the definition of assessment scores for each social impact aspect can be found in TAG Unit A3 Environmental Impact Appraisal.

Table 6-15: A66 Social Impact Assessment

Social Impact Aspect	Summary of A66 Outcomes	Qualitative Score (7-Point Scale)
Physical Activity	Potential slight increase in number of people walking and cycling on new, shared, active travel routes which run alongside the new A66 at Center Parcs (scheme 03), and Rokeby (scheme 08), and which run along the bypassed sections of existing A66, which are retained at Kirkby Thore / Crackenthorpe (schemes 04/05), Warcop / Langrigg (scheme 06), and Ravensworth / West and East Layton (scheme 09). There is no extra hindrance to people crossing the upgraded sections of the A66, because most tunnels or bridges are retained, and most at-grade crossings are substituted with new, safer, and more user-friendly grade-separated or signal-controlled arrangements.	Slight Beneficial
Journey Quality	The likely outcome is improved journey quality for road users on A66, because the project provides new dual carriageway sections where the layout is faster, safer and enables easier overtaking of heavy vehicles. The improvement offers a more consistent route standard and level of service along the A66 between Penrith and Scotch Corner.	Moderate Beneficial

Social Impact Aspect	Summary of A66 Outcomes	Qualitative Score (7-Point Scale)
	The project also provides safer grade-separated junctions for accessing the A66 and better lay-by facilities. It introduces more technology to assist drivers and allow safer and more secure journeys, in the form of variable message signs (VMS), vehicle / incident detection equipment and CCTV installations	
Security	The project has no meaningful impact on public transport provision or use, and so it has no effect on the security of passengers.	Neutral
Accessibility of Services & Facilities	The project has no meaningful impact on public transport provision or use, and so has no effect on the access to services and facilities	Neutral
Affordability	Overall, the road user expenditure impact of the A66 project (vehicle operating cost and toll charges), as assessed in TUBA, is strongly negative, representing a net road user disbenefit. However, this additional expense impact on affordability is only slight, as it is heavily outweighed by road user travel time savings by a factor of 6. The VOC disbenefits are shared fairly evenly, amongst 5 income deprivation categories (quintiles) of LSOA, in the region of focus. As the disbenefits are shared fairly evenly, and while users may see the monetary cost, it is on the whole worth the additional expense due to the amount of time saved. It is therefore only judged as 'Slight Adverse' Masked total VOC and toll disbenefits are £98.434m.	Slight Adverse
Severance	The TAG severance appraisal has considered those using non-motorised modes only. The severity of severance effects of the project are measured on roads in the area of focus where daily traffic flow changes exceed 10%, and they are scaled in terms of: – The existing daily traffic volume range. – The presence of nearby services, facilities, amenities and resident population, which generate pedestrian crossing movements. The severity of impact on each road (7-point scale from -3 through 0 to +3) is weighted by the size of local LSOA population to give a severance score. The overall severance score across 75 road locations is 0.09 per resident, representing a neutral impact. No roads have large adverse or large beneficial severance impacts. In terms of moderate adverse / beneficial outcomes: – Total 9,180 local residents, living near to 11 road locations, are disadvantaged by a moderate adverse severance increase. – Total of 12,405 local residents, living near to 10 road locations, gain from a moderate beneficial severance decrease.	Neutral
Optional Usage / Non-Usage Value	The project has no meaningful impact on public transport provision or use, and so it has no effect on people's perception of option value.	Neutral

Environmental Impacts

6.3.6 The TAG Unit A3 describes that only some environmental impacts are quantified and included in the BCR. These impacts are noise, air quality and greenhouse gases. For other impacts, these are appraised qualitatively. As such each are described and given a score following the guidance set out in TAG Unit A3. A summary of the impacts is presented in Table 6-16.

Table 6-16: Summary of qualitative environmental appraisals

Impact	Qualitative appraisal summary	Score
Landscape	In the west, the character of the Eden valley is influenced by the last Ice age with its distinct glacial drumlin and esker features. The central area is typified by the character of the upland moor landscape within the North Pennines AONB and the moorland fringes and foothills are defined by its geology. To the east, the character is rural arable farming. Tranquillity is an important characteristic of the Eden Valley although tempered by the existing A66. Tranquillity and dark night skies are an important characteristic of the AONB, although this is affected in close proximity to the A66. The landscape has a strong cultural association with a Roman communication link and the Scotland and England border disputes. Landcover varies from the more intimate and settled fertile landscapes within the Eden Valley to the west and the settled mixed farmland in the east. These landscapes contrast with the central remote open moorland landscape within the AONB. The project would result in incremental encroachment into the landscape of the North Pennines AONB and its setting. The widening of the A66 and off line options would potentially have a direct effect on the pattern, tranquillity, cultural and landcover aspects of the landscape. As a result of the scheme at year 15 there would be adverse permanent significant effects experienced by 10 visual receptors. The appraisal on landscape impacts measures residual impacts beyond year 15. The project would potentially result in moderate adverse change to the pattern, cultural and landcover aspects of the landscape within and in the setting to the North Pennines AONB, including the important Eden Valley to the west. The modification and new road infrastructure would form additional new elements impacting directly and indirectly on national, regional and locally valued features. Mitigation measures have been considered which look to avoid or reduce the negative effects of the project options on the landscape and or townscape resource and on the visual amenity of the study area.	Moderate Adverse
Historic environment	Impacts on four types of heritage in the historic environment are assessed: scheduled monuments, listed buildings, registered park and garden (Rokeby), and non-designated heritage. The effects on each type of heritage are measured in respect of six aspects: form, survival, condition, complexity, context and period. The impacts on each type of heritage are appraised both inside and outside the A66 project boundary, with the following results: Inside A66 boundary (order limits)– Scheduled monuments – Moderate Adverse Listed Buildings - Neutral	Moderate Adverse

Impact	Qualitative appraisal summary	Score
	Registered park and garden - Neutral Non-designated heritage – Moderate Adverse Outside A66 boundary (within area of focus[34]) All heritage types - Neutral Overall Impact (inside and outside A66 boundary) – Moderate Adverse	
Biodiversity	Several designated sites are located, in part or wholly, within the Order Limits of the Project. Important biodiversity features identified within the Order Limits included, but were not limited to, habitats of principal importance, 'important' hedgerows, bat roosts, otter holts and barn owl breeding sites. The construction phase will result in the permanent or temporary loss of all semi-natural habitats affected by construction. The largest areas of habitat removal will be of improved grassland, poor semi-improved grassland, arable land and woodland. Approximately 648ha of replacement habitats will be provided during the construction phase to mitigate for baseline habitat losses. The residual impact on habitats or principle important are slight adverse, with the exception of swamp habitat within the Stephen Bank to Carkin Moor scheme, where a significant adverse effect on swamp habitat is likely as a result of construction of the Project and the loss of this habitat cannot be fully mitigated through habitat creation. The majority of potential impacts affecting protected species/species of principal importance will arise during the construction phase, comprising habitat loss, fragmentation of habitats and populations, disturbance to species, habitat degradation and species injury and mortality. All species are subject to a slight adverse of neutral impact as a result of the Project, with the exception of barn owl, where there is a moderate adverse impact as obstacle planting is unable to be guaranteed to mitigate the increased collision risk. Operational impacts of the Project on biodiversity features will largely be limited to species injury and mortality and permanent fragmentation.	Slight Adverse
Water environment	The assessment considers the Project's impacts upon the quality and quantity of surface watercourses, ponds, groundwater, groundwater to surface water interactions, abstractions and changes in flood risk and road drainage within the Order Limits and a 1km buffer of the Order Limits. The construction phase of the Project may result in permanent and temporary losses of quality and quantity of surface watercourses, groundwater and ponds, groundwater terrestrial ecosystems (GWDTEs) or changes to flood risk. With appropriate mitigation measures in place to prevent pollution from construction sources (including hydrocarbons, concrete and sediment) in normal and flood conditions, and embedded mitigation to manage surface water and dewatering activities,	Slight Adverse

[34] As described in **Chapter 8.4 Assessment Methodology** of **Chapter 8 Cultural Heritage** of **3.2 Environmental Statement**

Impact	Qualitative appraisal summary	Score
	the residual impacts upon the water environment are slight adverse. During the operational phase of the Project, permanent losses to the quality or quantity of surface watercourses, groundwater and ponds, GWDTEs or changes to flood risk may occur. With embedded mitigation such as the design and installation of open span watercourse crossings or viaducts, design and installation of a drainage system and flood risk management measures (such as flood compensatory storage) and the avoiding of sensitive GWDTE habitats, residual impacts upon the water environment are slight adverse.	

Distributional Impacts

6.3.7 The Distributional Impact Appraisal (DIA) considers the spread of outcomes from the A66 NTP project amongst communities, in which there is a significant presence of people in a vulnerable category as defined by several DfT indicators in TAG Unit A4.2 Distributional Impact Appraisal, which are:

- Proportion of affected LSOA in each of 5 income deprivation quintiles (decreasing severity from 1 to 5), relative to 20% national average.
- Children aged <16.
- Young adults aged 16-25.
- Older adults aged 70 and over.
- People with a disability.
- People of Black / Minority / Ethnic (BME) origin.
- People without access to car.
- Households with dependent children.

6.3.8 Distributional impacts are appraised using TAG principles and worksheets. A 3-step procedure is applied to determine outcomes, where relevant, as follows:

- Step 1 – Screening to retain only meaningful A66 impacts for further appraisal.
- Step 2 – Measuring of criteria against which distributional effects are judged.
- Step 3 – Deriving distributional impact scores from the measured criteria (7-point scale from large / moderate / slight adverse, through neutral, to slight / moderate / large beneficial).

6.3.9 Table 6-17 provides a summary of the A66 distributional impact outcomes. Those aspects that the Project are deemed to have no impact upon (see Table 6-15) are excluded from further appraisal.

Table 6-17: A66 Distributional Impact Assessment

Distributional Indicator	Summary of Key impacts	7-Point Scale Assessment
User Benefits	Road user travel cost impacts (travel time, VOC and user charges) are measured within the area of focus captured in the masked TUBA appraisal. The costs and savings are allocated to 5 income deprivation categories of LSOA in	Slight Beneficial

Distributional Indicator	Summary of Key impacts	7-Point Scale Assessment
	the region of focus (20% quintiles from 1, most deprived, to 5, least deprived). Overall, the travel cost impact of the A66 project is strongly positive, providing net road user benefits. Both road user benefits and disbenefits are shared similarly, and fairly evenly, amongst 5 income deprivation categories of LSOA in the region of focus. 50-60% of both benefits and disbenefits are in least deprived categories 4 and 5, and 25-35% of both are in most deprived categories 1 and 2. The proportion of disbenefits in categories 1 and 2 is slightly higher than the proportion of benefits. The converse is true in categories 4 and 5. The impact in categories 1 and 2 is amplified by these quintiles representing a higher-than-average proportion of the affected population (49% in total). However, a higher-than-average proportion of road user disbenefits (51%) are experienced by the least income deprived LSOA (categories 4 and 5).	
Noise	Severity of noise impact is gauged on a scale of dB increases and decreases, within the A66 corridor perimeter captured in the environmental assessment. There are no meaningful residential noise impacts for the most income deprived LSOA in the study area (category 1). There are day and night residential noise increases in income deprivation quintiles 2, 4 and 5, but decreases in quintile 3. Most noise disbenefit (96%) is experienced by the least income deprived LSOA (4 and 5). Noise impacts are therefore unevenly distributed but overall quite small. During both daytime and night-time, the distribution of qualitative noise impact scores amongst income deprivation quintiles Q1 – Q5 are: Q1 Neutral, Q2 Slight Adverse, Q3 Moderate Beneficial, Q4 Large Adverse, Q5 Moderate Adverse. There are minimal non-residential noise changes at locations used by vulnerable community members. Around 90% of facilities have negligible noise change. Of the remaining 10% of affected locations, about 8% experience noise decreases and 2% noise increases.	Moderate Adverse
Air Quality	Severity of air quality impact is measured on a scale of significant changes in NO2 concentration (> +0.4ug/m3, < -0.4ug/m3) within the area of focus analysed in the environmental assessment. There are no meaningful air quality impacts for receptors in the most income deprived LSOA in the study area (category 1). There are NO2 concentration increases for receptors in income deprivation quintiles 3, 4 and 5, but decreases in quintile 2. Most air quality disbenefit (93%) is experienced by receptors in the least income deprived LSOA (3, 4 and 5). Some 33% of air quality benefit is experienced by receptors in quintile 2. The distribution of qualitative air quality impact scores amongst income deprivation quintiles Q1 – Q5 are: Q1 Neutral, Q2 Large Beneficial, Q3 Large Adverse, Q4 Large Adverse, Q5 Large Adverse. There are 3 schools in Penrith, out of 18 schools in the study area, where a receptor within 200m distance shows	Moderate Adverse

Distributional Indicator	Summary of Key impacts	7-Point Scale Assessment
	a decline in air quality. The remaining schools experience no significant impact.	
Accidents	Accident impacts are measured for roads in the area of focus captured in the COBALT appraisal, where daily traffic flows change by >5% and by >50 vehicles per day. Amongst 6 vulnerable groups of road users and communities, the overall weighted score of positive accident impacts (52% on A66 and 56% in area of focus) balances that for negative impacts (48% on A66 and 44% in area of focus), giving a neutral outcome. The weighted scores for both beneficial and adverse accident impacts are evenly distributed amongst 6 vulnerable groups of road users and local communities, in both the A66 corridor and in the wider area of focus. There is no over-representation of accidents in any vulnerable group.	Neutral
Personal Security	Initial screening indicates that the project has no meaningful impact on personal security.	Not Applicable
Severance	Severance impacts are measured in terms of severity, for road links within the area of focus where daily traffic flow change is >10%, by relating the flow change to the existing daily traffic volume and the presence of facilities which generate pedestrian crossing movements. Weighted impact scores are calculated by factoring the 7-point severity score (-3, through 0, to +3) by the number of people in the nearby vulnerable groups (4 categories). There are no road links which experience a large beneficial or adverse severance effect for vulnerable groups. Moderate impacts are measured in 3 locations: Penrith to Kirkby Thore (vicinity of A66), Kirkby Stephen to Brough (vicinity of A685), and Barnard Castle (vicinity of A67 and A66). The sum of weighted severance scores across all locations is close to zero. Overall, the negative and positive severance effects are insubstantial and are balanced, giving a neutral outcome. Out of 70 affected locations, 59% experience neutral impact, 18% slight or moderate adverse impact, and 23% slight or moderate beneficial impact.	Neutral
Accessibility	Initial screening indicates that the project has no meaningful impact on personal accessibility.	Not Applicable
Affordability	Affordability impacts are measured in terms of changes in vehicle operating costs within the area of focus captured in the masked TUBA appraisal. The VOC are allocated to 5 income deprivation categories of LSOA in the region of focus (20% quintiles from 1, most deprived, to 5, least deprived). Overall, the VOC impact of the A66 project is strongly negative, representing a net road user disbenefit. VOC disbenefits are shared fairly evenly, amongst 5 income deprivation categories of LSOA in the region of focus. 46% of disbenefits are in least deprived categories 4 and 5, and 39% are in most deprived categories 1 and 2. The disbenefit in categories 1 and 2 is amplified by these quintiles representing a higher-than-average proportion of the affected population (49% in total).	Slight Adverse

Distributional Indicator	Summary of Key impacts	7-Point Scale Assessment
	The distribution of qualitative affordability score (2010) amongst income deprivation quintiles Q1 - Q5 is as follows: Q1 Slight Adverse, Q2 Moderate Adverse, Q3 Moderate Adverse, Q4 Large Adverse, Q5 Moderate Adverse.	

6.4 Project Costs

6.4.1 The costs to public accounts of constructing, operating and maintaining the improved A66 route are estimated by National Highways and are converted to 2010 present year values and market prices, discounted, for the core scenario initial BCR.

6.4.2 The net impact, (equivalent to DM expenditure subtracted from DS user expenditure), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive.

6.4.3 The National Highways' PCF Stage 3 capital expenditure (CAPEX) economic estimate is prepared for the Most Likely 5-year construction scenario, with a price base of Q1 2019. The estimate includes Portfolio Risk and is converted to 2010 prices in line with TAG GDP deflator (from TAG Data Book v1.17, November 2021), with allowance for construction-related inflation. It is discounted to 2010 values at 3.5% pa for the first 30 years, 3% thereafter and converted from factor cost to market prices. This estimate has been combined with the 60-year Operation and Maintenance (O&M) estimate, which represents the incremental O&M cost of the with-scheme scenario minus the without-scheme scenario.

6.4.4 The National Highways capital expenditure estimate for A66 construction comprises the following cost components:

- Preparation
- Supervision
- Construction works
- Land

6.4.5 It also includes allowances for risk, uncertainty, unscheduled items, and National Highways' portfolio risk uncertainty. These items together represent the equivalent of Optimism Bias.

6.4.6 The 5-year construction estimate at 2010 prices is derived from a yearly profile of base costs at Q1 2019 prices (2022 to 2034 inclusive), inflated to outturn costs using National Highways projected yearly construction related inflation, and then adjusted to 2010 prices using a yearly GDP deflator from TAG Data Book v1.17 (November 2021).

6.4.7 The 2010 cost is adjusted to market prices by applying the TAG indirect tax correction factor of +19% and is discounted to 2010 values from year of occurrence at a discount rate of 3.5% per annum.

6.4.8 The profile of construction costs, split by expenditure item, is shown in Table 6-18.

Table 6-18: A66 Capital Expenditure RDP Central Estimate Construction Cost at 2010 Market Prices and Values, Discounted

	Preparation	Supervision	Construction Works	Land	Total
2022	19.264	0	2.073	2.081	23.419
2023	37.36	0	27.043	4.267	68.67
2024	0	2.25	168.403	35.187	205.84
2025	0	5.416	196.528	11.13	213.074
2026	0	4.143	131.601	5.536	141.279
2027	0	1.55	28.233	5.37	35.154
2028	0	1.421	0	1.168	2.589
2029	0	0	0	0.552	0.552
2030	0	0	2.62	0.26	2.88
2031	0	0	0	0.133	0.133
2032	0	0	0	0.091	0.091
2033	0	0	0	0.052	0.052
2034	0	0	0	0.011	0.011
Total	56.624	14.78	556.502	65.837	693.743

6.4.9 The Central Estimate of the project construction cost, at 2010 prices and values, discounted, amounts to £693.743m.

6.4.10 The proportion of total project cost which is contributed by each A66 scheme is shown in Table 6-19.

Table 6-19: Percentage Split of Most Likely Project Costs Amongst A66 Schemes

A66 Scheme	A66 Route Section	Scheme Cost as % of Project Total (Ranked in Descending order of magnitude)
Scheme 04 & 05	Temple Sowerby to Appleby	27.1%
Scheme 06	Appleby to Brough	23.2%
Scheme 03	Penrith to Temple Sowerby	13.2%
Scheme 09	Stephen Bank to Carkin Moor	11.6%
Scheme 08	Cross Lanes to Rokeby	8.6%
Scheme 02	A66/A6/A686 Kemplay Bank	7.2%
Scheme 07	Bowes Bypass	6.1%
Scheme 01	A66/M6 J40 Skirsgill	2.7%
Scheme 11	A66/A1(M) J53 Scotch Corner	0.3%
All Schemes		100.0%

6.4.11 Operation and maintenance costs have been compared by comparing do something costs to do minimum costs for the overall route. Costs have been provided for the 60-year assessment period at Quarter 1 2019 real prices, excluding future year inflation.

6.4.12 In line with TAG procedure (Unit A1.2 Scheme Costs, November 2021), future year construction cost increases have been added from a 2019 base, relative to general inflation from a 2019 base, before deflating back from 2019 to 2010 prices, using the GDP deflator series (TAG Data Book v1.17, November 2021). The costs are shown in Table 6-20.

Table 6-20: Operational and Maintenance Costs

	Minimum	Most Likely	Maximum
Q1 2019 real cost without inflation:	144.899	290.691	437.423
Q1 2019 real cost with relative price increases:	144.603	290.102	436.544
2010 real cost with relative price increases	122.984	246.729	371.277
2010 real cost with relative price increases, at market prices, discounted to 2010 values	28.351	56.919	85.715

6.4.13 The most likely estimate of the project construction cost, at 2010 prices and values, discounted, amounts to £56.919m.

6.5 Economic Result Summary

6.5.1 The key monetised benefits and costs for the Project are shown in Table 6-21.

Table 6-21: Key monetised Benefits and Costs (£m, at 2010 Market Prices, Discounted)

	Items	Totals
Transport Economic Efficiency		
Road Users (Travel Time, VOC, Charges)	521.097	
Public Finances (Indirect Tax)	79.129	600.226
Construction		
Road Users (Travel Time, VOC, Charges)	-61.067	
Public Finances (Indirect Tax) & Greenhouse Gases	0.061	-61.006
Safety		
Accidents	29.646	29.646
Environment		
Noise	1.240	
Air Quality	-9.739	
Greenhouse Gases	-202.047	-210.546
Present Value of Benefits (PVB)		**358.320**
Public Accounts		
Capital Expenditure (Construction)	693.743	
Capital Expenditure (Operation & Maintenance)	56.919	
Operator Revenue (Normal Operation)	-0.112	
Operator Revenue (Construction)	-0.052	750.498
Present Value of Costs (PVC)		**750.498**
Net Present Value (PVB – PVC)		**-392.178**
Benefit to Cost Ratio (PVB / PVC)		0.48
Journey Time Reliability		
Road Users (Travel Time Variability)	151.159	
Road Users (Incident Delay)	121.045	272.204
Wider Economic Impacts		
Business Output in Imperfectly Competitive Market - TUBA	47.759	
Business Output in Imperfectly Competitive Market - MyRIAD	12.474	
Labour Supply (Income Tax Revenue)	1.227	61.460
Adjusted Present Value of Benefits (PVB)		**691.984**
Adjusted Net Present Value (PVB – PVC)		**-58.514**
Adjusted Benefit to Cost Ratio (PVB / PVC)		**0.92**

6.5.2 Combining the core scenario economic appraisal outcomes in the category ‘A’ established assessment, gives an initial PVB of £358.320m.

This is offset by a PVC of £750.498m, giving a NPV of -392.178 and a BCR of 0.48.

6.5.3 When further outcomes are included, the adjusted PVB amounts to £691.984m. Offsetting this against the PVC, gives an adjusted NPV of £-58.514m and an adjusted BCR of 0.92.

6.6 References

6.6.1 For further details on the information provided in Appendix E: Transport Economics Package.

7 Sensitivity tests

7.1 Introduction

7.1.1 Demand sensitivity tests were undertaken to assess the impact of low and high traffic growth levels on the benefits. Additionally, a core scenario sensitivity test around costs has been undertaken.

7.2 Demand Sensitivity

Inputs

7.2.1 The core scenario is based on the most unbiased and realistic set of assumptions that will form the central case, defined in TAG Unit M4 Forecasting and Uncertainty as follows:

- NTEM growth in demand, at a suitable spatial area.
- Sources of local uncertainty that are more likely to occur than not.
- Appropriate modelling assumptions.

7.2.2 In addition to the core scenario, TAG requires that additional sensitivity tests be undertaken. Specifically, high and low growth scenarios are defined to assess whether the Project is still effective in reducing congestion in high demand scenarios and is still economically viable in low demand scenarios.

7.2.3 The high scenario adds a proportion of the base demand to that of the core scenario. For highway demand, the proportion is 2.5% multiplied by the square root of the number of years from the base year. Rail demand is adjusted in the same manner, using a proportion of 2.0% multiplied by the square root of the number of years from the base year. The Low scenario removes demand from the Core scenario by the same proportions of that added in the High for both highway and rail demand.

7.2.4 In addition to raising / lowering the core scenario, the level of certainty considered for developments from the uncertainty log is also adjusted. For the High scenario, developments which are “Reasonably Foreseeable” are modelled in addition to those already considered in the core scenario. For the low scenario, only developments which are considered “Near Certain” have been modelled.

7.2.5 Table 7-1 shows the base and reference forecast highway demand matrix totals.

Table 7-1: Sensitivity Test Reference Forecast Highway Demand Totals (24 hour, vehicles)

Mode	Year	Base	Core (Core vs. Base %)	Low (Low vs. Base %)	High (High vs. Base %)
Highway vehicles	2029	76,664,726	83,068,932 (8.4%)	77,008,053 (0.4%)	89,129,812 (16.3%)
	2044		91,543,778 (19.4%)	81,960,689 (6.9%)	101,126,869 (31.9%)
	2051		95,471,427 (24.5%)	84,629,399 (10.4%)	106,313,456 (38.7%)

Forecast Network Performance

7.2.6 The pattern of changes in the network statistics are similar to the core scenario results, presented earlier in this report, apart from the change from base to reference forecast which varies depending on low growth scenario or high growth scenario demand assumptions. The low growth scenario future year fixed speeds are very similar to the base, which is reflected in the results showing network speeds.

7.2.7 Base year 2019 and 2044 forecast traffic flows along the A66 corridor and mainline M6 either side of J40 and likewise for the A1(M) Scotch Corner, for each sensitivity test, are shown in Table 7-2 and Table 7-3 respectively.

7.2.8 The results show that traffic flow along the A66 corridor is less in the low growth scenario and more in the high growth scenario compared with the core scenario. Traffic flows for the low growth scenario are approximately 7% lower for both DM and DS compared with the core scenario forecast, whilst flows for the high growth scenario are approximately 5% higher for DM and 6% higher for DS. The relative traffic flow change between the DM and DS are comparable with the core scenario results (presented earlier in this report).

7.2.9 The Bowes bypass sites represents a mid-point along the A66 corridor. In the low growth scenarios base 2015 to 2044 DM traffic flows increase by 17% and then in the DS a further 42%. In the high growth scenario, the equivalent growth is 38% and 41% respectively.

Table 7-2: 12-Hour Traffic Flows (vehicles, two-way) – 2044 – Low Growth Scenario

Road	Location	Base 2019	DM	DS	DM vs. Base	DM vs. Ref	DS vs. DM
A66	West of M6 J40	16,585	19,953	20,754	942 (6%)	2,427 (14%)	801 (4%)
A66	Between M6 J40 and Kemplay Bank	25,699	31,046	35,083	1,638 (6%)	3,710 (14%)	4,036 (13%)
A66	Directly East of Kemplay Bank	17,612	21,262	27,705	1,564 (9%)	2,087 (11%)	6,443 (30%)
A66	Temple Sowerby	14,472	17,710	24,963	1,369 (9%)	1,869 (12%)	7,253 (41%)
A66	Between Kirkby Thore and Appleby	15,644	18,819	23,139	1,124 (7%)	2,051 (12%)	4,320 (23%)
A66	Between Appleby and Brough	13,053	15,843	22,472	877 (7%)	1,913 (14%)	6,629 (42%)
A66	East of Brough	14,986	19,560	26,022	1,630 (11%)	2,944 (18%)	6,462 (33%)
A66	Bowes Bypass	12,405	16,582	23,624	2,093 (17%)	2,083 (14%)	7,041 (42%)
A66	West of Greta Bridge	15,105	19,671	27,363	2,209 (15%)	2,356 (14%)	7,693 (39%)
A66	East of Smallways	15,096	19,564	27,624	2,168 (14%)	2,300 (13%)	8,060 (41%)
A66	West of Scotch Corner	15,541	20,394	28,307	2,615 (17%)	2,238 (12%)	7,913 (39%)
A1(M)	North of Scotch Corner	48,829	67,955	70,204	7,728 (16%)	11,398 (20%)	2,249 (3%)
A1(M)	South of Scotch Corner	51,041	68,020	71,178	5,815 (11%)	11,163 (20%)	3,158 (5%)
M6	North of M6 J40	42,657	57,167	58,882	4,366 (10%)	10,144 (22%)	1,715 (3%)
M6	South of M6 J40	31,464	41,222	39,373	2,509 (8%)	7,249 (21%)	-1,849 (-4%)

Table 7-3: 12-Hour Traffic Flows (vehicles, two-way) – 2044 – High Growth Scenario

Road	Location	Base 2019	DM	DS	DM vs. Base	DM vs. Ref	DS vs. DM
A66	West of M6 J40	16,585	23,679	25,092	5,210 (31%)	1,885 (9%)	1,412 (6%)
A66	Between M6 J40 and Kemplay Bank	25,699	34,935	40,218	6,382 (25%)	2,854 (9%)	5,283 (15%)
A66	Directly East of Kemplay Bank	17,612	24,225	31,914	5,386 (31%)	1,227 (5%)	7,689 (32%)
A66	Temple Sowerby	14,472	19,579	28,575	3,907 (27%)	1,200 (7%)	8,996 (46%)
A66	Between Kirkby Thore and Appleby	15,644	21,199	26,466	4,183 (27%)	1,372 (7%)	5,267 (25%)
A66	Between Appleby and Brough	13,053	17,752	25,706	3,326 (25%)	1,374 (8%)	7,953 (45%)
A66	East of Brough	14,986	22,408	29,502	4,813 (32%)	2,609 (13%)	7,094 (32%)
A66	Bowes Bypass	12,405	18,974	26,773	4,771 (38%)	1,798 (10%)	7,799 (41%)
A66	West of Greta Bridge	15,105	22,240	31,231	5,398 (36%)	1,737 (8%)	8,991 (40%)
A66	East of Smallways	15,096	21,354	31,236	4,964 (33%)	1,294 (6%)	9,882 (46%)
A66	West of Scotch Corner	15,541	22,739	31,570	5,771 (37%)	1,428 (7%)	8,831 (39%)
A1(M)	North of Scotch Corner	48,829	76,641	78,571	18,984 (39%)	8,829 (13%)	1,929 (3%)
A1(M)	South of Scotch Corner	51,041	78,494	81,273	17,750 (35%)	9,704 (14%)	2,778 (4%)
M6	North of M6 J40	42,657	68,072	69,980	15,311 (36%)	10,104 (17%)	1,908 (3%)
M6	South of M6 J40	31,464	51,114	50,073	11,935 (38%)	7,715 (18%)	-1042 (-2%)

7.2.11 Journey times on the A66 corridor in 2044 between Scotch Corner and M6 J40 are shown in Table 7-4 and Table 7-5.

Table 7-4: A66 Corridor Journey times (mm:ss) – 2044 – Low Growth Scenario

Time Period	Direction	Base 2019	DM	DS	DM vs. Base	DS vs. DM
AM	A66 - Eastbound	53:17	55:04	44:57	01:46 (3%)	-10:06 (-18%)
	A66 - Westbound	54:06	55:51	45:12	01:44 (3%)	-10:39 (-19%)
IP	A66 - Eastbound	54:08	56:22	45:20	02:15 (4%)	-11:02 (-20%)
	A66 - Westbound	54:04	56:41	45:11	02:37 (5%)	-11:29 (-20%)
PM	A66 - Eastbound	54:47	57:11	45:28	02:24 (4%)	-11:44 (-21%)
	A66 - Westbound	54:24	56:51	45:39	02:27 (5%)	-11:12 (-20%)
OP	A66 - Eastbound	49:24	49:32	44:10	00:07 (0%)	-05:22 (-11%)
	A66 - Westbound	49:24	49:44	44:10	00:20 (1%)	-05:34 (-11%)

Table 7-5: A66 Corridor Journey times (mm:ss) – 2044 – High Growth Scenario

Time Period	Direction	Base 2019	DM	DS	DM vs. Base	DS vs. DM
AM	A66 - Eastbound	53:17	57:32	45:22	04:14 (8%)	-12:10 (-21%)
	A66 - Westbound	54:06	59:27	45:46	05:20 (10%)	-13:40 (-23%)
IP	A66 - Eastbound	54:08	59:24	45:43	05:16 (10%)	-13:41 (-23%)
	A66 - Westbound	54:04	60:05	45:46	06:01 (11%)	-14:19 (-24%)
PM	A66 - Eastbound	54:47	60:36	45:57	05:49 (11%)	-14:40 (-24%)
	A66 - Westbound	54:24	61:05	46:20	06:42 (12%)	-14:46 (-24%)
OP	A66 - Eastbound	49:24	49:51	44:12	00:26 (1%)	-05:39 (-11%)
	A66 - Westbound	49:24	50:04	44:12	00:40 (1%)	-05:52 (-12%)

7.2.12 The DM and DS journey times for the Low Growth Scenario and High Growth Scenario logically sit either side of the core scenario forecasts, with slightly less of a time saving in the Low Growth Scenario and slightly more in the High Growth Scenario, with time savings of 18-21 minutes and 21-24 minutes for the Low Growth Scenario and High Growth Scenario, respectively.

Sensitivity test economic results

7.2.13 Total transport economic efficiency outcomes for road users, during normal operation of the A66 route, are shown in Table 7-6 for the Core, Low and High Scenario. Benefits cover the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted.

Table 7-6: Transport User Impacts by purpose during Normal Operation

Road User Cost Item	Total Net Valuation (£m, at 2010 Market Prices, Discounted)		
	Core Scenario	Low Scenario	High Scenario
Business Users	477.589	399.161	518.731
Commuter Users	24.638	18.192	28.576
Other Users	18.870	-0.808	19.243
All Users	521.097	416.545	566.550

7.2.14 The benefits for road users are analysed further in Table 7-7, split by travel cost aspects and vehicle sub-modes.

Table 7-7: Transport User Impacts by vehicle class during Normal Operation

Road User Category	Total Net Valuation (£m, at 2010 Market Prices, Discounted)		
	Core Scenario	Low Scenario	High Scenario
Car Users	388.823	311.358	412.474
LGV Users	41.592	33.958	48.431
HGV Users	90.681	71.230	105.645
All Users	521.097	416.545	566.550

Indirect Tax Benefits

7.2.15 The total valuation of indirect tax benefits (indirect tax revenue and operator revenue) for the Low and High Scenarios, are shown in Table 7-8. Benefits cover the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted.

Table 7-8: Indirect Tax and Operator Revenue by purpose during Normal Operation

Road User Cost Item	Total Net Valuation (£m, at 2010 Market Prices, Discounted)		
	Core Scenario	Low Scenario	High Scenario
Business Users	32.345	29.079	34.464
Commuter Users	11.344	10.211	11.953
Other Users	35.440	38.016	37.393
All Users	79.129	77.306	83.810

7.2.16 Table 7-9 presents the adjusted BCR for the Low and High Scenarios using the Central estimate for capital expenditure and the Most Likely estimate for Operation and Maintenance expenditure. In the Low growth scenario, the adjusted BCR provide is less than 1. In the High growth scenario, the adjusted BCR is close to 1.

Table 7-9: Sensitivity around Project Cost for Core Scenario

	Core Scenario	Low Scenario	High Scenario
PVB	358.320	251.945	408.454
PVC (Capital, Operation and Maintenance Expenditure) (Including: Core / Low / High Operator Revenue from TUBA)	750.498	750.482	750.557
Initial BCR	0.48	0.34	0.54
PVB (with JTR/WEBs) (Including: Business Output under Imperfect Market Competition as 10% of Core / Low / High Business User TEE Benefit from TUBA)	691.984	585.609	742.118
Adjusted BCR	0.92	0.78	0.99

Note: 2010 prices and discounted to 2010 in £m

7.3 Core scenario sensitivity around costs

7.3.1 The sensitivity of the Core Scenario adjusted BCR around scheme cost was assessed using National Highways Minimum and Maximum project cost estimates, alongside the Core Scenario traffic model growth forecast only, and the associated benefits.

7.3.2 Table 7-10 and Table 7-11 set out the estimated PVC for the project 5-year construction Core Scenario for the minimum and the maximum project cost respectively. The costs were converted to market prices and discounted to 2010, using publicly available Treasury discount rates.

Table 7-10: Core Scenario (5-year construction) Present Value of Cost – Minimum Cost (£m)

Year	Preparation	Supervision	Works	Lands	Operation & Maintenance	Total
Total	33.626	7.289	386.529	34.306	28.351	490.101

Note: 2010 prices and discounted to 2010 in £m

Table 7-11: Core Scenario (5-year construction) Present Value of Cost – Maximum Cost (£m)

Year	Preparation	Supervision	Works	Lands	Operation & Maintenance	Total
Total	94.107	26.199	772.375	84.080	85.715	1,062.477

Note: 2010 prices and discounted to 2010 in £m

7.3.3 Table 7-12 presents the adjusted BCR for the Core Scenario using the minimum, most likely and the maximum project cost. Using the minimum cost estimate, the adjusted BCR is greater than 1. Using the maximum cost, the adjusted BCR is less than 1 for the Core Scenario.

Table 7-12: Sensitivity around Project Cost for Core Scenario

Metric Historic)	Core Scenario		
	Minimum Cost	Central Cost	Maximum Cost
PVB	358.320	358.320	358.320
PVC	489.937	750.498	1,062.31
Initial BCR	0.73	0.48	0.34
PVB (with JTR/WEBs)	691.984	691.984	691.984
Adjusted BCR	1.41	0.92	0.65

Note: 2010 prices and discounted to 2010 in £m

7.4 References

7.4.1 For further details on the information provided in this chapter, please see Appendix D: Transport Forecasting Package and Appendix E: Transport Economics Package.

8 Glossary and abbreviations

8.1 Glossary

8.1.1 The table below sets out the glossary for terms used in this document.

Table 8-1:Glossary

Term	Definition
(The) Act	The Planning Act 2008
Annual average daily traffic (AADT)	The total volume of vehicle traffic of a motorway or road for a year divided by 365 days.
Applicant	National Highways
Application	This refers to an application for a Development Consent Order. An application consists of a series of documents and plans which are submitted to the Planning Inspectorate and published on its website.
Appraisal	A process that looks at the worth of a course of action.
Area of Outstanding Natural Beauty (AONB)	An area of countryside considered to have significant landscape value.
Assessment	A process by which information about effects of a proposed plan, project or intervention is collected, assessed and used to inform decision-making.
Baseline environment	The environment as it appears (or would appear) immediately prior to the implementation of the project together with any known or foreseeable future changes that will take place before completion of the project.
Benefit Cost Ratio (BCR)	The benefit cost ratio is a presentation of the amount of benefit being bought for every £1 of cost to the public purse – the higher the BCR the greater the benefit for every £1 spent.
Biodiversity	The variety of life forms, the different plants animals and microorganisms, the genes they contain and the ecosystems they form.
Compensation	Measures taken to offset or compensate for residual adverse effects that cannot be mitigated, or for which mitigation cannot entirely eliminate.
Consultation	A process by which regulatory authorities, statutory and non-statutory bodies, local authorities, local communities, and those with an interest in the land are approached for information and opinions regarding a development proposal.
Design Manual for Roads and Bridges (DMRB)	A set of documents that provide a comprehensive manual system which accommodates all current standards, advice notes and other published documents relating to the design, assessment and operation of trunk roads.
Development Consent Order (DCO)	The means of obtaining permission for developments categorised as nationally significant infrastructure projects.
Effect	Term used to express the consequence of an impact (expressed as the 'significance of effect'), which is determined by correlating the magnitude of the impact to the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria. For example, land clearing during construction results in habitat loss (impact), the effect of which is the significance of the habitat loss on the ecological resource.
Enhancement	A measure that is over and above what is required to mitigate the adverse effects of a project.

Term	Definition
Environmental assessment	A method and a process by which information about environmental effects is collected, assessed and used to inform decision-making.
Environmental Assessment Report	Documents the findings of an Environmental Assessment.
Environmental designation	A defined area which is protected by legislation that is threatened by change from manmade and natural influences (for example Ramsar sites, Sites of Special Scientific Interest and Special Areas of Conservation).
Environmental Impact Assessment (EIA)	A statutory process by which the environmental impact of certain planned projects must be assessed through an EIA before a formal decision to proceed can be made.
Ground investigation	To obtain information on the physical properties of soil and rock around a site.
Grade-separated junction	Roads crossing the carriageway pass at a different level, so as not to disrupt the flow of traffic. Slip roads connect the carriageway to the junction.
Impact	Change that is caused by an action (for example land clearing (action) during construction which results in habitat loss (impact)).
Legislation	A law or set of laws proposed by a government and given force/made official by a parliament.
Listed building	A structure which has been placed on the Statutory List of Buildings of Special Architectural or Historic Interest to protect its architectural and historic interest.
Mitigation	Measures including any process, activity, or design to avoid, reduce, remedy or compensate for negative environmental impacts or effects of a development.
Mitigation measures	Methods employed to avoid, reduce, remedy or compensate for significant adverse impacts of development proposals.
Monitoring	A continuing assessment of the performance of the project, including mitigation measures. This determines if effects occur as predicted or if operations remain within acceptable limits, and if mitigation measures are as effective as predicted.
National Networks National Policy Statement 2014 (NN NPS)	A national policy document issued by the government which sets out the government's objectives and the need for the development of nationally significant infrastructure projects on road and rail networks in England. It is also known as National Policy Statement for National Networks. The NN NPS is the basis for the examination of a Development Consent Order application by the Planning Inspectorate and decisions by the Secretary of State. It was adopted as national policy by the UK Parliament in March 2015.
Nationally Significant Infrastructure Project (NSIP)	Large scale developments which require a type of consent known as 'development consent' under procedures governed by the Planning Act 2008.
Net present value	Net present value (NPV) is simply calculated as the sum of future discounted benefits minus the sum of future discounted costs.
Operational	The functioning of a project on completion of construction.
Order limit	The extent of land required for the Project
Phase 1 Habitat Survey	Recognised standard methodology for collating information on the habitat structure of a particular site.

Term	Definition
Planning Act 2008 (PA2008)	Act of Parliament which sets out the statutory requirements and planning application process for nationally significant infrastructure projects, such as energy, water, transport and waste. Applications for Development Consent Order are submitted following the processes set out in the Planning Act. The Act has subsequently been amended.
Planning Inspectorate	The government agency responsible for operating the planning process for nationally significant infrastructure projects and for examining applications for development consent under the Planning Act 2008, on behalf of the Secretary of State.
Preliminary design	The design on which the application for development consent is based.
Programme	A series of steps that have been identified or series of projects that are linked by dependency.
Receptor	A defined individual environmental feature usually associated with population, fauna and flora that has potential to be affected by a project.
Registered Parks and Gardens	Parks and gardens listed on a register that includes sites of particular historic importance and of special historic interest in England. The main purposes of the register is to celebrate designed landscapes of note and to encourage appropriate protection.
Secretary of State (SoS)	The Secretary of State for Transport.
Sensitivity	The extent to which the receiving environment can accept and accommodate change without experiencing adverse effects.
Statutory	Related to legislation or prescribed in law or regulation.
Traffic modelling or forecasting	The process used to estimate the number of vehicles using a specific section of road or defined network of roads.
Walkers, cyclists and horse riders	Walkers, cyclists and horse riders using the network.

8.2 Abbreviations

8.2.1 The table below sets out the abbreviations for terms used in this document.

Acronym	Definition
A66TM	A66 Traffic Model
AADT	Average Annual Daily Traffic
AAWT	Average Annual Weekday Traffic
AoDM	‘Area of Detailed Modelling’
AONB	Area of Outstanding Natural Beauty
ARCADY	Software tool to assess roundabout junctions
ATC	Automatic Traffic Count
COBALT	Cost and Benefit to Accidents – Light Touch
DCO	Development Consent Order
DfT	Department for Transport
DI	Distributional Impacts
DIA	Distributional Impact Appraisal
DIADEM	Dynamic Integrated Assignment and Demand Modelling Software
DM	Do-Minimum

Acronym	Definition
DS	Do-Something
DoS	Degree of Saturation
DTDV	Day to Day Variability
GPS	Global Positioning Service
GVA	Gross Value Added
HDV	Heavy Duty Vehicle
HGV	Heavy Goods Vehicle
LinSig	A software tool by JCT Consultancy which allows traffic engineers to model traffic signals and their effect on traffic capacities and queuing
LGV	Light Goods Vehicle
LSOA	Lower Super Output Area
MCC	Manual Classified Count
MMQ	Mean Max Queue
MND	Mobile Network Data
MyRIAD	Motorway Reliability Incidents and Delays
NoHAM	Northern Highway Assignment Model
NRTM	Northern Regional traffic Model
NTEM	National Trip End Model
NTM	National Traffic Model
NTP	Northern Trans-pennine
NTPR	North Trans-Pennine Routes
OBR	Office for Budget Responsibility
OD	Origin – Destination
OS ITN	Ordnance Survey Integrated Transport Network
PCU	Passenger Car Unit
PICADY	Software tool to assess priority junctions
PRC	Practical Reserve Capacity
RTF	Road Traffic Forecasts (Published by the Department for Transport)
RTM	Regional Traffic Model
SATURN	Simulation and Assignment of Traffic to Urban Road Networks
SRN	Strategic Road Network
TAG	Transport Analysis Guidance (Published by the Department for Transport)
TCG	Technical Consistency Group
Tempro	Modelling Software used to interrogate the National Trip End Model
TIS	Traffic Information System
TPG	Transport Planning Group (TPG)
TRICS	Trip Rate Information Computer System
TUBA	Transport Users Benefit Appraisal
VDM	Variable Demand Model
VISSIM	German for "Traffic in cities - simulation model"
VPD	Vehicles per Day
WCH	walkers, cyclists and horse-riders
WebTRIS	National Highways Web based Traffic count Information System

A ComMA Summary Tables

A.1 ComMA Summary Tables

High level benefits and costs

Present Value of Benefits (initial)	£358.320m
Present Value of Benefits (adjusted)	£691.984m
Present Value of Costs	£750.498m
Initial BCR	0.48
Adjusted BCR	0.92

Sources of Costs

8.2.2 The costs to public accounts of constructing, operating and maintaining the improved A66 route are estimated by National Highways and are converted to 2010 present year values and market prices, discounted, for the core scenario initial BCR.

8.2.3 The net impact, (equivalent to DM expenditure subtracted from DS user expenditure), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive.

8.2.4 The 5-year construction estimate at 2010 prices is derived from a yearly profile of base costs at Q1 2019 prices (2022 to 2034 inclusive), inflated to outturn costs using National Highways projected yearly construction related inflation, and then adjusted to 2010 prices using a yearly GDP deflator from TAG Data Book v1.17 (November 2021).

8.2.5 The National Highways capital expenditure estimate for A66 construction comprises the following cost components over the 2022 to 2034 period:

- Preparation **(£56.624m**)
- Supervision **(£14.780m**)
- Construction works (**£556.502m**)
- Land **(£65.837m**)

8.2.6 Total capital expenditure (Central Estimate) for the Project, at 2010 prices and values, discounted, amounts to **£693.743m**.

8.2.7 Scheme 0405 (Temple Sowerby to Appleby) and Scheme 06 (Appleby to Brough) costs, when combined, are estimated to make up approximately 50% of the project total and therefore have the highest scheme costs. Scheme 01 (A66/M6 J40 Skirsgill), Scheme 07 (Bowes Bypass) and Scheme 11 (A66/A1(M) J53 Scotch Corner) costs, when combined, are estimated to make up just under 10% of the project total and therefore have the lowest scheme costs.

8.2.8 In addition to capital expenditure, the most likely estimate of operational and maintenance costs, at 2010 prices and values, discounted, amounts to **£56.919m.**

Sources of Benefits

8.2.9 The sources of benefits and disbenefits (i.e. the net impact equivalent to DM without-scheme benefit subtracted from DS with-scheme benefit), is summed over the 60-year economic appraisal period 2029 – 2088, inclusive and is converted to 2010 present year values and market prices, discounted, is summarised into the following categories:

- Transport users – Transport Economic Efficiency (TEE) outcomes for road users during normal operation of the A66 route which are calculated using Transport Users Benefit Appraisal (TUBA). Benefit of **£521.097m** across all users.
- Delays during construction - Effects of the A66 improvement upon road users during project construction and route maintenance. Temporary Traffic Management (TTM) arrangements during roadworks for each construction scenario have been modelled in the opening year 2029. Impacts of TTM upon route choices and travel costs are then calculated in TUBA, in the same way as for TTE and public finance impacts during normal operation. Disbenefit **of -£61.067m** across all construction scenarios.
- Indirect tax – Other TEE impacts including indirect tax revenue and operator revenue which produce a benefit of **£79.241m.**
- Road safety - Implications for the social welfare of users, in terms of road safety and accidents, are appraised using COBALT for the project's area of focus and influence. Over 60-years, there are 281 personal injury accidents saved by the A66 improvement, of which 3% are fatal and 21% are serious. Benefit of **£29.646m** across all accident components.
- Noise, greenhouse gases and air quality – environmental impacts which quantify changes in noise levels, air pollutants and emissions of greenhouse gases. Total disbenefit of **-£210.546m.**
- Journey time reliability - Reliability effects on the A66 associated with the Project are assessed in MyRIAD in terms of Travel Time Variability (TTV) and travel time delays during incidents shorter than 6 hours. Benefit of **£272.204m** across all reliability components and users.
- Route resilience - Represents the potential for the road to recover to normal operating conditions and travel times, after an incident blockage and carriageway closure longer than 6 hours. Benefit of **£4.580m** across existing single and dual carriageway sections.
- Network resilience - represents the potential for other routes on the adjacent strategic and local road network to recover to normal operating conditions and travel times, after an incident blockage and carriageway closure longer than 6 hours. Benefit of **£19.49m.**

- Wider economic impacts – implications of improving the A66 for the wider economy. Monetised impacts include business output change under imperfect market competition, (whereby reduced travel costs lead to market value of output greater than cost of production) and labour supply change, (whereby better transport access releases inactive workers into the labour market and provides tax revenue). Benefit of **£61.460m**
- Other social, environmental, and distributional impacts. Includes total 33.1km of new walking, cycling and horse-riding routes along and across the proposed scheme sections.

Demand Growth along the Route (Do Minimum)

Link	AADT (opening year)	AADT (design year)	AADT change (%)
Scheme 1 - M6 J40	36,368	41,791	14.9%
Scheme 2 - Kemplay Bank	25,018	28,827	15.2%
Scheme 3 - Penrith to Temple Sowerby	22,180	25,522	15.1%
Scheme 4 - Temple Sowerby to Appleby	20,513	23,144	12.8%
Scheme 6 - Appleby to Brough	18,147	21,108	16.3%
Scheme 7 - Bowes Bypass	21,415	26,186	22.3%
Scheme 8 - Cross Lanes to Rokeby	20,435	25,031	22.5%
Scheme 9 - Stephen Bank to Carkin Moor	20,829	24,951	19.8%
Scheme 11 - A1(M) junction 53 Scotch Corner	23,019	27,807	20.8%
Distance-weighted Average	**20,615**	**24,108**	**16.9%**

Demand Growth along the Route (Do Something – each option)

Link	AADT (opening year)	AADT (design year)	AADT change (%)
Scheme 1 - M6 J40	40,893	47,261	15.6%
Scheme 2 - Kemplay Bank	30,925	36,657	18.5%
Scheme 3 - Penrith to Temple Sowerby	29,177	34,762	19.1%
Scheme 4 - Temple Sowerby to Appleby	27,836	33,066	18.8%
Scheme 6 - Appleby to Brough	24,611	29,487	19.8%
Scheme 7 - Bowes Bypass	27,358	34,036	24.4%
Scheme 8 - Cross Lanes to Rokeby	27,676	34,356	24.1%
Scheme 9 - Stephen Bank to Carkin Moor	28,973	35,866	23.8%
Scheme 11 - A1(M) junction 53 Scotch Corner	30,380	37,168	22.3%
Distance-weighted Average	**27,612**	**33,364**	**20.8%**

Key Monetised Benefits and Costs

Present values of costs and benefits over the appraisal period in 2010 prices.

Category	Benefits and costs in £'000 (PV)
Business Users	
Journey Time Savings	476,275
Vehicle Operating Costs	1,314
Non-Business users	
Journey Time Savings	143,256
Vehicle Operating Costs	-99,748
Reliability	
Business Reliability	124,739
Non-business Reliability	147,465
Safety	
Safety	29,646
Environmental Impacts	
Noise	1,240
Local Air Quality	-9,739
Greenhouse Gases	-210.5
Landscape	0 (not assessed)
Wider Economic Impacts	
Agglomeration	0 (not assessed)
Market Competition	60,233
Dependent Development	0 (not assessed)
Labour Supply	1,227
Customer Impact	
Traffic delays due to Construction	-61,067
Traffic impacts due to Maintenance	0 (not assessed)
Journey Quality	0 (not monetised)
Developer contributions	
Developer contributions	0 (not assessed)
Other Impacts	
Indirect tax Revenues	79,241
[Other – Operator Revenue]	164
Costs	

Category	Benefits and costs in £'000 (PV)
Cost to Broad Transport Budget	750,662
Cost savings(where relevant)*	0 (not assessed)

Key quantified benefits / costs

Category	Quantified impacts	Units
Journey times		
Journey Time Savings**	11 minutes (2044)	*(average saving per journey on scheme sections in minutes)**
Safety		
Accidents*	281	*(total number saved)*
Fatalities	15	*(total number saved)*
Seriously injured	123	*(total number saved)*
Slightly injured	368	*(total number saved)*
*Personal Injury Accidents only (not including damage only accidents)		
Environmental Impacts		
Number of Noise important areas affected	11	*(number)*
Names of AQMAs	No AQMAs	*(names)*
Change in NOx emissions	732	*(tonnes)*
Change in PM2.5 emissions	211	*(PM2.5 only) - (tonnes)*
Change in greenhouse gas emissions	2,578,329	*(tonnes CO2e)*
*No AQMAs likely to be affected by the Project (potential for a future AQMA to be declared at Castlegate, Penrith)		
Customer Impact: Totals		
Traffic delays due to Construction	5.061m	*(total loss on scheme sections in hours)*
Traffic impacts due to Maintenance	-	*(total impact on scheme sections in hours)*
Customer Impact: Per journey		
Traffic delays due to Construction (cars)***	6 minutes	*(average loss per journey on scheme sections in minutes) **
Traffic delays due to Construction (LGVs)***	6 minutes	*(average loss per journey on scheme sections in minutes) **
Traffic delays due to Construction (HGVs)***	6 minutes	*(average loss per journey on scheme sections in minutes) **
Traffic impacts due to Maintenance (cars)	Not Calculated	*(average impact per journey on scheme sections in minutes) **
Traffic impacts due to Maintenance (LGVs)	Not Calculated	*(average impact per journey on scheme sections in minutes) **

Category	Quantified impacts	*Units*
Traffic impacts due to Maintenance (HGVs)	Not Calculated	*(average impact per journey on scheme sections in minutes) **

**Defined as total saving or loss on all scheme sections per day divided by distance-weighted AADT on scheme sections*

***Also weighted by flow and time period*

****Average weighted loss per journey across all construction scenarios. Assumes same delays for cars, LGVs and HGVs.*

Strategic Outcome	KPI	Scheme Contribution – Qualitative	Scheme Contribution - Quantitative
Making the network safer	The number of KSIs on the SRN.	138 (On the upgraded sections of the A66) 91 (on the A66 between Scotch Corner and Penrith)	Over 60-years, there are 281 personal injury accidents saved by the A66 improvement, of which 3% are fatal, 21% are serious Within the personal injury accidents saved, there is a reduction of 530 casualties, of which 3% are fatal, 28% are serious The total accident savings are £30.138m.
Delivery of better environmental outcomes	Noise: Number of Noise Important Areas mitigated.	N/A	**Noise** More households are affected by a noise increase (1,598 daytime and 788 night-time) than by a noise decrease (597 daytime and 489 night-time) in the area of focus. However, the overall magnitude of noise reductions outweighs noise uplifts, giving a net environment benefit. This is caused by the A66 project bypassing properties on the existing route and encouraging traffic to divert on to the A66 from adjacent minor roads. Proposed mitigation for noise impacts include the use of barriers at the following locations: • Skirsgill Lodge, Redhills Lane. • North Bitts Farm, Cross Lanes, Barnard Castle. • Pembroke Close and Lady Anne Drive, Brough. **Air Quality** There are net emissions increases of 732 tonnes of NOx and 211 tonnes of PM2.5, over 60 years in the area of focus.

Strategic Outcome	KPI	Scheme Contribution – Qualitative	Scheme Contribution - Quantitative
			In areas where the NO2 Limit Value is exceeded, there is a net NOx increase of 0.014 tonnes in 2029, but no change in 2044. In areas where the NO2 Limit Value is not exceeded, there are net NOx increases of 9.583 tonnes in 2029, and 12.606 tonnes in 2044.
Helping cyclists / walkers and other vulnerable users	The number of new and upgraded crossings	All schemes have some level of betterment compared with the provision on the existing single carriageway sections. For most schemes, this includes a parallel shared multi-user route segregated from the dual carriageway. This parallel provision is in the form of either a new path adjacent to the dualling or has been provided along the verge of the old de-trunked A66, where it remains. Where Public Rights of way are severed by or converge at the upgraded A66 carriageway, then they have been gathered and redirected to the nearest grade-separated crossing facility in order to provide a safe place to cross the dual carriageway. The nearest crossing may be a new grade-separated junction, an accommodation underpass or overbridge, or a designated WCH underpass or bridge.	Some 33km of additional Walking Horse Riding or Cycling Route has been brought into scope pf the Project.

B Transport Data Package

Refer to **3.8 Combined Modelling and Appraisal – Appendix B TDCR (HE565627-AMY-GEN-S00-RP-TR-000006)**

C Transport Model Package

Refer to **3.8 Combined Modelling and Appraisal – Appendix C TMP (HE565627-AMY-GEN-S00-RP-TR-000010)**

D Transport Forecasting Package

Refer to **3.8 Combined Modelling and Appraisal – Appendix D TFR (HE565627-AMY-GEN-S00-RP-TR-000015)**

E Transport Economics Package

Refer to **3.8 Combined Modelling and Appraisal – Appendix E Stage 3 Economic Appraisal (HE565627-AMY-GEN-S00-RP-TR-000016)**