Lincolnshire Local Plan Tool

Lower Tier Modelling Report

Lincolnshire COUNTY COUNCIL
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Executive Summary

Mouchel, working as part of the Lincolnshire County Council Highways Alliance, has been appointed to undertake the Lincolnshire Local Planning Tool (LLPT) project.

The project is divided into two stages:

- In the first stage (the Upper Tier), a tool was developed to carry out a high-level assessment of the whole county and to identify the potential impact of planned growth on the County's highway infrastructure.

- In the second stage (the Lower Tier), more detailed modelling work was carried out on the Greater Lincoln area to provide a more comprehensive assessment of the impact of planned growth on the City of Lincoln and the surrounding area.

This report describes that Lower Tier work undertaken for the Greater Lincoln area. Due to the shorter timescales to develop the draft Local Plan for Central Lincolnshire, Lower Tier work for Greater Lincoln has been prioritised and equivalent work for other areas and plans will be undertaken as and when required.

The lower tier modelling is based on the Core Scenario of growth developed in the first, upper tier, phase of the project. Due to the four local plans in Lincolnshire being at different stages of development, worst case (in a traffic growth sense) high growth development quantities, for both housing and employment, have been assumed for each local plan area in the Core Scenario. The traffic growth forecasts resulting from the upper tier phase are therefore robust but likely to be higher than the growth result from the four local plans when they are formally adopted.

The Core Scenario includes growth across the four Lincolnshire Local Plan areas amounting to increases in housing of 30% and employment of 13.2%. In the Lincoln area, this level of development is forecast to generate increases in peak hour traffic of 3% by 2021, 12% by 2026, up to 20% in 2031 and up to 28% in 2036.

Overall, the traffic modelling and analysis shows some significant impacts of that level of traffic growth on the operation of the highway network. Whilst some of the highway infrastructure included in the Do-Minimum modelling (e.g. Lincoln Eastern Bypass, East-West Link and the link through the Western Growth Corridor from Skellingthorpe Road to Tritton Road) will generate significant benefits in their own right, they will not alone mitigate some of those significant impacts.

Using the Lincoln Integrated Transport Strategy as a base for identifying mitigation, a number of link capacity improvements have been modelled. These 'Do-Something' options include widening of existing carriageways and the construction of entirely new sections of carriageway. A 'Do-Maximum' scenario has also been modelled, which has used a number of the Do-Something options and combined them into the

development of a full, dual-carriageway ring-road of Lincoln, in addition to some more minor schemes.

Of the Do-Something options, the construction of a full Lincoln Southern Bypass, dualled between the A46 and A15, will deliver the greatest benefits of any individual scheme. The Do-Maximum scenario would generate the greatest benefits but this is unlikely to be deliverable during the plan period. This combination of schemes, starting with the Lincoln Southern Bypass could potentially deliver traffic relief sufficient to reduce levels of congestion in 2036 close to projected Do-Minimum levels for 2031.

Modal shift sensitivity testing has been undertaken to assess the potential impact of significant reductions in vehicular trip generation for journeys purely within the urban area of Lincoln, i.e. those most likely to be affected by improvements to sustainable modes of transport. This analysis has revealed that while improvements that generate mode shift would bring congestion benefits, either higher levels of mode shift or combinations of mode shift and highway capacity improvements would be required to substantially mitigate the traffic growth to be generated over the coming plan period.

As stated above, the level of traffic growth modelled has been based on the LLPT Core Scenario, which represents a worst case. Alongside the likely inclusion in the four local plans of projections for housing and employment growth that are lower than those contained in the Core Scenario, there are a number of reasons why the growth in the AM and PM peak hour traffic identified in this report may be somewhat lower. The application of policy to encourage modal shift away from private cars, changes in household composition and demand responses to increased congestion (such as changes in travel times), may reduce level of impact identified in this report. Notwithstanding the mode shift sensitivity testing undertaken in this report, the traffic modelling undertaken has assumed a static share of travel by car, therefore, the application of robust policies on sustainable transport will reduce the projected level of traffic growth.

The conclusion of this report is that the Lincoln Southern Bypass scheme should be prioritised as part of Central Lincolnshire Local Plan (route protected, including ability for it to be dualled) to provide mitigation of some of the impacts of projected housing and employment growth and resulting impacts on the highway network. This should be implemented alongside robust policies on sustainable transport. The delivery of further elements of additional highway capacity on the existing Lincoln relief roads would provide benefits but are lower priority than Lincoln Southern Bypass.

Further, more detailed analysis is also required on the impacts on traffic growth on key junctions within the highway network, to robustly assess the likely impacts and identify mitigation sufficient to resolve the issues found.

1 Introduction

1.1 Lincolnshire Local Planning Tool

1.1.1 Introduction

Mouchel, working as part of the Lincolnshire County Council Highways Alliance, has been appointed to undertake the Lincolnshire Local Planning Tool (LLPT) project. The project is divided into two stages:

- In the first stage (the Upper Tier), a tool was developed to carry out a high-level assessment of the whole county and to identify the potential impact of planned growth on the County's highway infrastructure.
- In the second stage (the Lower Tier), more detailed modelling work was carried out on the Greater Lincoln area to provide a more comprehensive assessment of the impact of planned growth on the City of Lincoln and the surrounding area.

This report describes the Lower Tier work undertaken for the Greater Lincoln area. Due to the shorter timescales to develop the draft Local Plan for Central Lincolnshire, Lower Tier work for Greater Lincoln has been prioritised. Lower Tier work for other areas and plans will be undertaken as and when required.

1.1.2 Context

The County of Lincolnshire is administered at a district level by seven councils, which are responsible for producing local plans setting out the scale and location of growth over the next 15-20 years. The four local plans covering the county are as follows:

- East Lindsey – being developed by East Lindsey District Council
- Central Lincolnshire – being developed by the Central Lincolnshire Joint Planning Unit (City of Lincoln Council, North Kesteven District Council, West Lindsey District Council and Lincolnshire County Council)
- South East Lincolnshire – being developed by the South East Lincolnshire Joint Planning Unit (Boston Borough Council and South Holland District Council)
- South Kesteven – adopted by South Kesteven District Council in 2010 but with new Local Plan now under development

Before any of the emerging local plans can be adopted as policy, they must be examined by an independently appointed Planning Inspector, who must be satisfied that the plan is sound. Sites allocated for development in the plan must be deliverable, and any allocated sites where deliverability may be compromised by infrastructure constraints are likely to be challenged. There is therefore a need for both the LPAs and Joint Planning Units (JPUs) and the County Council to have the

evidence to demonstrate that the county's highway infrastructure is able to support the planned development set out in the local plans.

For planned growth to be deliverable targeted improvements to the county's highway infrastructure may be required. There is therefore the need for evidence of the likely impacts of planned development on the capacity of the County's highway network.

There will also be a need for the evidence showing current and future capacity of the County's highway network in order to assess planning applications which may have an impact upon capacity, and as a basis for setting developer contributions to highway infrastructure through Community Infrastructure Levy (CIL) systems or Section 106 mechanisms.

The LLPT project will provide the evidence needed to demonstrate the combined impact of development proposed in the emerging local plans on the county's highway infrastructure at a strategic level and at a more detailed level for the Greater Lincoln area, and will identify the locations where there may be a need for future interventions to support planned growth. However, the outputs from the project do not replace the normal planning application and development management processes, including the production and review of Transport Assessments and Statements, which need to assess the impacts of development in greater detail.

1.1.3 Approach

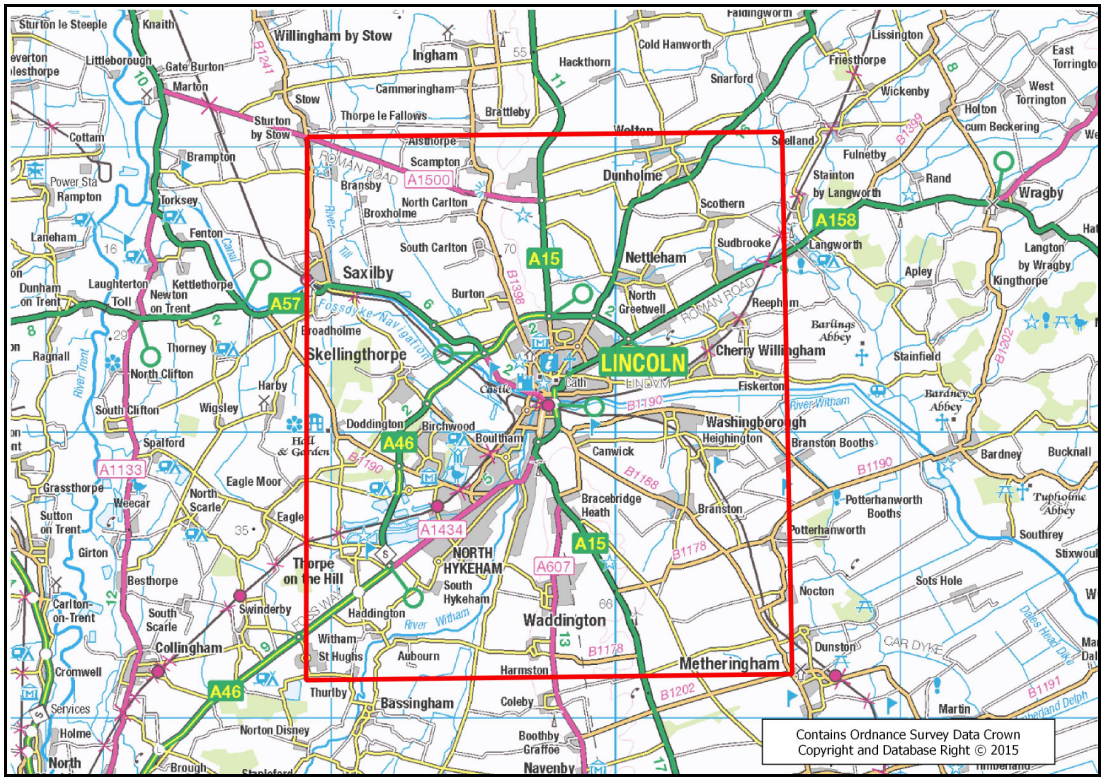
The Lower Tier phase of work is based upon the Greater Lincoln Traffic Model (GLTM). The planning assumptions developed for the Upper Tier tool have been added to the model as a forecast year scenario (discussed in Section 2 of this report) and the identified infrastructure interventions have been included (discussed in Sections 4 to 7 of this report).

It should be noted that the outputs provided by this model are based on the LLPT 'Core Scenario', which sets out the maximum potential level of growth within the County in the period to 2036. Furthermore, no allowances have been made for modal shift (away from private car travel), and, therefore, the modelling undertaken represents a 'worst-case' scenario in terms of traffic growth. For these reasons, the amount of traffic growth to 2036 may actually turn out to be lower. This is discussed further in Section 8 of this report.

1.1.4 Scope

The Lower Tier Model provides an assessment of the growth of vehicle traffic within the Greater Lincoln Area; a cordon has been applied to the model, as shown in the figure below, to focus outputs on the Lincoln area. Traffic growth in other areas of Central Lincolnshire (such as Sleaford and Gainsborough) cannot be assessed by this model (although growth in housing and employment in areas outside of Greater Lincoln is considered as an input to the model).

Figure 1-1 – Cordoned Network Area



1.2 Purpose of this Report

The purpose of this report is to present the outcome of the Lower Tier work; describing the methodology taken in developing the model and discussing the findings.

1.3 Report Structure

Following on from this introduction, the remainder of this report is set out as follows:

- **Section 2** summarises the approach to and outputs from the previous stage of the study (the Upper Tier tool);
- **Section 3** explains the approach to the Lower Tier modelling;
- **Section 4** describes the approach to the Do-Minimum modelling, and summarises the results;
- **Section 5** describes the approach to the Do-Something modelling looking specifically at link capacity improvements, and summarises the results;
- **Section 6** describes the approach to the Do-Something modelling sensitivity tests to assess the potential impact of modal shift interventions, and summarises the results;;
- **Section 7** describes potential responses to traffic growth;

- **Section 8** gives a summary of the findings; and
- **Section 9** provides a glossary of terms.

2 LLPT Upper Tier

2.1 Introduction

The first phase, or Upper Tier, of the LLPT Project constructed an Upper Tier tool. This took into account planned development across Lincolnshire and the adjacent authorities in the period to 2036, and provided a high-level assessment of future traffic conditions across the whole county.

2.2 Approach

The Upper Tier tool, a simplified version of a strategic traffic model, consisted of 196 zones, of which 132 were in Lincolnshire with the remaining 64 making up the rest of England and Wales. All A-roads and B-roads within Lincolnshire were included in the network, along with committed/planned future highway schemes within the county (such as the Lincoln Eastern Bypass); the strategic highway network in the surrounding regions was included in the model but at a more coarse level of detail. The tool was created using a fixed speed network build; that is, it was assumed that traffic travels at appropriate speeds for the road (based on observed peak hour speeds for the base year) and is not slowed by congestion resulting from traffic growth. The resulting traffic flows on individual highway links within the model therefore reflected demand rather than actual flows that could be accommodated within the capacities of links. This model assessed the impact of growth on highway links and did not assess impact on junctions.

The future year scenario identified the quantity and, where possible, specific locations of all planned housing and job growth within the county, together with all planned housing and job growth set out in the adopted or emerging development plans of the adjacent authorities.

2.3 Quantity of Planned Growth

The four Lincolnshire Local Plan teams (covering the seven Local Planning Authorities) provided details on the quantity and location of planned growth in housing and employment in the period to 2036, based upon work being done for the emerging local plans and (in the case of South Kesteven) the adopted Core Strategy and Site Allocation and Policies Development Plan Document. Due to the processes to develop the four local plans was at different stages, each Local Plan team provided their highest estimates of growth in housing and employment. This resulted in the Upper Tier modelling presenting the worst case, highest growth, scenario and actual growth in each of the local plans is likely to be lower.

The identified planned growth in housing and employment that was agreed with the four Local Plan areas is set out in the following table.

Table 2-1 – Housing and Employment Targets in Emerging Local Plans

Planning Unit		Housing Growth (Households)			Employment Growth (Jobs)		
	District	Plan Period	Across Plan Period	2014-2036	Forecast Period	Across Forecast Period	2014-2036
East Lindsey		**2016-2031**	**9,091**	**13,333**	**2016-2031**	**2,880**	**4,224**
Central Lincolnshire	City of Lincoln				2012-2036	8,572	7,858
	North Kesteven				2012-2036	8,518	7,808
	West Lindsey				2012-2036	5,380	4,932
	Total	**2011-2036**	**45,000**	**42,444**	**2012-2036**	**22,470**	**20,598**
South East Lincolnshire	Boston	2011-2036	9,180	8,677			
	South Holland	2011-2036	14,000	13,434			
	Total	**2011-2036**	**23,180**	**22,111**	**2012-2031**	**6,081**	**7,041**
South Kesteven		**2011-2036**	**17,650**	**15,316**	**2008-2026**	**3,164**	**3,867**
Total				**93,205**			**35,730**

Notes:

Housing and Employment Growth 2014-2036 is calculated by removing units completed during that part of the plan period prior to 2014 and/or by extrapolating housing growth and employment growth from the end of the plan period to 2036.

Central Lincolnshire JPU has not disaggregated housing targets by its component Districts.

The South East Lincolnshire Employment Land Review does not disaggregate jobs by District.

The above figures were used in the second iteration of the LLPT run in June 2015 and may be subject to change as the local plans are developed.

Source: East Lindsey DC, Central Lincolnshire JPU, South East Lincolnshire JPU, South Kesteven DC

The growth identified above is presented in the following as percentages of the existing (2014) quantum of households and jobs in each of the seven Lincolnshire districts.

Table 2-2 – Growth in Housing and Jobs 2014-2036

Planning Unit	District	Housing			Jobs		
		2014	Growth to 2036	Growth (%)	2014	Growth to 2036	Growth (%)
East Lindsey		**61,800**	**13,333**	**21.6%**	**40,500**	**4,224**	**10.4%**
Central Lincolnshire	City of Lincoln	40,400			55,100	7,858	14.3%
	North Kesteven	47,800			35,000	7,808	22.3%
	West Lindsey	39,800			24,700	4,932	20.0%
	Total	**128,000**	**42,444**	**33.2%**	**114,800**	**20,598**	**17.9%**
South East Lincolnshire	Boston	27,800	8,677	31.2%	31,300		
	South Holland	38,200	13,434	35.2%	32,600		
	Total	**66,000**	**22,111**	**33.5%**	**63,900**	**7,041**	**11.0%**
South Kesteven		**58,000**	**15,316**	**26.4%**	**51,600**	**3,867**	**7.5%**
Total		**315,000**	**93,315**	**29.6%**	**270,800**	**35,730**	**13.2%**

Source: Source: 2012-based Household Projections (Published February 2015), DCLG, NOMIS

2.4 Outputs

The main findings with regard to Central Lincolnshire from the analysis undertaken on the outputs from the LLPT Upper Tier can be summarised as follows:

2.4.1 Central Lincolnshire

- Significant capacity issues on Lincoln's Western and Northern Relief Roads.
- Capacity issues on arterial routes into Lincoln, especially on the A1434/A15 and B1188 to the south and B1398 to the north east.
- Other possible capacity issues on the approaches to Gainsborough and Sleaford.
- Potential impacts on trips via the A1 near Newark resulting from increased volumes.

2.5 Core Scenario

Another output from the Upper Tier work was the agreement of a 'Core Scenario' for use in future modelling. The Core Scenario comprises the agreed worst case assumptions for growth in housing and employment in Lincolnshire, based on the four emerging Local Plans. These assumptions were agreed following the second LLPT stakeholder workshop in May 2015 and are summarised earlier in this section of the report (and set out in further detail in the Upper Tier Tool report). The use of the scenario enables any local modelling for one of the four Local Plans to be undertaken using 'static' land use assumptions for the other three Local Plans. Sensitivity testing may be necessary in specific local areas, where local plan teams

want to assess the impact of differing levels of development and the use of the Core Scenario will enable the wider development assumptions, outside of individual local plans areas, to remain consistent.

It is expected that when any of the four local plans is adopted, the land use assumptions in the Core Scenario will be updated to reflect the adopted allocations. Furthermore, where appropriate, it is expected that the Core Scenario will also be updated to reflect the delivery of the local plans and could be updated using outputs from the local plan monitoring process and feed into the associated reporting process.

It should be noted that in putting together the Core Scenario, in the case of any uncertainty over targets, a conservative approach has been taken and the higher growth figure has been used (thus giving a ‘worst case’ scenario). When the Core Scenario is updated, it is more likely to result in a lower levels of traffic growth than used in the modelling presented by this report.

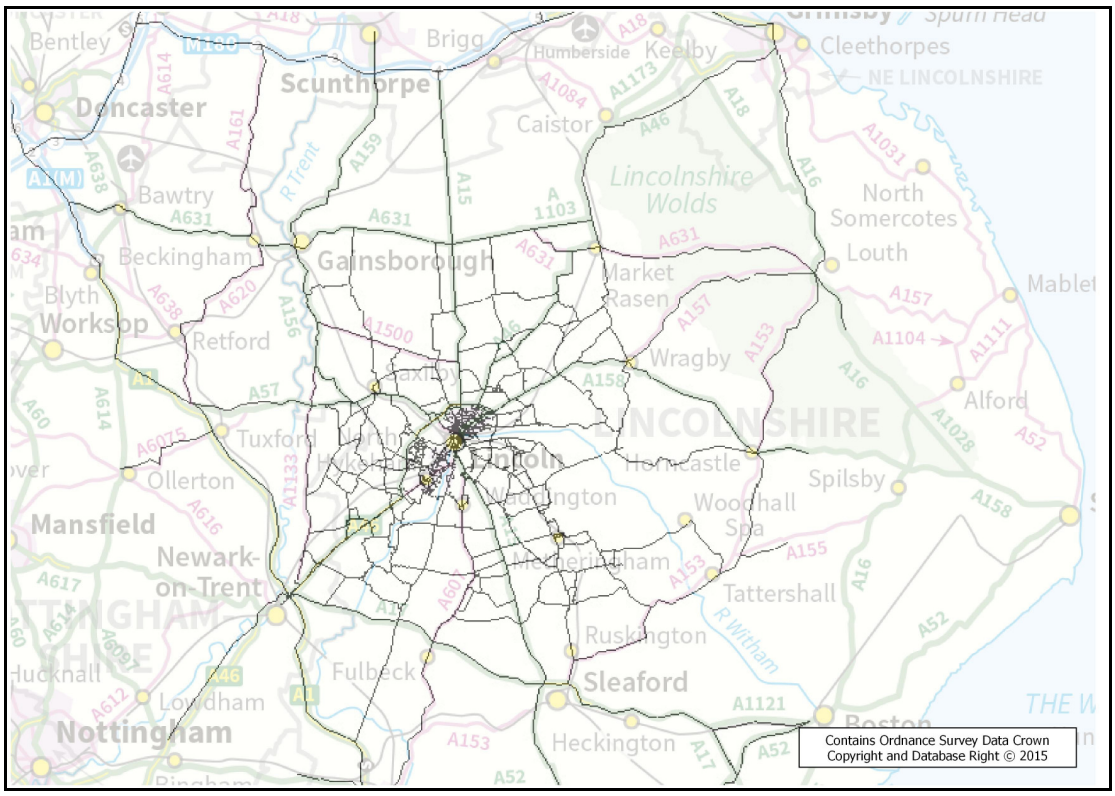
3 Central Lincolnshire Lower Tier Modelling

3.1 Introduction

The Lower Tier phase of the LLPT project concentrates on the Greater Lincoln area covered by the Central Lincolnshire Local Plan and specifically on the area for which the impacts of traffic growth can be assessed using the Greater Lincoln Traffic Model (GLTM).

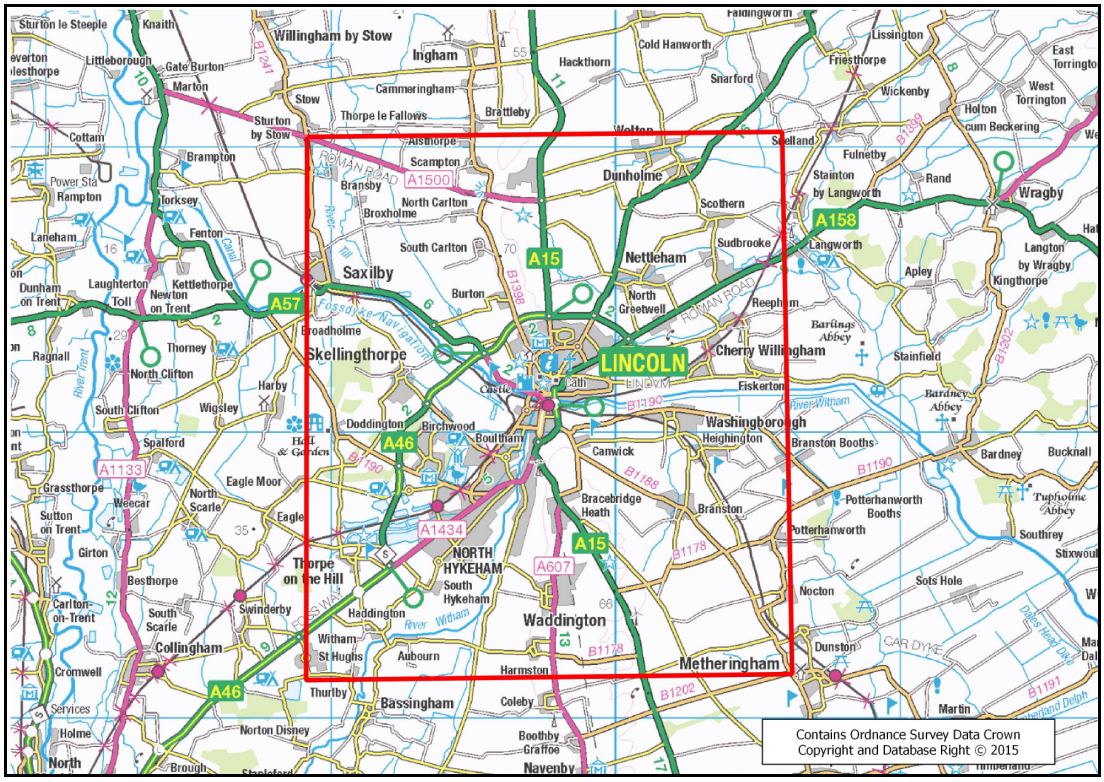
The area of Central Lincolnshire, and beyond, covered by the 'simulation' network (i.e. where the highway network is modelled in detail) is shown in the figure below.

Figure 3-1 – GLTM Simulation Network Area



As stated in Section 1, or the purposes of clarity and to focus on the Lincoln area, the outputs from the GLTM have been 'cordoned' to cover the roads broadly presented in the figure below.

Figure 3-2 – Cordoned Network Area



Without using a cordon, outputs from the model would include roads, and their associated traffic, that are some distance from Lincoln, e.g. the A1. This would lead to the analysis presented in this report not being focussed on the Lincoln area and, instead, being representative of the wider county and adjoining districts. This would limit the value of the analysis in understanding the impacts of growth specifically on the Lincoln area.

3.1.1 *Scope*

The purpose of the Lower Tier modelling is to assess the impact of traffic growth in more detail identified through the use of the Upper Tier Tool by applying that growth to the GLTM network. Throughout the Lower Tier modelling, the Core Scenario for growth, generated by the Upper Tier work, will be used to provide the assumed level of housing and employment growth.

The scope of this work is:

- The area and highway network covered by the GLTM (but with outputs cordoned to the Lincoln area specifically)
- The growth during and up to the end of the emerging Central Lincolnshire Local Plan period; this being up to 2036
- The impacts of that growth up to 2036 on the highway network covered by the GLTM

- The potential improvements to the highway network where significant impacts are found on strategic links.

3.2 Scenario Testing

Alongside the use of the LLPT Core Scenario for growth, three sets of infrastructure scenarios have been used as part of the Lower Tier modelling tasks:

- **Do-Minimum**

  The Do-Minimum, or Do-Min, scenarios represent the future situation with Core Scenario levels of development and its associated traffic growth included, as well as any committed or planned infrastructure improvements that are assumed to delivered either independently of growth or specifically alongside developments. Essentially, the Do-Minimum modelling assesses the impact of planned growth and committed highway improvements before any mitigation of resulting impacts are considered.

- **Do-Something**

  The Do-Something, or Do-Som, scenarios represent the Do-Minimum but with additional infrastructure included to mitigate and resolve issues identified through the modelling of the Do-Minimum scenarios.

- **Do-Maximum**

  Similar to the Do-Something, the Do-Maximum, or Do-Max, scenario represents the Do-Minimum but with additional infrastructure and measures included to mitigate and resolve issues identified through the modelling of the Do-Minimum scenarios. The Do-Maximum differs from the Do-Something through the implementation of the highest capacity version of each infrastructure option e.g. the dual-carriageway rather than single carriageway versions of options.

4 Do-Minimum Modelling

4.1 Introduction

As stated in the previous section, the Do-Minimum modelling uses the GLTM to assess the impact of growth on the highway network. This section presents the outputs of the Do-Minimum scenario modelling to identify the potential impacts of growth through the Local Plan period up to 2036.

4.2 Scenarios

The specific Do-Minimum scenarios modelled cover an initial forecast year of 2018 and subsequent forecast years of 2021, 2026, 2031 and 2036. The Upper Tier work identified a worst case growth scenario (the Core Scenario) for the period up to 2036 and the resulting traffic forecasts have been applied to the Lower Tier modelling. The traffic growth applied to the intermediate years between 2018 and 2036 has been applied evenly assuming a linear rate of delivery of the planned growth.

Included in all Do-Minimum scenarios are the following committed highway schemes:

- Lincoln Eastern Bypass (single carriageway)
- East-West Link

Also included in all Do-Minimum scenarios, except the initial forecast year of 2018, are infrastructure currently proposed as part of the four proposed Sustainable Urban Extensions (SUEs); the four SUEs are:

- North East Quadrant
- South East Quadrant
- Western Growth Corridor
- South West Quadrant

The assumptions on highway infrastructure associated with the SUEs included in the Do-Minimum scenario includes:

- Western Growth Corridor Link between Skellingthorpe Road and Beevor Street
- Lincoln Southern Bypass Section One between the A46/Newark Road roundabout and Boundary Lane as part of South West Quadrant.
- Access junctions for the four SUEs

These elements of SUE highway infrastructure are assumptions at present as detailed work is required on access strategies for each site.

4.3 Modelling Results

The results from the Do-Minimum modelling are presented in the following sub-sections through analysis of a number of different outputs from the model.

- **Total Trips**

  The total AM and PM peak hour vehicle trips for each Do-Minimum forecast year shows how traffic on the highway network will increase over the plan period.

- **Link capacity**

  For each Do-Minimum forecast year and associated AM and PM peak hour, plans show the ratio of traffic volume to the capacity of each link in the highway network (a link is a section of road between two junctions).

- **Junction capacity**

  For each Do-Minimum forecast year and associated AM and PM peak hour, figures show junctions which have delays on at least one turning movement of up to two minutes or more.

  It should be noted that GLTM is a strategic traffic model and its primary purpose is to assess the impact of large scale highway schemes such as bypasses and increases in carriageway standard (e.g. improvements from single to dual-carriageway). Appropriately for this type of model, validation of GLTM has been undertaken on the basis of link flows and journey times rather than junction performance. Whilst the model can be used to inform where junction improvements may be necessary, caution should be taken as this is not the model's primary purpose. Professional judgement and local knowledge should be used alongside such junction-related outputs from the model to ensure that appropriate conclusions, which may include identifying the need for more detailed analysis, are reached.

- **Journey times**

  Eight indicative journeys to, from and past Lincoln have been identified to provide an understanding of the impact of traffic growth on typical local and strategic journeys that drivers will make in each of the Do-Minimum years. The routes have been chosen to reflect either journeys into Lincoln city centre on key radial routes or strategic journeys past the Lincoln urban area, either to the east or west.

4.4 Total Trips

The following table provides a summary of the projected growth in traffic during the AM and PM peak hours within the Lincoln area of the GLTM. In the 2018 model, there are 37,066 vehicular trips in the AM peak hour and 35,124 in the PM peak

hour. By 2036, vehicular trips in each of the two peak hours are forecast to increase by almost 10,000 with almost 47,000 in the AM peak hour, an increase of 27%, and over 45,000 in the PM peak hour, an increase of 28%. These figures compare to the overall growth in households of 33% in Central Lincolnshire and 30% across Lincolnshire as a whole by 2036; this growth is based on worst case growth projections used in the LLPT Core Scenario.

Table 4-1 – Peak Hour Vehicle Trips and Percentage Change – Do-Min

Peak Hour		2018	2021	2026	2031	2036
AM	Vehicle Trips	37,066	38,235	41,539	44,046	46,944
	% Change	0%	3%	12%	19%	27%
PM	Vehicle Trips	35,124	36,118	39,199	42,269	45,119
	% Change	0%	3%	12%	20%	28%

4.5 Link Capacity

This section reviews the outputs from the Do-Minimum scenario modelling in terms of the effects of traffic growth on link capacity; links being the sections of road between two junctions. The outputs from the modelling are presented in both tabular and map-based formats.

4.5.1 Vehicle Hours – AM Peak

The following two tables present, for 2018 and 2036, the vehicle hours in the AM peak hour on links with different speed limits and operating at different percentages of capacity. Where a link is operating above 85% of capacity, the flow of traffic starts to breakdown until absolute capacity of 100% or above is reached, where, theoretically, no more traffic can enter a link (although in practice flows in excess of 100% of theoretical capacity are common in urban environments).

The first table shows that in the 2018 AM peak hour, traffic within the cordoned area will amount to 5,442 vehicle hours. This traffic includes journeys totally within the cordon or those elements of longer journeys that take place within the cordon. The table also shows that there are relatively few vehicle hours on links that are operating at or above 100% of their capacity with no links with speed limits over 64kph operating at this level.

Table 4-2 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Min – 2018 – AM

Link Speed Limit kph (mph)	Percentage of Capacity				
	<70	70-85	85-100	>100	Total
<=32 (20)	689	84	45	33	851
48 (30)	1,927	286	116	25	2,354
64 (40)	633	93	46	0	772
80 (50)	487	19	2	0	508
96 (60)	563	128	67	0	758
112 (70)	199	0	0	0	199
Total	**4,498**	**610**	**276**	**58**	**5,442**

The following table shows that traffic growth to 2036 will increase the amount of AM peak hour traffic to 8,382 vehicle hours with traffic on links operating at or above their operational capacity, from 58 hours in 2018 to 414 hours in 2036. In addition, traffic on links operating between 85% and 100% of their capacity will increase from 276 hours to 1,082 hours.

Table 4-3 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Min – 2036 – AM

Link Speed Limit kph (mph)	Percentage of Capacity					Change in Total from 2018
	<70	70-85	85-100	>100	Total	
<=32 (20)	852	82	97	106	1,137	34%
48 (30)	2,799	453	513	193	3,958	68%
64 (40)	925	49	2	115	1,091	41%
80 (50)	587	97	122	0	806	59%
96 (60)	613	120	348	0	1,081	43%
112 (70)	309	0	0	0	309	55%
Total	**6,085**	**801**	**1,082**	**414**	**8,382**	**54%**

The following table presents total vehicle hours in each percentage of capacity band for each of the Do-Minimum years. This table shows that traffic growth between 2018 and 2036, through the intervening years, will generate a gradual increase in congestion in the AM peak hour. The decrease in links operating over 100% of capacity in 2021 may be as a result of the Do-Minimum highway improvements such as the link through the Western Growth Corridor site.

Table 4-4 – Vehicle Hours by Percentage of Link Capacity – Do-Min – Summary – AM

Year	Percentage of Capacity					Change in Total from 2018
	<70	70-85	85-100	>100	Total	
2018	4,498	610	276	58	5,442	-
2021	4,758	700	323	49	5,830	7%
2026	5,118	862	422	197	6,599	21%
2031	5,631	973	597	274	7,475	37%
2036	6,085	801	1,082	414	8,382	54%

The following table shows the distribution of vehicle hours across each percentage of capacity band for each Do-Minimum year. The table shows that over the course of the plan period, there will be a gradual shift of vehicle hours from links operating well within their capacities to those operating towards the upper end of their capacities. By 2036, around 5% of vehicle hours will be spent on links operating at or above their theoretical capacities. However, in 2036 82% of links will still be operating below 85% of capacity and 95% under 100% of capacity; mitigation would not be needed on those links.

Table 4-5 –Distribution of Vehicle Hours 2018 to 2036 – Do-Min – Summary – AM

Year	Percentage of Capacity				
	<70	70-85	85-100	>100	Total
2018	82.7%	11.2%	5.1%	1.1%	100.0%
2021	81.6%	12.0%	5.5%	0.8%	100.0%
2026	77.6%	13.1%	6.4%	3.0%	100.0%
2031	75.3%	13.0%	8.0%	3.7%	100.0%
2036	72.6%	9.6%	12.9%	4.9%	100.0%

4.5.2 *Vehicle Hours – PM Peak*

The following two tables present the vehicle hours outputs for the Do-Minimum PM peak hours in 2018 and 2036. A total of 6,156 vehicle hour of traffic occur in the 2018 PM peak and this is forecast to increase to nearly 9,000 by 2036. Vehicle hours on links operating at or above 100% of capacity will increase from 183 in 2018 to 620 in 2036.

Table 4-6 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Min – 2018 – PM

Link Speed Limit kph (mph)	Percentage of Capacity				
	<70	70-85	85-100	>100	Total
<=32 (20)	700	76	68	33	877
48 (30)	2,188	390	177	45	2,800
64 (40)	734	141	39	105	1,019
80 (50)	441	32	0	0	473
96 (60)	665	94	0	0	759
112 (70)	228	0	0	0	228
Total	**4,956**	**733**	**284**	**183**	**6,156**

Table 4-7 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Min – 2036 – PM

Link Speed Limit kph (mph)	Percentage of Capacity					Change in Total from 2018
	<70	70-85	85-100	>100	Total	
<=32 (20)	836	119	134	88	1,177	34%
48 (30)	3,133	462	459	368	4,422	58%
64 (40)	875	147	28	112	1,162	14%
80 (50)	335	346	65	52	798	69%
96 (60)	632	227	201	0	1,060	40%
112 (70)	288	0	0	0	288	26%
Total	**6,099**	**1,301**	**887**	**620**	**8,907**	**45%**

The following table presents total PM peak hour vehicle hours in each percentage of capacity band for each of the Do-Minimum years. Again, there will be a gradual

increase in traffic between 2018 and 2036 with some transitioning towards links operating at or above their capacity.

Table 4-8 – Vehicle Hours by Percentage of Link Capacity – Do-Min – Summary – PM

Year	Percentage of Capacity					Change in Total from 2018
	<70	70-85	85-100	>100	Total	
2018	4,956	733	284	183	6,156	-
2021	5,045	1,005	342	86	6,478	5%
2026	5,537	904	709	206	7,356	19%
2031	5,770	1,154	836	333	8,093	31%
2036	6,099	1,301	887	620	8,907	45%

The following table shows the distribution of vehicle hours across each percentage of capacity band for each Do-Minimum year. By 2036, in the PM peak hours, around 7% of vehicle hours will be spent on links operating at or above their theoretical capacities, compared to 3% in 2018. However, this therefore indicates that around 93% of vehicle hours will be spent on links operating under 100% of their capacity.

Table 4-9 –Distribution of Vehicle Hours 2018 to 2036 – Do-Min – Summary – PM

Year	Percentage of Capacity				
	<70	70-85	85-100	>100	Total
2018	80.5%	11.9%	4.6%	3.0%	100.0%
2021	77.9%	15.5%	5.3%	1.3%	100.0%
2026	75.3%	12.3%	9.6%	2.8%	100.0%
2031	71.3%	14.3%	10.3%	4.1%	100.0%
2036	68.5%	14.6%	10.0%	7.0%	100.0%

4.5.3 *Ratio of Flow to Capacity*

The following figures present the ratios of traffic volumes to link capacities and are a visual representation of the above tables. The colour shading highlights the ratios with green being under 50% of capacity and red being over 85% of capacity. The figures also show the modelled 'actual' flows on each link.

Care should be exercised when interpreting these plots as a number links shown to be operating at over 85% of capacity are relatively minor with low flows. In addition, a link shown as having a high volume to capacity ratio, does not necessarily have poor conditions over its entire length.

The first figure shows the outputs for the 2018 Do-Minimum AM peak hour. The figures shows relatively few links operating at over 85% of their capacity (links shown in red). Of those links that are operating at or above this level, a number of relatively minor, lightly trafficked roads and therefore will have minimal impact on the operation of the highway network.

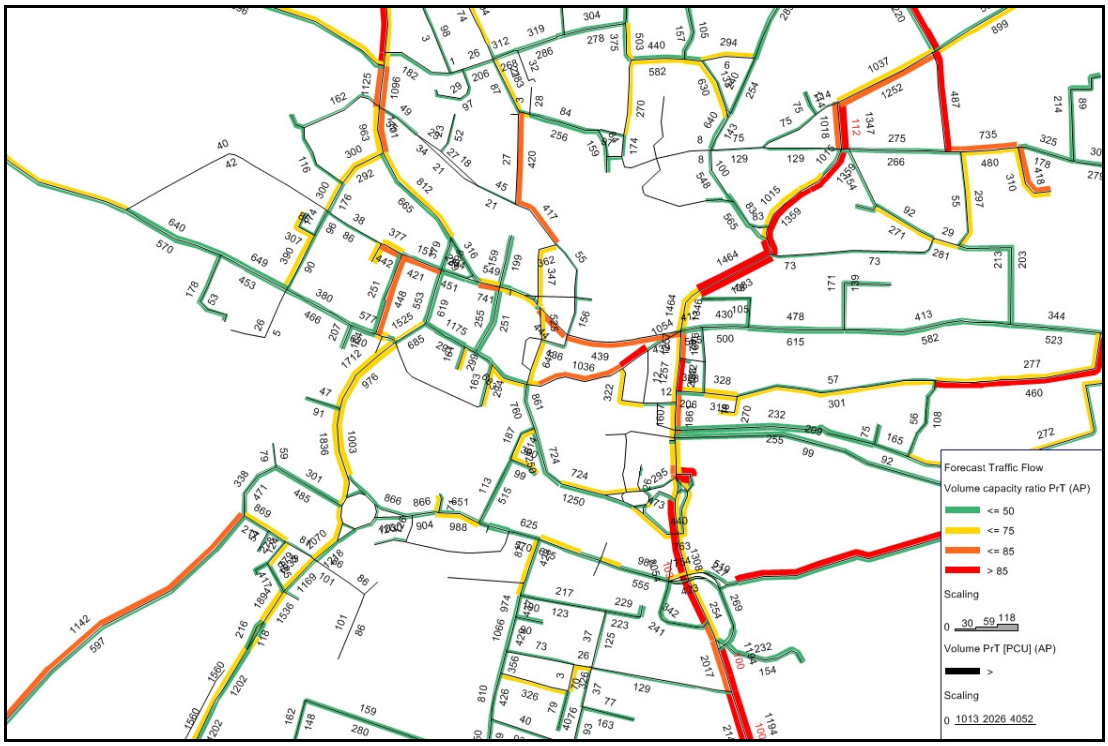
Figure 4-1 – Link Volume to Capacity Ratio – Do-Min – 2018 – AM

The following figure presents the outputs for the 2036 Do-Minimum AM peak hour. This figure shows a general increase in ratios of traffic flow to capacity across the network and an increase in links operating above 85% of capacity. Again a proportion of these links are relatively minor, however, some are significant radial routes into the city centre.

Figure 4-2 – Link Volume to Capacity Ratio – Do-Min – 2036 – AM

The following figure presents the same information but focussed on the central urban area of Lincoln. It can be seen that the current A15, through the centre of Lincoln, will experience flows at levels above 85% of capacity.

Figure 4-3 – Link Volume to Capacity Ratio – Do-Min – 2036 – AM – Lincoln City Centre



The following three figures present the same information but for the PM peaks. Again there are limited links operating over 85% of capacity and of those that are, many are minor links with little traffic.

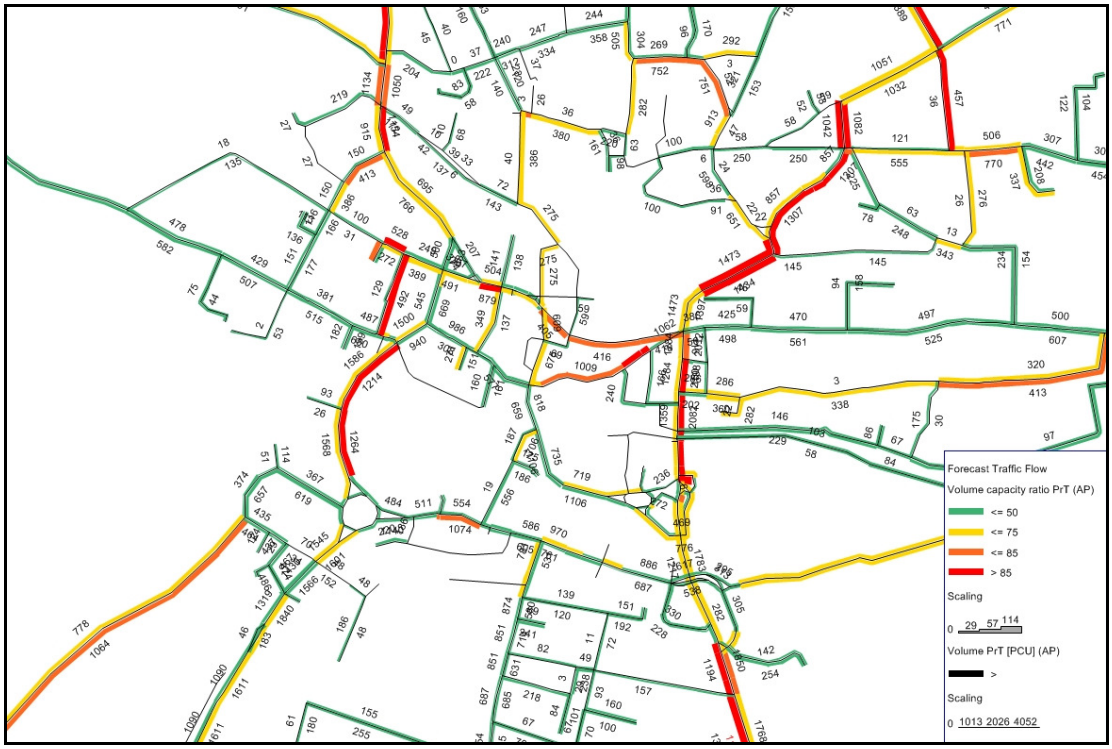
Figure 4-4 – Link Volume to Capacity Ratio – Do-Min – 2018 – PM

In 2036, in the PM peak hour, more links operate above 85% of their capacity, as shown in the figure below and of particular note is the one northbound section of the Lincoln Eastern Bypass.

Figure 4-5 – Link Volume to Capacity Ratio – Do-Min – 2036 – PM

Within the city centre, the current A15 shows some network stress as does Brayford Way.

Figure 4-6 – Link Volume to Capacity Ratio – Do-Min – 2036 – PM – Lincoln City Centre



A review of the above AM and PM peak figures reveals that the following significant links are forecast to be operating above 85% of capacity in 2036:

- Lincoln Eastern Bypass between Greetwell Road and Washingborough Road
- Tritton Road between Skellingthorpe Road and Dixon Street
- Newark Road between Brant Road and St. Catherine's
- Canwick Road between Canwick Avenue and Norman Street
- Lindum Road and Wragby Road between Monks Road and Langworthgate
- Silver Street
- Brayford Way
- Lee Road and Queensway
- Yarborough Road between Hampton Street and Burton Road
- Burton Road north of Yarborough Road

In addition, there are a number of other less significant routes which will operate over 85% of their link capacity. For example, Birchwood Avenue appears to attract additional traffic due to the Western Growth Corridor Link between Skellingthorpe Road and Beevor Street, and Meadow Lane and Brant Road appear to attract more traffic due to their connections to the South West Quadrant.

4.6 Junction capacity

The following figures identify junctions where at least one of the turning movements experiences delay of up to two minutes or more. The figures show these junctions for the 2018 and 2036 Do-Minimum scenarios for both the AM and PM peak hours.

Figure 4-7 – Junctions with Turning Movement Delays – Do-Min – 2018 – AM

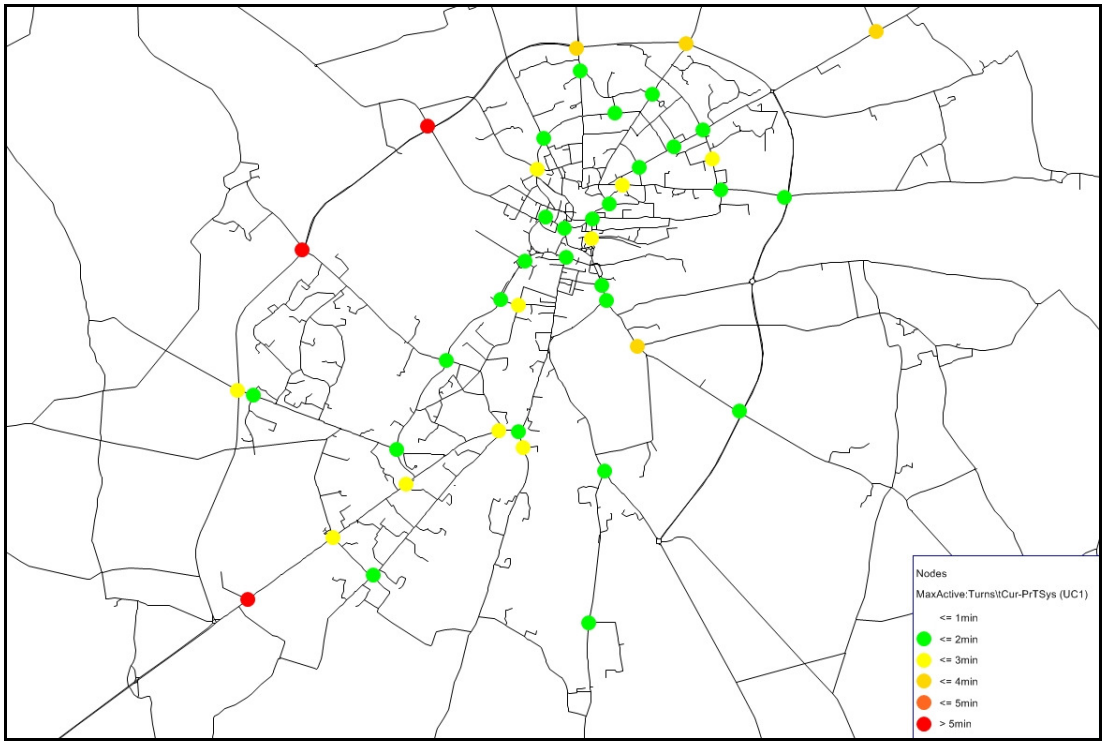


Figure 4-8 – Junctions with Turning Movement Delays – Do-Min – 2036 – AM

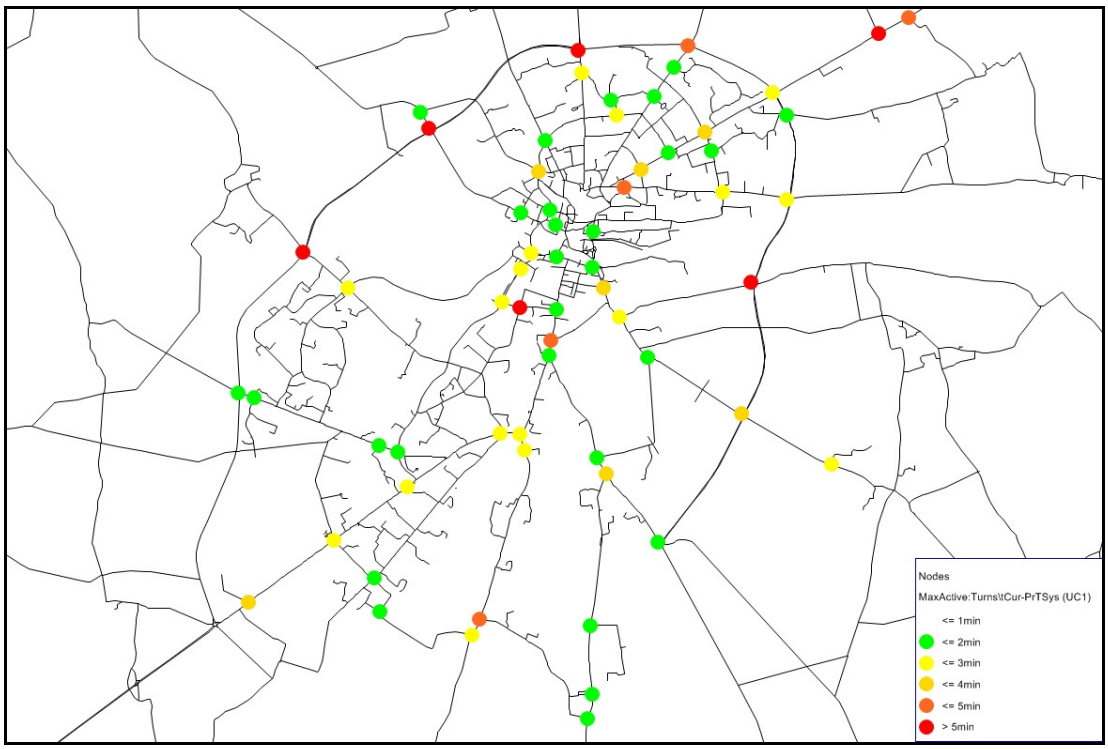


Figure 4-9 – Junctions with Turning Movement Delays – Do-Min – 2036 – AM – Lincoln City Centre

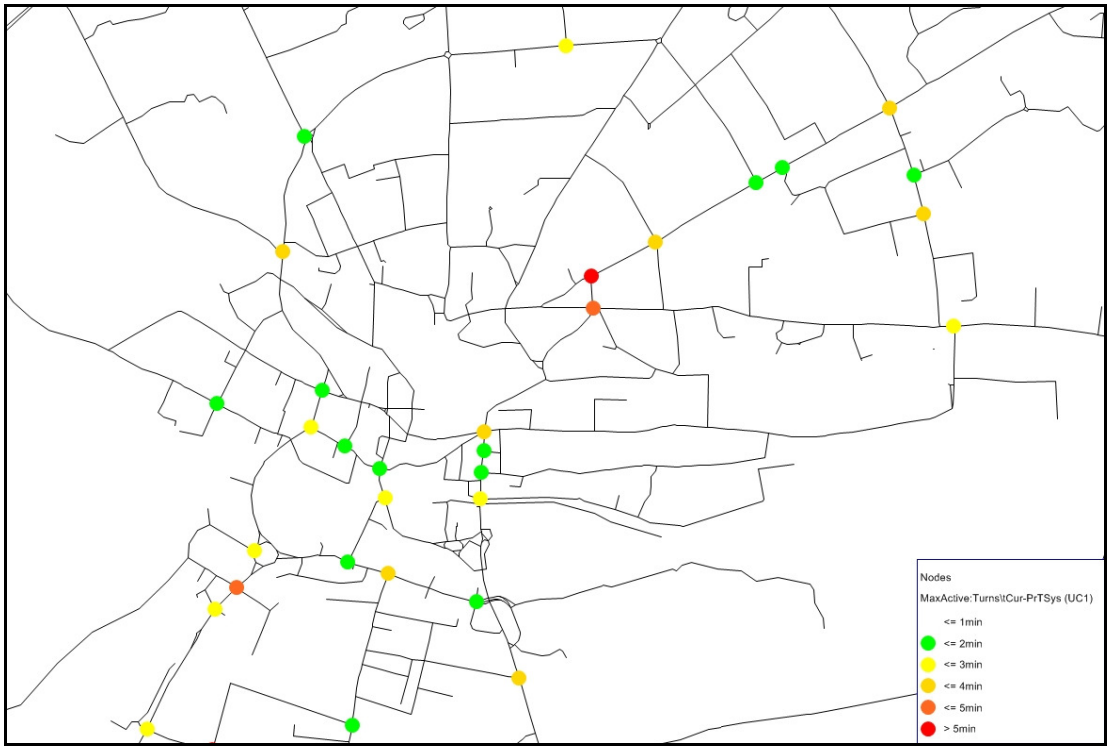


Figure 4-10 – Junctions with Turning Movement Delays – Do-Min – 2018 – PM

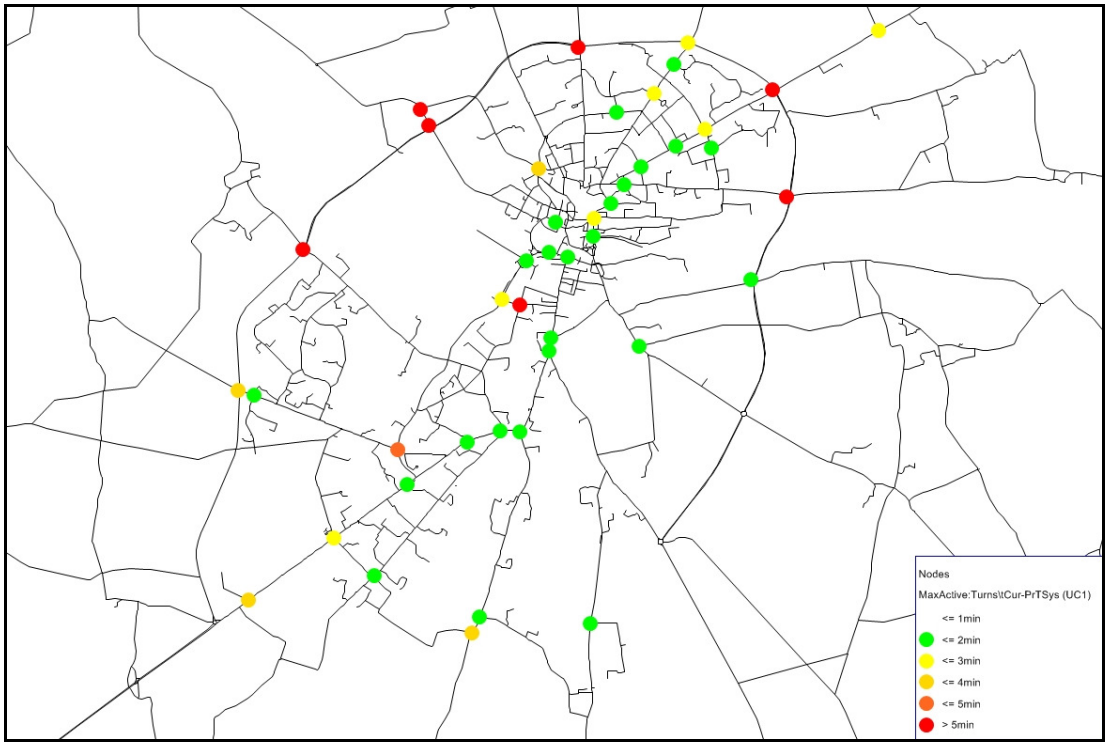


Figure 4-11 – Junctions with Turning Movement Delays – Do-Min – 2036 – PM

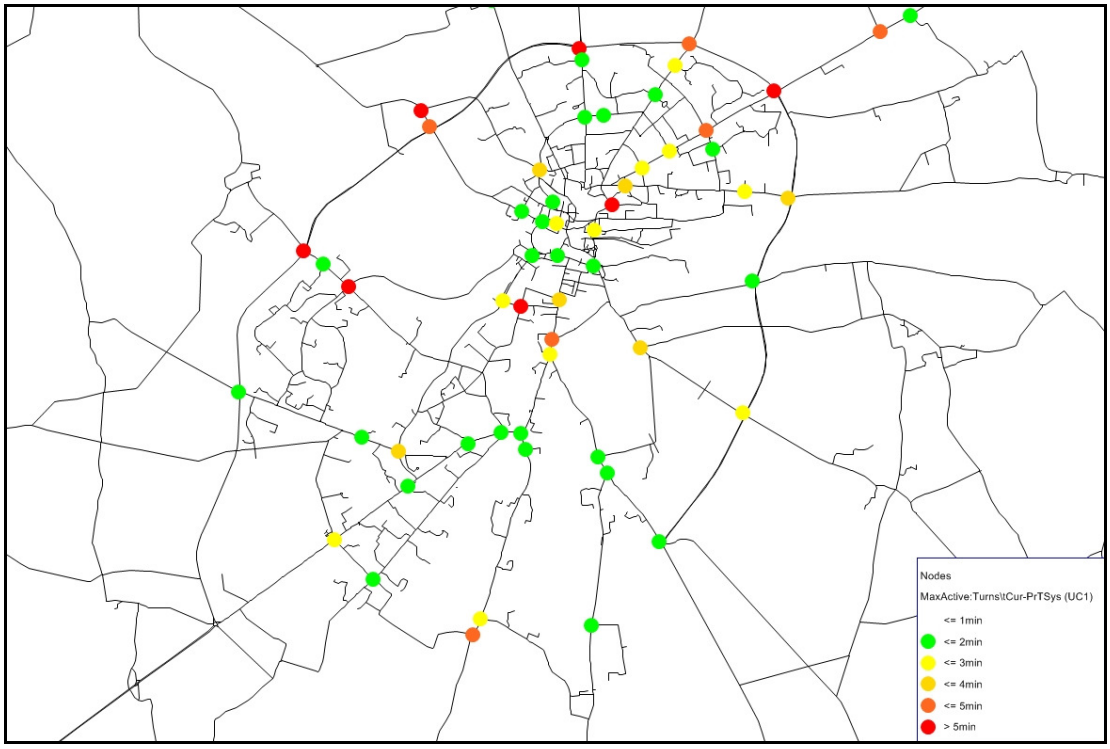
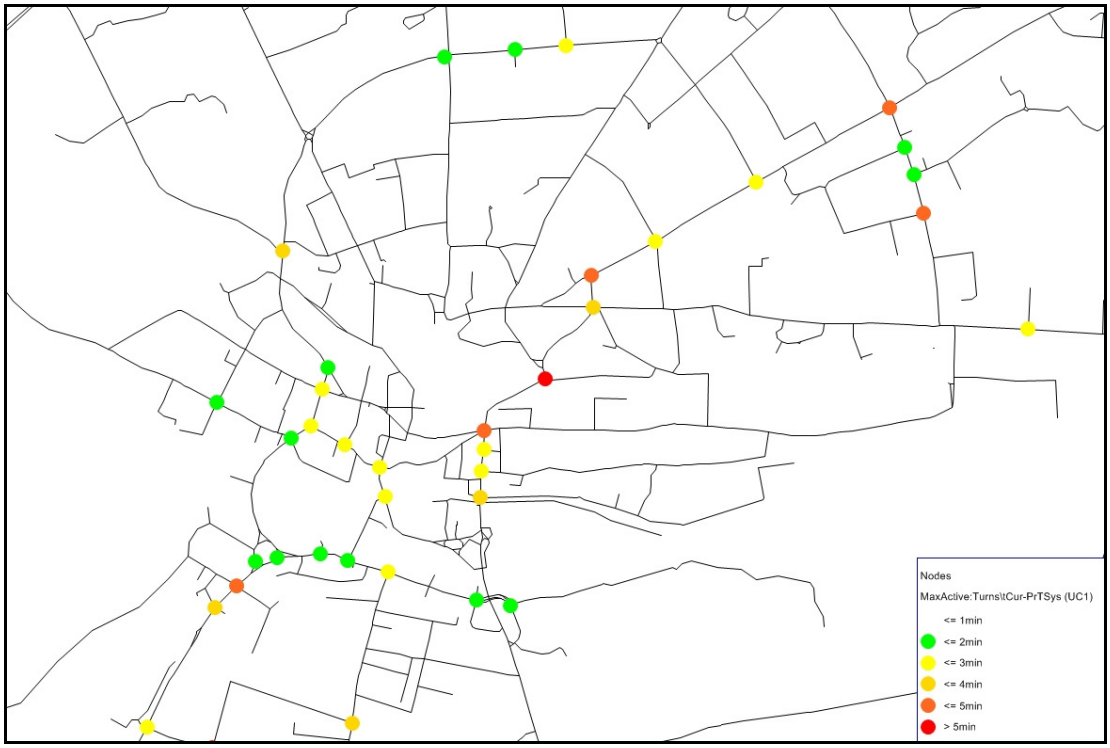


Figure 4-12 – Junctions with Turning Movement Delays – Do-Min – 2036 – PM – Lincoln City Centre



A review of the above figures reveals that, in 2036, the following significant junctions are forecast to have at least one turning movement that experiences delays of over five minutes (highlighted by red dots):

- A46/Skellingthorpe Road
- A46/A57 Saxilby Road
- A57/Long Leys Road
- A46/A15/Riseholme Road
- A46/A158 Wragby Road
- A158/Lodge Lane
- Lincoln Eastern Bypass/Washingborough Road
- Lindum Road/Lindum Terrace
- Dixon Street/Boultham Park Road
- Skellingthorpe Road/Birchwood Avenue/Western Growth Corridor Link

The following junctions are forecast to have turning movements that experience delays of over four to five minutes (highlighted by dark orange dots):

- A46/Nettleham Road
- A158/Kennel Lane
- Greetwell Road/Wragby Road
- Monks Lane/Broadgate
- Wragby Road/Outer Circle Road
- Tritton Road/Beevor Street
- High Street/South Park/St Catherine's
- Brant Road/Meadow Lane

The following junctions are forecast to have turning movements that experience delays of over three to four minutes (highlighted by dark yellow dots):

- Lincoln Eastern Bypass/B1188 Lincoln Road
- Sleaford Road/Grantham Road
- Lee Road/Wragby Road
- Yarborough Road/Long Leys Road

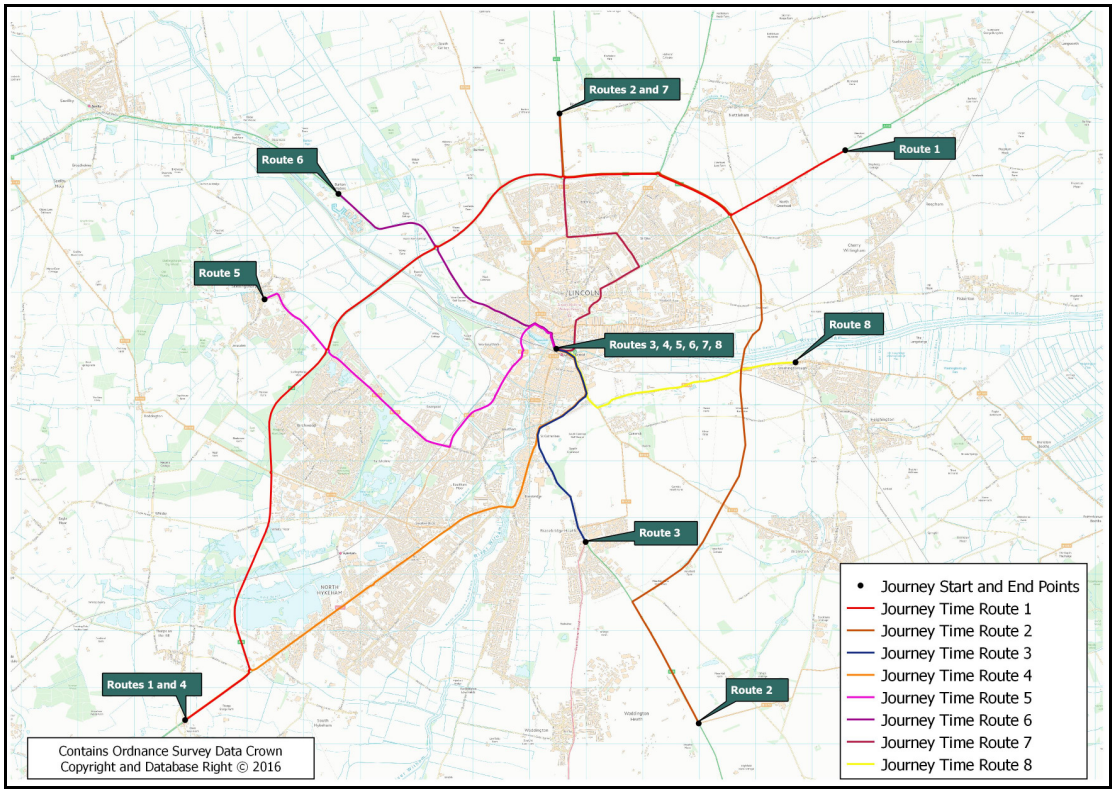
- High Street/Tentercroft Street
- Broadgate/Waterside North
- Canwick Road/Portland Street
- Canwick Road/Heighington Road
- Doddington Road/Tritton Road
- Tritton Road/Centaur Road

As stated above, whilst the model can be used to inform where junction improvements may be necessary, caution should be taken as this is not the model's primary purpose. Professional judgement and local knowledge should be used alongside such junction-related outputs from the model to ensure that appropriate conclusions, which may include identifying the need for more detailed analysis, are reached.

4.7 Journey times

As stated above, eight journey time routes have been identified to enable a comparison between 2018 initial forecast year and the four subsequent Do-Minimum forecast years. The routes reflect a number of common journeys either to and from the city centre or on routes past the city. The eight routes are presented in the figure below.

Figure 4-10 – Journey Time Routes



The following tables present the journey times for each of the Do-Minimum scenarios and provide a comparison between the 2018 and 2036 scenarios in terms of change in minutes and percentage. There are significant increases in journey times on the majority of routes and directions, with some journeys nearly doubling in length, although Route 5 shows an improvement due to traffic being removed by the Western Growth Corridor Link.

Journey times for strategic journeys passing around the outside of the city on the relief roads and Lincoln Eastern Bypass will increase substantially, although less so in the northbound direction on the western and northern relief roads.

A number of the routes experience journey time increases in percentage terms that are significantly above the level of growth in traffic (27%-28% - see Section 4.4); these are highlighted by bold text in the tables below. A significant proportion of these journeys are counter-peak flow i.e. those heading in the opposite direction to the prevailing direction of traffic in the peak periods e.g. leaving the city centre in the AM peak and vice versa. This is indicative of peak flow journeys (highlighted in grey in the tables) already being constrained and therefore less able to cater for additional traffic, resulting in re-routing, while counter-peak flow journeys are likely to be less constrained and therefore more able to cater for additional traffic and, consequently, journey times increasing more significantly.

Table 4-11 – Selected Journey Times (MM:SS) – Do-Min – AM

Route		Length	Path	2018	2021	2026	2031	2036	Change (mins) '18-'36	% Change '18-'36
1	A46 – A158 via LWRR/LNRR	11.3 mile (18.1km)	Northbound	25:18	29:26	30:46	32:03	32:46	07:28	30%
			Southbound	**27:42**	**36:43**	**40:21**	**41:55**	**45:03**	**17:21**	**63%**
2	A15 – A15 via LEB	9.6 miles (15.4km)	Northbound	**16:08**	**18:13**	**20:42**	**22:54**	**28:04**	**11:56**	**74%**
			Southbound	**21:28**	**22:38**	**25:08**	**28:21**	**30:34**	**09:06**	**42%**
3	Bracebridge Heath – City Centre	2.8 miles (4.5km)	Northbound	08:49	09:39	10:44	10:22	10:58	02:09	24%
			Southbound	**09:08**	**09:37**	**10:46**	**14:28**	**17:21**	**08:13**	**90%**
4	A46/A1434 – City Centre	6.8 miles (10.9km)	Northbound	31:39	34:41	36:16	36:22	36:42	05:03	16%
			Southbound	**24:59**	**24:48**	**28:07**	**33:46**	**38:04**	**13:05**	**52%**
5	Skellingthorpe – City Centre	5.3 miles (8.5km)	Eastbound	29:18	22:18	24:45	26:59	27:50	-01:28	-5%
			Westbound	20:22	18:01	21:19	24:07	25:12	04:50	24%
6	Burton Waters – City Centre	4.5 miles (7.2km)	Eastbound	12:54	12:31	14:31	15:40	15:16	02:22	18%
			Westbound	**09:09**	**09:07**	**10:39**	**12:18**	**13:30**	**04:21**	**48%**
7	Riseholme – City Centre	3.9 miles (8.2km)	Southbound	22:22	23:32	24:08	27:16	29:17	06:55	31%
			Northbound	**12:27**	**13:01**	**13:47**	**14:44**	**17:13**	**04:46**	**38%**

Route		Length	Path	2018	2021	2026	2031	2036	Change (mins) '18-'36	% Change '18-'36
8	Washingborough – City Centre	3.3 miles (5.3km)	Westbound	**10:32**	**12:58**	**17:05**	**18:34**	**20:07**	**09:35**	**91%**
			Eastbound	**08:38**	**09:01**	**09:58**	**13:36**	**16:17**	**07:39**	**89%**

Table 4-12 – Selected Journey Times (MM:SS) – Do-Min – PM

Route		Length	Path	2018	2021	2026	2031	2036	Change (mins) '18-'36	% Change '18-'36
1	A46 – A158 via LWRR/LNRR	11.3 mile (18.1km)	Northbound	35:58	36:10	37:25	37:13	36:39	00:41	2%
			Southbound	**29:53**	**39:27**	**40:58**	**43:43**	**43:27**	**13:34**	**45%**
2	A15 – A15 via LEB	9.6 miles (15.4km)	Northbound	**19:48**	**20:35**	**23:38**	**29:23**	**32:56**	**13:08**	**66%**
			Southbound	**19:54**	**19:56**	**22:07**	**24:08**	**27:37**	**07:43**	**39%**
3	Bracebridge Heath – City Centre	2.8 miles (4.5km)	Northbound	**08:41**	**09:20**	**10:14**	**10:25**	**15:29**	**06:48**	**78%**
			Southbound	12:49	13:53	16:25	17:08	17:16	04:27	35%
4	A46/A1434 – City Centre	6.8 miles (10.9km)	Northbound	27:44	28:26	29:34	30:52	35:12	07:28	27%
			Southbound	32:57	33:24	36:01	36:48	36:20	03:23	10%
5	Skellingthorpe – City Centre	5.3 miles (8.5km)	Eastbound	19:48	15:42	16:55	18:46	19:56	00:08	1%
			Westbound	27:41	23:43	28:37	27:52	25:03	-02:38	-10%
6	Burton Waters – City Centre	4.5 miles (7.2km)	Eastbound	**09:51**	**09:04**	**09:57**	**13:12**	**16:25**	**06:34**	**67%**
			Westbound	19:06	20:19	23:02	23:15	20:21	01:15	7%
7	Riseholme – City Centre	3.9 miles (8.2km)	Southbound	**19:46**	**19:52**	**21:57**	**24:09**	**26:24**	**06:38**	**34%**
			Northbound	21:55	22:22	23:01	24:00	24:08	02:13	10%
8	Washingborough – City Centre	3.3 miles (5.3km)	Westbound	**07:41**	**08:01**	**08:28**	**09:07**	**13:16**	**05:35**	**73%**
			Eastbound	13:12	14:14	16:41	17:02	16:46	03:34	27%

4.8 Summary

The modelling of the Do-Minimum scenarios has revealed a number of predictions for the effect of growth on the highway network in the Lincoln area. The most significant of these predictions are as follows:

- The predicted growth in households and employment will lead to a 27% and 28% increase in AM and PM peak vehicular journeys in the Lincoln area respectively.
- Growth will lead to a 54% and 45% increase in vehicle hours in the Lincoln area in the 2036 AM and PM peak hour respectively

- Vehicle hours occurring on highway link operating above their capacity will increase to 414 and 620 in the 2036 AM and PM peaks respectively. These vehicle hours will increase from 1% and 3% of all AM and PM peak vehicle hours respectively, to 5% and 7%.

- The predicted growth in traffic will lead to an increase in the number of highway links operating above 85% of their theoretical capacity (the point at which the free-flow of traffic starts to breakdown). However, in 2036 82% of links will still be operating below 85% of capacity and 95% of links will be operating under 100% of capacity in the AM peak. In the PM peak in 2036, 93% of traffic will be on links operating under 100% of their capacity.

- The predicted growth in traffic will also lead to an increase in junctions that experience significant delays on one or more of their turning movements.

- In terms of journey times, the growth contained in the Core Scenario would increase duration substantially both on routes bypassing Lincoln and on radial routes into and from the city centre.

Overall, the analysis shows some significant impacts of growth on the operation of the highway network. Whilst some of the highway infrastructure included in the Do-Minimum modelling (e.g. Lincoln Eastern Bypass, East-West Link and the link through the Western Growth Corridor from Skellingthorpe Road to Tritton Road) will generate significant benefits in their own right, they will not alone mitigate some of those impacts of growth.

As stated previously in this report, the above conclusions are based on the use of the Core Scenario for predicted growth in housing and employment, which is based on worst case, highest growth, assumptions of the development that could be included in the four Lincolnshire Local Plans.

It should be noted that the above analysis is for the AM and PM peak hours only and they reflect the both the conditions when the highest levels of traffic will be on the highway network, and the worst case highest level of growth used in the Core Scenario. Outside of the peak hours, traffic levels will be lower and congestion will be less. Data from the annual surveys of the cordon across Lincoln centre indicates that the average inter-peak hour traffic (i.e. between 09:00 and 17:00) is approximately 76% the AM peak hour and 73% of the PM peak hour.

5 Do-Something Modelling – Link Capacity Improvements

5.1 Scope

Following on from the modelling of Do-Minimum scenarios, options for improving the operation of the highway network have been identified and tested through the use of 'Do-Something' scenarios. Sections 5, 6, 7 and 8 review the outputs from the Do-Something modelling with their individual focus being:

- Section 5 – Link Capacity Improvements
- Section 6 – Junction Capacity Improvements
- Section 7 – Mode Shift

As stated above, this section reviews the outputs from modelling of potential improvements to link capacity.

5.2 Options

The starting point for the identification of options has been the adopted Lincoln Integrated Transport Strategy (LITS) which contains a number of established highway capacity improvements including the following:

- Lincoln Eastern Bypass (single carriageway)
- East-West Link (Rope Walk to South Park Avenue)
- Western Growth Corridor Link (previously known as the Swanpool Link)
- Lincoln Southern Bypass
- Relief Road Improvements

Both the Lincoln Eastern Bypass (single carriageway) and East-West Link are included in the Do-Minimum scenarios and the latter is presently under construction. The Western Growth Corridor Link is also included in the Do-Minimum scenarios but only as a link between Skellingthorpe Road and Beevor Street. The Do-Minimum scenarios also include the first section of the Lincoln Southern Bypass single carriageway (between Newark Road and Boundary Lane/South Hykeham Road which is expected to be delivered as part of the South Western Quadrant SUE.

A progress review of LITS was undertaken in 2013 and the dualling of LEB was added to the Strategy as a further scheme of consideration.

In Section 4.5.3, a list of significant links which will experience traffic volumes above 85% of their capacity have been identified. In addition to one link on LEB, only

Tritton Road has been assessed as having potential for significant link capacity improvements and is included in the Link Improvement scenarios below.

The following table provides a summary of the scenarios used to model the above link capacity improvements.

Table 5-1 – Do-Som Link Improvement Scenarios

Scenario	Option	Short Title
1	Tritton Road – two (in each direction) lane single carriageway between Skellingthorpe Road and Dixon Street	Tritton Road
2	Lincoln Southern Bypass (Phase 2) between Phase 1 and Brant Road – single carriageway	LSB Ph2 Single
3	Lincoln Southern Bypass (Full) between Phase 1 and A15 – single carriageway	LSB Full Single
4	Lincoln Southern Bypass (Phase 2) between Phase 1 and Brant Road – dual carriageway	LSB Ph2 Dual
5	Lincoln Southern Bypass (Full) between Phase 1 and A15 – dual carriageway	LSB Full Dual
6	Western Growth Corridor A46 Link	WGC A46 Link
7	Lincoln Northern Relief Road – dualling between A158 and A46	LNRR Dual A158-A46
8	Lincoln Northern Relief Road – dualling between A46 and A15	LNRR Dual A46-A15
9	Lincoln Northern Relief Road – full dualling between A158 and A46	LNRR Full Dual
10	Lincoln Western Relief Road – dualling between B1378 Skellingthorpe Road and B1190 Doddington Road	LWRR Dual B1378-B1190
11	Lincoln Western Relief Road – dualling between Whisby Road and A1434 Newark Road	LWRR Dual Whisby-A1434
12	Lincoln Western Relief Road – full dualling	LWRR Full Dual
13	Lincoln Eastern Bypass – dualling between Greetwell Road and Washingborough Road	LEB Dual Greet-Wash
14	Lincoln Eastern Bypass – full dualling	LEB Full Dual
17	Do-Maximum	Do-Max

The above scenarios include a Do-Maximum which incorporates the most significant variation of each of the options identified in the table above and, therefore, includes:

- Tritton Road two lane (in each direction) single carriageway
- Lincoln Southern Bypass (full) dual carriageway
- Western Growth Corridor A46 Link
- Lincoln Northern Relief Road full dualling
- Lincoln Western Relief Road full dualling

- Lincoln Eastern Bypass full dualling.

Whilst the delivery of the Do-Maximum infrastructure in its entirety over the course of the next plan period, up to 2036, is not presently realistic, due to the affordability of such schemes, the Do-Maximum scenario has been modelled to indicate the potential impact of implementing all of the major schemes.

5.3 Modelling Results

As with the Do-Minimum results in Section 4, the results for the Do-Something modelling are presented through analysis of a number of different outputs from the model.

- **Link capacity**

  For each Do-Something forecast year and associated AM and PM peak hour, figures show the ratio of traffic volume to the capacity of each link in the highway network (a link is a section of road between two junctions).

- **Journey times**

  Eight indicative journeys to, from and past Lincoln have been identified to provide an understanding of the impact of traffic growth on typical local and strategic journeys that drivers will make in each of the Do-Something years.

5.4 Link Capacity

This section reviews the outputs from the Do-Something scenario modelling in terms of the effects of growth on link capacity.

5.4.1 Vehicle Hours – AM Peak

The following table shows the effect of each of the capacity improvements on the 2036 AM peak hour vehicles hours on the highway network in the Lincoln area and specifically the vehicle hours spent on links at different percentages of capacity. Starting with the effect of the improvements on traffic travelling on links operating at or over 100% of capacity, the two versions of the Lincoln Southern Bypass scheme have the most significant effects reducing such hours to close to the equivalent 2031 Do-Minimum. The dualling of the remaining single carriageway sections of the Lincoln Western Relief Road will also deliver significant benefits. The greatest effect comes from the Do-Maximum combination of schemes which reduces all vehicle hours on links operating over 85% of capacity to below the 2031 Do-Minimum. The other individual schemes have significantly lesser effects than the Lincoln Southern Bypass schemes. Improvements to Lincoln Northern Relief Road appear to generate some disbenefits in some cases; this may be a result of releasing more traffic onto already constrained junctions.

Table 5-2 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Som – 2036 – AM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	4,498	610	276	58	334	5,442
-	Do-Minimum 2031	5,631	973	597	274	871	7,475
-	Do-Minimum 2036	6,085	801	1,082	414	1,496	8,382
2036							
1	Tritton Road	6,221	726	1,109	379	1,488	8,435
2	LSB Ph2 Single	6,062	846	1,110	366	1,476	8,384
3	LSB Full Single	6,248	974	775	275	1,050	8,272
4	LSB Ph2 Dual	6,156	853	1,078	364	1,442	8,451
5	LSB Full Dual	6,263	954	781	290	1,071	8,288
6	WGC A46 Link	6,065	795	986	413	1,399	8,259
7	LNRR Dual A158-A46	6,134	757	1,096	419	1,515	8,406
8	LNRR Dual A46-A15	6,208	704	1,038	443	1,481	8,393
9	LNRR Full Dual	6,089	812	1,086	396	1,482	8,383
10	LWRR Dual B1378-B1190	6,244	694	985	388	1,373	8,311
11	LWRR Dual Whisby-A1434	6,414	728	868	423	1,291	8,433
12	LWRR Full Dual	6,446	710	804	391	1,195	8,351
13	LEB Dual Greet-Wash	6,280	720	1,007	387	1,394	8,394
14	LEB Full Dual	6,282	625	1,012	397	1,409	8,316
17	Do-Maximum	6,571	496	595	257	852	7,919

The following table shows the distribution of vehicle hours across the percentage of capacity bands for the 2036 AM peak hour. In terms of links operating over 100% of capacity, the proportion of vehicle hours on these links is lower for the Lincoln Southern Bypass schemes than the 2031 Do-Minimum while the proportions over 85% of capacity are slightly above the 2031 Do-Minimum for these options. Again, the Do-Maximum scenario performs better than the 2031 Do-Minimum.

Table 5-3 –Distribution of Vehicle Hours 2018 to 2036 – Do-Som – Summary – AM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	82.7%	11.2%	5.1%	1.1%	6.1%	100.0%
-	Do-Minimum 2031	75.3%	13.0%	8.0%	3.7%	11.7%	100.0%
-	Do-Minimum 2036	72.6%	9.6%	12.9%	4.9%	17.8%	100.0%
2036							
1	Tritton Road	73.8%	8.6%	13.1%	4.5%	17.6%	100.0%
2	LSB Ph2 Single	72.3%	10.1%	13.2%	4.4%	17.6%	100.0%
3	LSB Full Single	75.5%	11.8%	9.4%	3.3%	12.7%	100.0%
4	LSB Ph2 Dual	72.8%	10.1%	12.8%	4.3%	17.1%	100.0%
5	LSB Full Dual	75.6%	11.5%	9.4%	3.5%	12.9%	100.0%
6	WGC A46 Link	73.4%	9.6%	11.9%	5.0%	16.9%	100.0%
7	LNRR Dual A158-A46	73.0%	9.0%	13.0%	5.0%	18.0%	100.0%
8	LNRR Dual A46-A15	74.0%	8.4%	12.4%	5.3%	17.6%	100.0%
9	LNRR Full Dual	72.6%	9.7%	13.0%	4.7%	17.7%	100.0%
10	LWRR Dual B1378-B1190	75.1%	8.4%	11.9%	4.7%	16.5%	100.0%
11	LWRR Dual Whisby-A1434	76.1%	8.6%	10.3%	5.0%	15.3%	100.0%
12	LWRR Full Dual	77.2%	8.5%	9.6%	4.7%	14.3%	100.0%
13	LEB Dual Greet-Wash	74.8%	8.6%	12.0%	4.6%	16.6%	100.0%
14	LEB Full Dual	75.5%	7.5%	12.2%	4.8%	16.9%	100.0%
17	Do-Maximum	83.0%	6.3%	7.5%	3.2%	10.8%	100.0%

5.4.2 Vehicle Hours – PM Peak

For the 2036 PM peak, again the Lincoln Southern Bypass schemes have the greatest effect on vehicle hours on congested links and the full dual-carriageway scheme out-performs the 2031 Do-Minimum in terms of vehicle hours on links operating at over 85% of capacity. The 2036 Do-Maximum scenario significantly out-performs the 2031 Do-Minimum.

Table 5-4 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Som – 2036 – PM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	4,956	733	284	183	467	6,156
-	Do-Minimum 2031	5,770	1,154	836	333	1,169	8,093
-	Do-Minimum 2036	6,099	1,301	887	620	1,507	8,907
2036							
1	Tritton Road	6,129	1,301	872	559	1,431	8,861
2	LSB Ph2 Single	6,107	1,103	912	599	1,511	8,721
3	LSB Full Single	6,202	1,191	763	463	1,226	8,619
4	LSB Ph2 Dual	6,097	1,291	839	595	1,434	8,822
5	LSB Full Dual	6,255	1,124	676	465	1,141	8,520
6	WGC A46 Link	6,028	1,265	869	625	1,494	8,787
7	LNRR Dual A158-A46	6,137	1,321	878	638	1,516	8,974
8	LNRR Dual A46-A15	6,159	1,239	928	611	1,539	8,937
9	LNRR Full Dual	6,097	1,236	887	667	1,554	8,887
10	LWRR Dual A1378-B1190	6,120	1,268	867	624	1,491	8,879
11	LWRR Dual Whisby-A1434	6,259	1,274	820	542	1,362	8,895
12	LWRR Full Dual	6,276	1,173	733	638	1,371	8,820
13	LEB Dual Greet-Wash	6,231	1,327	903	489	1,392	8,950
14	LEB Full Dual	6,313	1,198	847	555	1,402	8,913
17	Do-Maximum	6,798	735	449	395	844	8,377

The Lincoln Southern Bypass options also out-perform the 2031 Do-Minimum in terms of the percentage of vehicle hours operating above 85% of capacity (see following table) while the Do-Maximum scenario significantly outperforms it. Overall, individually, the other Do-Something options have significantly smaller effects than either the Lincoln Southern Bypass or Do-Maximum options.

Table 5-5 –Distribution of Vehicle Hours 2018 to 2036 – Do-Som – Summary – PM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	80.5%	11.9%	4.6%	3.0%	7.6%	100.0%
-	Do-Minimum 2031	71.3%	14.3%	10.3%	4.1%	14.4%	100.0%
-	Do-Minimum 2036	68.5%	14.6%	10.0%	7.0%	16.9%	100.0%
2036							
1	Tritton Road	69.2%	14.7%	9.8%	6.3%	16.1%	100.0%
2	LSB Ph2 Single	70.0%	12.6%	10.5%	6.9%	17.3%	100.0%
3	LSB Full Single	72.0%	13.8%	8.9%	5.4%	14.2%	100.0%
4	LSB Ph2 Dual	69.1%	14.6%	9.5%	6.7%	16.3%	100.0%
5	LSB Full Dual	73.4%	13.2%	7.9%	5.5%	13.4%	100.0%
6	WGC A46 Link	68.6%	14.4%	9.9%	7.1%	17.0%	100.0%
7	LNRR Dual A158-A46	68.4%	14.7%	9.8%	7.1%	16.9%	100.0%
8	LNRR Dual A46-A15	68.9%	13.9%	10.4%	6.8%	17.2%	100.0%
9	LNRR Full Dual	68.6%	13.9%	10.0%	7.5%	17.5%	100.0%
10	LWRR Dual B1378-B1190	68.9%	14.3%	9.8%	7.0%	16.8%	100.0%
11	LWRR Dual Whisby-A1434	70.4%	14.3%	9.2%	6.1%	15.3%	100.0%
12	LWRR Full Dual	71.2%	13.3%	8.3%	7.2%	15.5%	100.0%
13	LEB Dual Greet-Wash	69.6%	14.8%	10.1%	5.5%	15.6%	100.0%
14	LEB Full Dual	70.8%	13.4%	9.5%	6.2%	15.7%	100.0%
17	Do-Maximum	81.2%	8.8%	5.4%	4.7%	10.1%	100.0%

5.4.3 Ratio of Flow to Capacity

The following figures present the ratios of traffic volumes to link capacities and are a visual representation of the above tables. The colour shading highlights the ratios with green being under 50% of capacity and red being over 85% of capacity. The figures also show the modelled 'actual' flows on each link.

The first figure repeats the 2036 AM Do-Minimum while the following two figures are for the Lincoln Southern Bypass Full Dual-carriageway scheme and the Do-Maximum scenario.

Figure 5-1 – Link Volume to Capacity Ratio – Do-Min 1 – 2036 – AM

The figure below for the Lincoln Southern Bypass dual-carriageway scheme shows improvements on the 2036 Do-Minimum. As one might expect, the highway network to the south of Lincoln, around North and South Hykeham and the rural roads in the vicinity show the clearest improvement. There is also some improvement shown on the Western Relief Road, however, there is variable improvement and worsening of performance of routes into the city centre.

Figure 5-2 – Link Volume to Capacity Ratio – Do-Som 5: LSB Full Dual – 2036 – AM

The Do-Maximum scenario shows broad improvement both on Lincoln's radial routes and on the complete 'ring-road'. However, there appears to be limited improvement on the main links within the city centre and the impact on LEB varies depending on the direction of travel.

Figure 5-3 – Link Volume to Capacity Ratio – Do-Som 17: Do-Maximum – 2036 – AM

The following figures present the outputs for the PM peak hour in 2036.

Figure 5-4 – Link Volume to Capacity Ratio – Do-Min – 2036 – PM

The figure below shows that in the 2036 PM peak the a dual-carriageway Lincoln Southern Bypass will provide relief to links in the Hykeham area and south of Lincoln, as well as to the Western Relief Road. Again, there are variable impacts on the links into the city centre and the LEB benefits northbound but has an increase in traffic southbound.

Figure 5-5 – Link Volume to Capacity Ratio – Do-Som 5: LSB Full Dual – 2036 – PM

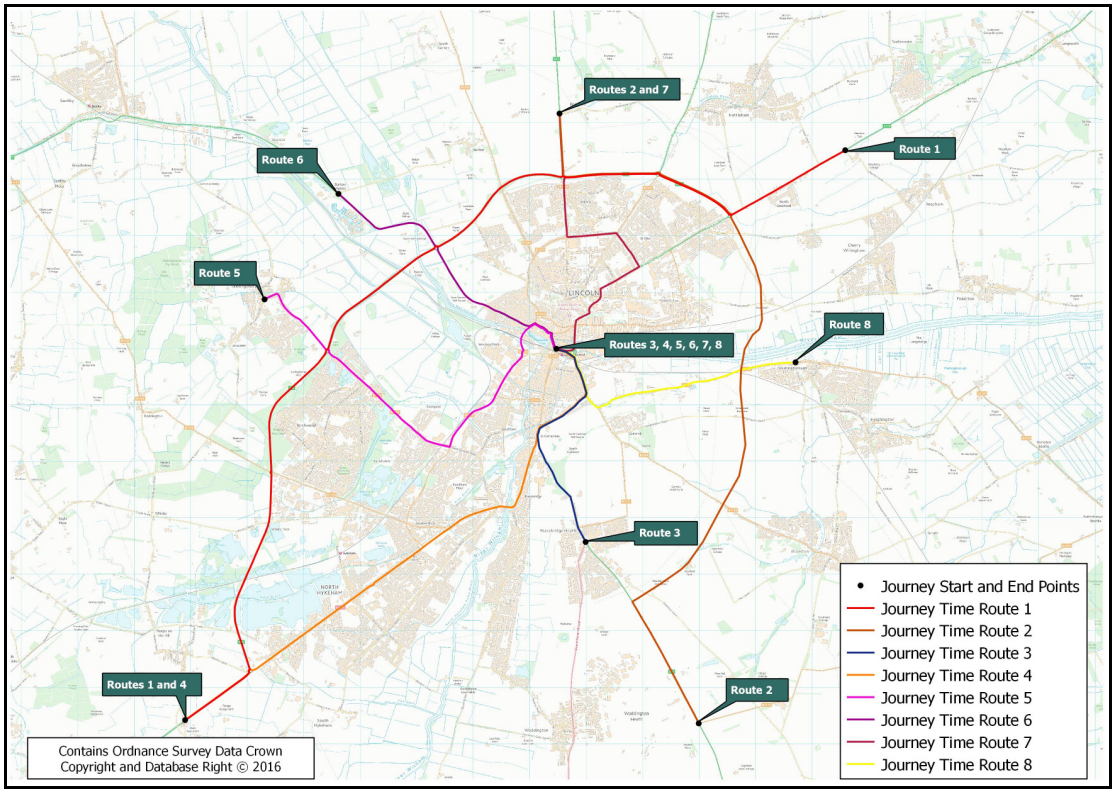
Again, the 2036 Do-Maximum scenario shows broad improvement both on the completed ring-road and on the city's radial routes but limited impacts within the heart of the city centre.

Figure 5-6 – Link Volume to Capacity Ratio – Do-Som 17: Do-Maximum – 2036 – PM

5.5 Journey times

This section reviews the impact on the eight journey time routes of the Do-Something scenarios and those routes are shown again below for reference.

Figure 5-6 – Journey Time Routes



It can be seen from the tables below that not all of the proposed interventions are uniformly positive in their effect on journey times (increased journey times are highlighted in red text and grey shading while changes of 5% or more are highlighted in bold). Although it should be noted that the journey times represent only a small sample of the possible journeys through the urban area of Greater Lincoln, it is notable that all interventions have negative impacts on some routes, and some interventions appear to have a negative impact on most routes (although it should of course be noted that some of these routes carry more traffic than others; impacts, positive or negative, on a route which carries a large volume of traffic will outweigh impact on a route carrying less traffic).

The most positive overall impact can be seen with the Do-Maximum. Importantly, this also provides savings on the route with the greatest volumes of traffic; Route 1, which uses the existing Lincoln Western Relief Road. It can be seen that a significant proportion of the savings from the Do-Maximum scenario come from the dualled Lincoln Southern Bypass scheme. This intervention provides bigger journey time savings than interventions 10, 11 and 12 (the full dualling of the Lincoln Western Ring Road), even on Route 1, which covers the LWRR itself.

Table 5-7 – Selected Journey Times (MM:SS) – Do-Som Options – AM

Route		Path	2018 DM	2031 DM	2036 DM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	17
1	A46 – A158 via LWRR/LNRR	N'bound	25:18	32:03	32:46	34:19	**34:54**	34:15	32:25	**31:00**	**38:41**	34:43	33:47	**37:52**	34:11	32:19	32:45	**34:49**	32:36	32:31
		S'bound	27:42	41:55	45:03	43:23	43:49	**40:44**	44:38	**40:15**	46:16	43:00	43:20	44:56	43:23	45:39	44:17	44:21	43:37	44:16
2	A15 – A15 via LEB	N'bound	16:08	22:54	28:04	**26:36**	27:23	29:07	27:29	29:20	27:33	26:49	26:52	26:58	27:57	26:56	**26:40**	27:10	**26:30**	29:20
		S'bound	21:28	28:21	30:34	31:18	31:40	30:32	30:14	**32:23**	31:24	30:32	29:34	30:12	31:28	30:35	30:59	**32:30**	31:04	31:12
3	Bracebridge Heath – City Centre	N'bound	08:49	10:22	10:58	10:58	**12:26**	10:40	**12:16**	10:38	11:01	10:41	**10:13**	09:59	10:22	**09:53**	**09:45**	11:00	11:16	11:20
		S'bound	09:08	14:28	17:21	17:13	18:03	17:21	17:51	17:25	17:17	17:12	17:15	17:20	17:12	17:05	17:06	17:23	16:58	17:02
4	A46/A1434 – City Centre	N'bound	31:39	36:22	36:42	36:50	35:14	34:40	35:27	**32:59**	37:26	36:42	36:02	35:49	36:17	35:32	35:22	36:38	36:34	**33:47**
		S'bound	24:59	33:46	38:04	38:35	36:22	**35:20**	37:25	**35:53**	37:28	37:56	37:51	37:36	38:25	**34:35**	**34:42**	38:00	37:37	34:54
5	Skellingthorpe – City Centre	E'bound	29:18	26:59	27:50	**31:25**	28:29	27:59	28:55	27:58	**23:58**	**31:04**	**30:19**	**29:55**	28:35	**30:23**	**29:44**	28:42	27:29	**26:11**
		W'bound	20:22	24:07	25:12	26:26	25:19	**29:47**	25:09	**29:21**	**20:46**	24:39	26:22	25:38	**26:43**	26:16	**26:51**	24:55	25:39	**21:14**
6	Burton Waters – City Centre	E'bound	12:54	15:40	15:16	**16:17**	15:59	**17:35**	15:42	**16:34**	15:10	15:51	**16:30**	**18:25**	15:48	15:53	15:58	**16:44**	15:22	14:49
		W'bound	09:09	12:18	13:30	12:55	**12:43**	**12:25**	**12:19**	13:02	**11:27**	12:51	13:20	13:42	13:54	**14:24**	**15:07**	13:41	13:45	**10:59**
7	Riseholme – City Centre	S'bound	22:22	27:16	29:17	29:21	**30:56**	**30:47**	30:00	29:54	29:58	29:00	28:00	**27:18**	30:15	29:08	29:06	29:46	28:52	**31:17**
		N'bound	12:27	14:44	17:13	17:23	16:50	**15:31**	17:45	**15:39**	17:57	**18:40**	**16:07**	17:18	17:03	17:27	**18:35**	17:02	17:18	**15:34**
8	Washingborough – City Centre	W'bound	10:32	18:34	20:07	20:17	20:28	**19:02**	19:59	19:44	19:52	20:16	19:13	**18:39**	19:56	19:10	19:48	19:18	19:19	20:30
		E'bound	08:38	13:36	16:17	16:17	17:02	16:54	16:51	16:59	15:59	16:13	16:16	16:24	16:11	16:10	16:11	16:26	16:06	16:36

Table 5-8 – Selected Journey Times (MM:SS) – Do-Som Options – PM

Route		Path	2018 DM	2031 DM	2036 DM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	17
1	A46 – A158 via LWRR/LNRR	N'bound	35:58	37:13	36:39	37:18	35:58	**34:50**	**34:40**	34:59	37:17	36:49	37:53	34:52	36:41	36:33	36:12	38:27	38:05	**33:59**
		S'bound	29:53	43:43	43:27	**47:51**	**48:26**	**45:50**	44:07	**48:56**	45:34	42:54	44:28	**46:03**	**45:41**	**47:03**	44:54	**44:44**	45:59	45:22
2	A15 – A15 via LEB	N'bound	19:48	29:23	32:56	33:11	**30:04**	**30:02**	31:57	**31:06**	31:20	32:38	32:03	**27:51**	32:22	32:35	32:59	**34:52**	31:20	**29:17**
		S'bound	19:54	24:08	27:37	26:18	**26:10**	26:31	**25:23**	27:20	27:38	**25:23**	27:21	**25:48**	27:34	27:23	26:44	**25:54**	**25:54**	26:59
3	Bracebridge Heath – City Centre	N'bound	08:41	10:25	15:29	**14:38**	**18:20**	**17:22**	**19:03**	**18:41**	15:11	15:31	15:00	**14:30**	15:08	**12:36**	14:49	15:03	14:44	**17:57**
		S'bound	12:49	17:08	17:16	17:23	**18:35**	17:56	16:51	17:45	17:34	17:10	17:31	17:23	17:18	17:10	17:29	17:01	17:01	16:35
4	A46/A1434 – City Centre	N'bound	27:44	30:52	35:12	34:24	34:53	33:40	**32:41**	34:01	34:50	35:27	34:43	34:02	34:47	**32:20**	34:11	34:57	34:39	**33:25**
		S'bound	32:57	36:48	36:20	36:43	37:47	34:54	35:12	34:40	37:03	36:14	37:00	36:25	36:43	36:35	36:52	36:07	35:58	**32:24**
5	Skellingthorpe – City Centre	E'bound	19:48	18:46	19:56	20:41	**18:37**	**18:41**	19:39	19:03	19:39	19:33	19:12	**18:47**	**21:10**	**21:15**	**21:49**	20:59	19:35	**18:39**
		W'bound	27:41	27:52	25:03	25:12	26:17	25:03	25:53	25:25	24:56	24:25	25:07	26:13	25:07	**26:45**	**27:17**	25:22	25:16	25:43
6	Burton Waters – City Centre	E'bound	09:51	13:12	16:25	**12:16**	**13:20**	**13:02**	15:45	**14:34**	16:47	16:29	16:05	**14:28**	**13:57**	**17:42**	**13:25**	**14:56**	17:06	**12:15**
		W'bound	19:06	23:15	20:21	**22:12**	**22:12**	20:55	21:21	**21:44**	**22:16**	19:39	20:54	21:02	20:59	**21:53**	**21:29**	**23:55**	20:16	20:28
7	Riseholme – City Centre	S'bound	19:46	24:09	26:24	26:21	26:43	26:15	27:04	26:55	25:44	26:06	**24:38**	26:01	26:19	25:50	27:04	26:47	25:13	**27:59**
		N'bound	21:55	24:00	24:08	25:18	**25:24**	**25:21**	23:05	24:22	25:05	25:06	24:22	**25:43**	25:15	24:30	25:17	24:15	24:07	24:13
8	Washingborough – City Centre	W'bound	07:41	09:07	13:16	**12:23**	12:56	**12:24**	**11:45**	12:53	12:45	13:08	13:13	13:09	13:05	**10:27**	12:33	13:13	13:05	**12:28**
		E'bound	13:12	17:02	16:46	16:57	**18:13**	17:08	16:07	17:21	17:02	16:48	16:53	17:05	16:45	16:27	16:56	16:15	17:31	16:56

5.6 Summary

The analysis of potential link-based improvements presented in this section of the report highlights that options to deliver a full Lincoln Southern Bypass, dualled, (between the A46 and A15) will deliver the greatest benefits of any individual scheme. The section also highlights that a Do-Maximum scenario, in effect delivering a dual-carriageway ring road around Lincoln, plus some smaller scale additional infrastructure, would generate the greatest benefits but this is unlikely to be deliverable during the plan period. A combination of schemes, starting with the Lincoln Southern Bypass could potentially deliver traffic relief sufficient to reduce levels of congestion in 2036 close to projected levels for 2031.

6 Do-Something Modelling – Modal Shift Sensitivity Testing

6.1 Scope

This section reviews the outputs from the Do-Something sensitivity testing undertaken to assess the potential impact of measures to encourage mode shift away from private car-based travel and towards more sustainable modes such as public transport, cycling and walking.

The GLTM is not a multi-modal model, therefore, it can only be used to assess the potential impact of reduced vehicular traffic brought about by mode shift.

6.2 Options

In addition to improvements to highway capacity, LITS contained a number of measures to support the shift from private car-based travel to more sustainable modes of transport. The measures included the following:

- Sustainable Travel Initiatives
- Small Scale Walking/Cycling/Public Transport Schemes
- Quality Bus Corridors
- Real-time Passenger Transport Information
- Public Transport Interchange
- Rail Service Improvements
- City Centre Pedestrian Improvements

The progress review of LITS added the following schemes to the Strategy:

- Access LN6
- Bus Network Review
- Lincoln Cycle Strategy

The above measures will help to deliver improvements to sustainable travel for journeys within, to, from and through Lincoln. Although the individual contribution to mode shift of each of the above measures may not be significant enough to make a large change in forecast traffic levels, together they should bring a reduction in private car-based travel.

Whilst no assessment has been made of the individual impact that the measures may make, two Do-Something model sensitivity test scenarios have been developed

to assess what impact the potential combined implementation of the measures could have.

Two scenarios have been developed based on reductions in peak hour vehicle journeys brought about by the implementation of LITS and other improvements and different percentage discounts to vehicular journeys have been applied. The following assumptions have been made in developing these two scenarios:

- The measures contained in LITS are predominantly focussed on the urban area of Lincoln, therefore, mode shift discounts have only been applied to journeys wholly within the urban area.

- It is assumed that sustainable travel measures will be implemented as part of the proposed housing developments, particularly in the SUEs, therefore, higher discounts have been applied to journeys starting or finishing in the new housing developments than existing residential areas. The Local Plan will have policies aimed at ensuring that the SUEs in particular provide for sustainable transport.

The following table provides a summary of the scenarios used to model the above mode shift variables.

Table 6-1 – Do-Som Mode Shift Improvement Scenarios

Scenario	Option	Short Title
15	Mode shift – 5% discount for existing trips between origins and destinations within the Lincoln urban area and 10% for new trips (i.e. generated by new developments) between origins and destinations within the Lincoln urban area. Mode shift discounts are not applied to trips with an origin or destination outside the Lincoln urban area.	Mode Shift 1
16	Mode shift – 2.5% discount for existing trips between origins and destinations within the Lincoln urban area and 5% for new trips (i.e. generated by new developments) between origins and destinations within the Lincoln urban area. Mode shift discounts are not applied to trips with an origin or destination outside the Lincoln urban area.	Mode Shift 2
19	Mode Shift 1 with Lincoln Southern Bypass Full Dual-Carriageway Scheme	Mode Shift 1 with LSB Full Dual
20	Mode Shift 1 with Do-Maximum	Mode Shift 1 with Do-Max

The percentage discounts identified above are typical of those requested by highways authorities, including Lincolnshire County Council, as part of negotiations with developers.

Commuting journeys account for a large proportion of trips during peak hours. The following table presents data from the 2011 Census showing the percentage of commuting journeys made by different modes. In the table, Lincoln is compared to similar cities for which equivalent information was available. As can be clearly seen in the table, Lincoln appears broadly in the middle in terms of the percentage of

people who drive to work. The cities of Cambridge and Oxford have, proportionately, significantly less driving to work, while others have somewhat higher rates.

Table 6-2 – 2011 Census Travel to Work Statistics – Lincoln and Similar Cities

City	Pop.	Train	Bus	Motor-cycle	Car – Driver	Car – Passgr	Pedal Cycle	On Foot	Other
Cambridge	55,581	5.2%	6.9%	0.9%	33.8%	3.0%	31.9%	16.9%	1.2%
Oxford	65,507	2.7%	17.4%	0.7%	36.2%	3.4%	18.7%	19.3%	1.4%
Norwich	59,894	1.3%	8.4%	1.2%	48.1%	5.4%	9.3%	24.9%	1.4%
York	93,696	2.7%	7.6%	1.0%	51.1%	4.9%	12.1%	19.5%	1.1%
Lincoln	43,108	0.8%	5.7%	1.1%	56.7%	7.8%	6.3%	20.3%	1.3%
Ipswich	63,263	2.6%	8.0%	1.1%	58.0%	7.2%	4.9%	17.3%	1.0%
Cheltenham	55,669	1.6%	6.0%	0.8%	59.1%	5.1%	7.0%	19.5%	0.9%
Lancaster	59,444	2.2%	6.4%	0.9%	62.2%	6.6%	4.3%	16.0%	1.5%
Gloucester	59,366	0.7%	7.7%	1.1%	66.6%	6.1%	5.2%	11.7%	0.8%

Source: 2011 Census

A 10% shift away from car 'driver' trips to work in Lincoln from new developments would equate to a 5.7 percentage point reduction (i.e. 10% of the 56.7% of commuters who currently drive to work); this is less than the difference in car driver levels between Lincoln and Norwich. The delivery of LITS schemes could help to achieve this as could the implementation of robust sustainable travel policies and infrastructure by those new developments, including the Sustainable Urban Extensions (SUEs).

The Access LN6 project, which has now been expanded to cover the whole of Lincoln (Access Lincoln) focussed on securing mode shift in one area of the city through both infrastructure provision and travel planning policies and support. The scheme has had significant success, including securing a 72% increase in passenger journeys on some bus services, patronage from Hykeham Station doubling and the estimated number of cyclists in the LN6 area also doubling during the course of the project. If such significant increases in travel by non-car modes were to be replicated for the new developments forecast in the emerging Local Plan, significant support would be given to delivering the mode shift percentages used in this sensitivity test.

It should be noted that the larger discounts used in the sensitivity testing apply only to new developments, which have the greater opportunities to achieve mode shift through the easier delivery of new infrastructure and the ability to influence new journeys as people move into the developments (rather than trying to change embedded travel patterns).

6.3 Modelling Results

The results for the mode shift modelling are presented through analysis of a number of different outputs from the model.

- **Link capacity**

  For each Do-Minimum forecast year and associated AM and PM peak hour, figures show the ratio of traffic volume to the capacity of each link in the highway network (a link is a section of road between two junctions).

- **Junction capacity**

  For each Do-Minimum forecast year and associated AM and PM peak hour, figures show junctions which have delays on at least one turning movement of up to two minutes or more.

- **Journey times**

  Eight indicative journeys to, from and past Lincoln have been identified to provide an understanding of the impact of traffic growth on typical local and strategic journeys that drivers will make in each of the Do-Minimum years.

6.4 Link Capacity

This section reviews the outputs from the Do-Something scenario modelling in terms of the effects of growth of link capacity; links being the sections of road between two junctions. The outputs from the modelling are presented in both tabular and map-based formats.

6.4.1 Vehicle Hours

The following tables show that mode shift would generate some decreases in links operating at or over capacity, however, some of the capacity improvements, shown in Section 5, would have substantially greater impacts. The addition of mode shift to the Do-Max option show significant benefits; in terms of vehicle hours on links over 85% of capacity, the Do-Max with Mode Shift 1 option significantly outperforms the 2031 Do-Minimum scenario in the AM peak and outperforms the 2026 Do-Minimum scenario in the PM peak.

Table 6-3 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Som 15 & 16 – 2036 – AM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	4,498	610	276	58	334	5,442
-	Do-Minimum 2031	5,631	973	597	274	871	7,475
-	Do-Minimum 2036	6,085	801	1,082	414	1,496	8,382
15	Mode Shift 1	6,080	640	995	367	1,362	8,082
16	Mode Shift 2	6,165	677	1,063	370	1,433	8,275
18	MS1 + LSB Full Dual	6,070	928	734	217	951	7,949
19	MS1 + Do-Max	6,350	536	527	204	731	7,617

Table 6-4 –Distribution of Vehicle Hours 2018 to 2036 – Do-Som 15 & 16 – Summary – AM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	82.7%	11.2%	5.1%	1.1%	6.1%	100.0%
-	Do-Minimum 2031	75.3%	13.0%	8.0%	3.7%	11.7%	100.0%
-	Do-Minimum 2036	72.6%	9.6%	12.9%	4.9%	17.8%	100.0%
15	Mode Shift 1	75.2%	7.9%	12.3%	4.5%	16.9%	100.0%
16	Mode Shift 2	74.5%	8.2%	12.8%	4.5%	17.3%	100.0%
18	MS1 + LSB Full Dual	76.4%	11.7%	9.2%	2.7%	12.0%	100.0%
19	MS1 + Do-Max	83.4%	7.0%	6.9%	2.7%	9.6%	100.0%

Table 6-5 – Vehicle Hours by Link Speed and Percentage of Capacity – Do-Som 15 & 16 – 2036 – PM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	4,956	733	284	183	467	6,156
-	Do-Minimum 2031	5,770	1,154	836	333	1,169	8,093
-	Do-Minimum 2036	6,099	1,301	887	620	1,507	8,907
15	Mode Shift 1	6,050	1,229	940	448	1,338	8,667
16	Mode Shift 2	6,091	1,256	951	488	1,439	8,786
19	MS1 + LSB Full Dual	6,072	1,111	683	421	1,103	8,287
20	MS1 + Do-Max	6,682	715	437	304	741	8,078

Table 6-6 –Distribution of Vehicle Hours 2018 to 2036 – Do-Som 15 & 16 – Summary – PM

Scenario	Short Title	Percentage of Capacity					
		<70	70-85	85-100	>100	>85	Total
-	Do-Minimum 2018	80.5%	11.9%	4.6%	3.0%	7.6%	100.0%
-	Do-Minimum 2031	71.3%	14.3%	10.3%	4.1%	14.4%	100.0%
-	Do-Minimum 2036	68.5%	14.6%	10.0%	7.0%	16.9%	100.0%
15	Mode Shift 1	69.8%	14.2%	10.8%	5.2%	15.4%	100.0%
16	Mode Shift 2	69.3%	14.3%	10.8%	5.6%	16.4%	100.0%
19	MS1 + LSB Full Dual	73.3%	13.4%	8.2%	5.1%	13.3%	100.0%
20	MS1 + Do-Max	82.7%	8.9%	5.4%	3.8%	9.2%	100.0%

6.4.2 *Ratio of Flow to Capacity*

The following figures present the ratios of traffic volumes to link capacities and are a visual representation of the above tables. The colour shading highlights the ratios with green being under 50% of capacity and red being over 85% of capacity. The figures also show the modelled 'actual' flows on each link.

The four figures below present the information for the AM and PM peak hour 2036 Do-Minimum and Do-Something 15 (Mode Shift 1) and 20 (Mode Shift 1 with Do-Maximum).

As can be clearly seen by comparing the figures, the mode shift by itself does not generate significant decreases in the ratio of traffic volumes to link capacities in either of the peak hours modelled. However, the addition of the higher level of mode shift to the Do-Maximum option shows further additional benefits over the Do-Maximum option alone.

Figure 6-1 – Link Volume to Capacity Ratio – Do-Min – 2036 – AM

Figure 6-2 – Link Volume to Capacity Ratio – Do-Som 15: Mode Shift 1 – 2036 – AM

Figure 6-3 – Link Volume to Capacity Ratio – Do-Som 20: Mode Shift 1 plus Do-Max – 2036 – AM

Figure 6-4 – Link Volume to Capacity Ratio – Do-Min – 2036 – PM

Figure 6-5 – Link Volume to Capacity Ratio – Do-Som 15: Mode Shift 1 – 2036 – PM

Figure 6-6 – Link Volume to Capacity Ratio – Do-Som 20: Mode Shift 1 plus Do-Max – 2036 – PM

6.5 Junction Capacity

The following figures identify junctions where the model indicates that at least one of the turning movements experiences delay of up to two minutes or more. The figures show these junctions for the 2036 Do-Minimum scenarios and the two Do-Something Mode Shift scenarios for both the AM and PM peak hours.

A review of the figures shows that in most cases the reduction in traffic brought about by mode shift does not have a significant impact on the majority of junctions i.e. reducing traffic sufficiently to cause delays to drop into a lower range of delay e.g. from 4 to 5 minutes range to the 3 to 4 minutes range. In some cases delays increase at junctions and this could be related to some junctions performing better due to lower traffic which in turn generates higher flows reaching down-stream junctions and therefore causing greater delays at those down-stream junctions.

Figure 6-7 – Junctions with Turning Movement Delays – Do-Min – 2036 – AM

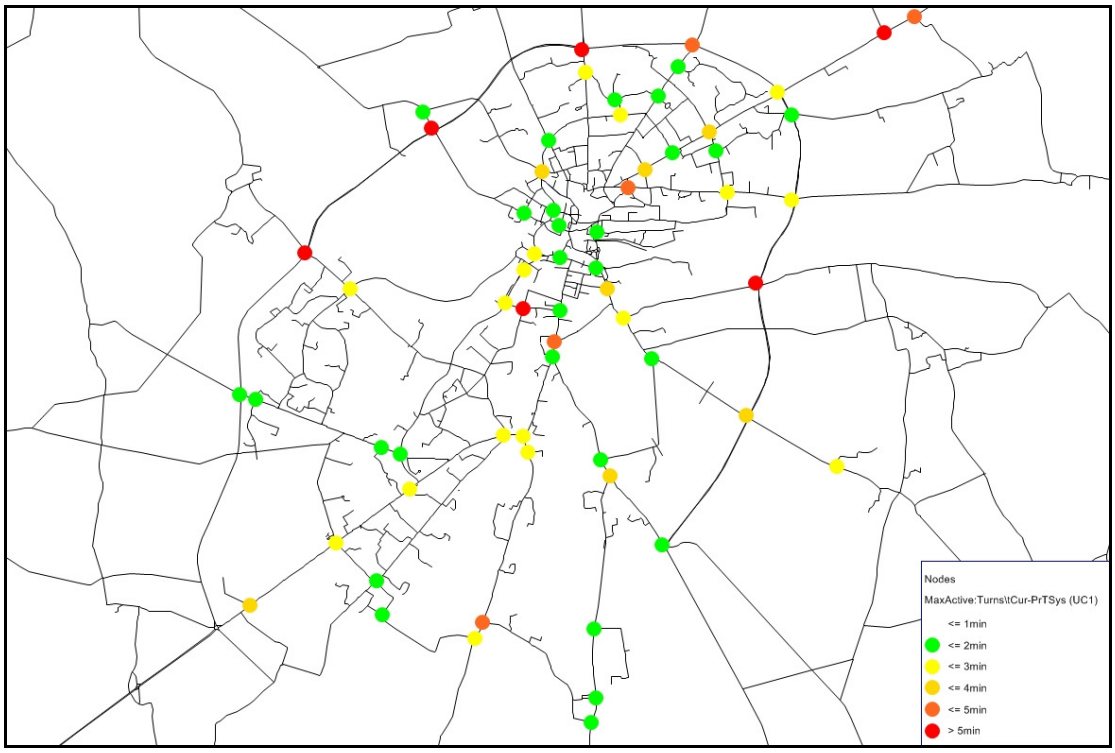


Figure 6-8 – Junctions with Turning Movement Delays – Do-Som 15: Mode Shift 1 – 2036 – AM

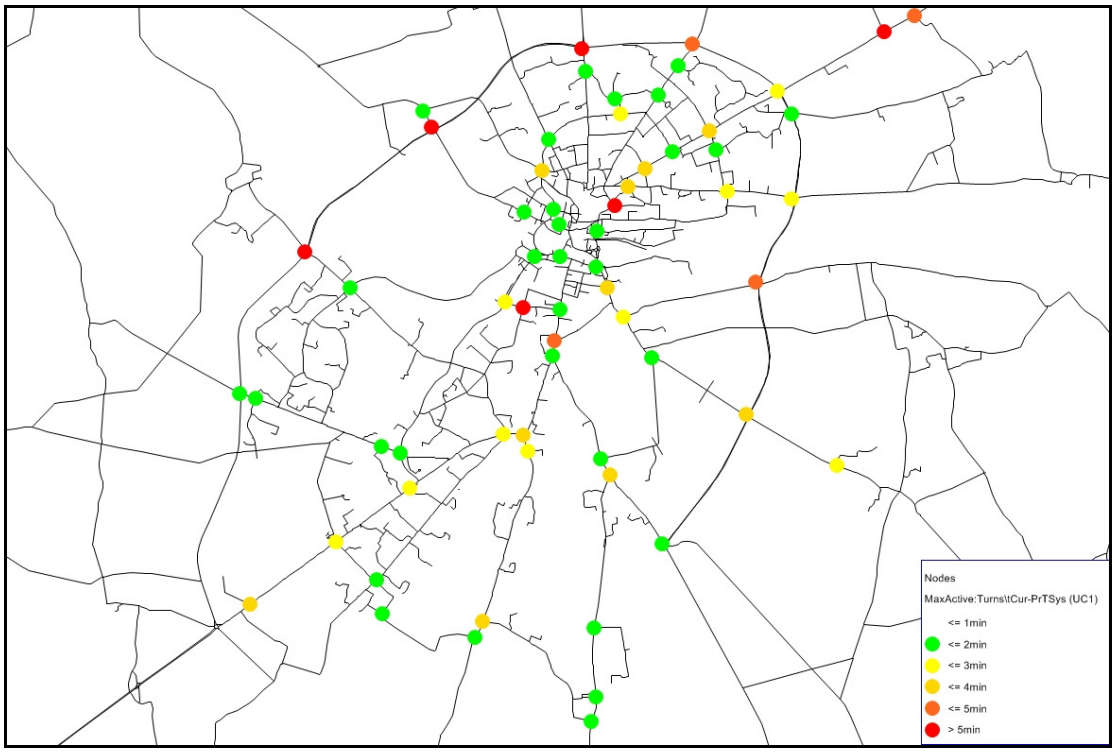


Figure 6-9 – Junctions with Turning Movement Delays – Do-Min – 2036 – PM

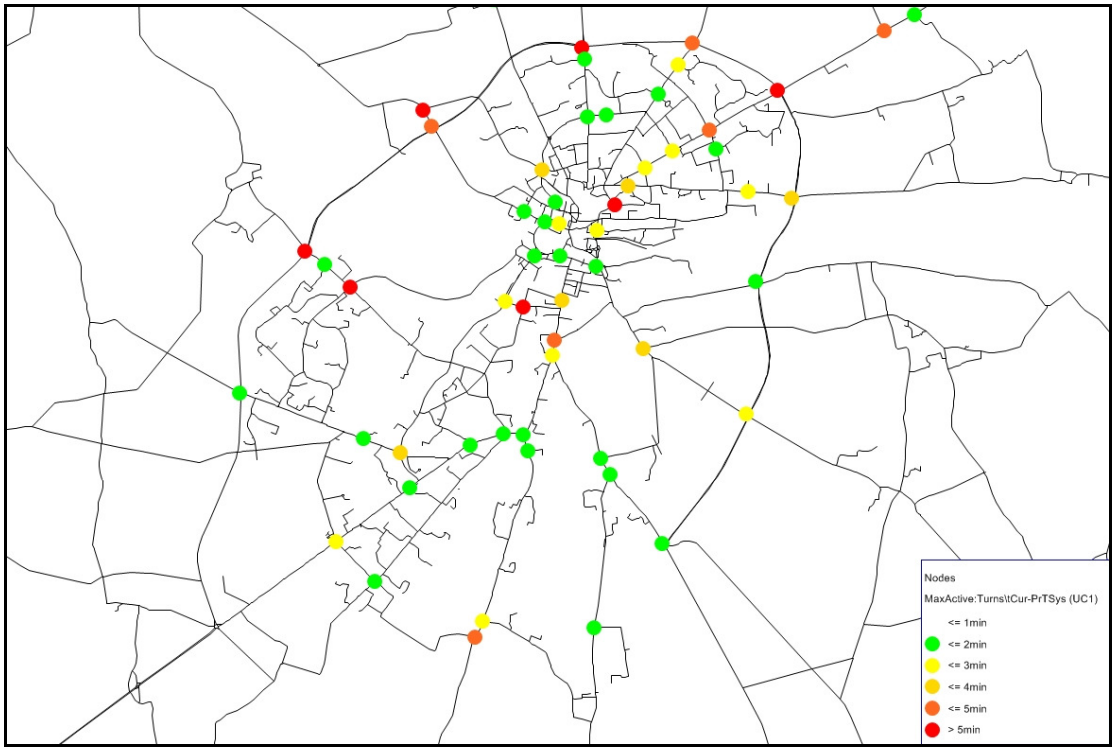
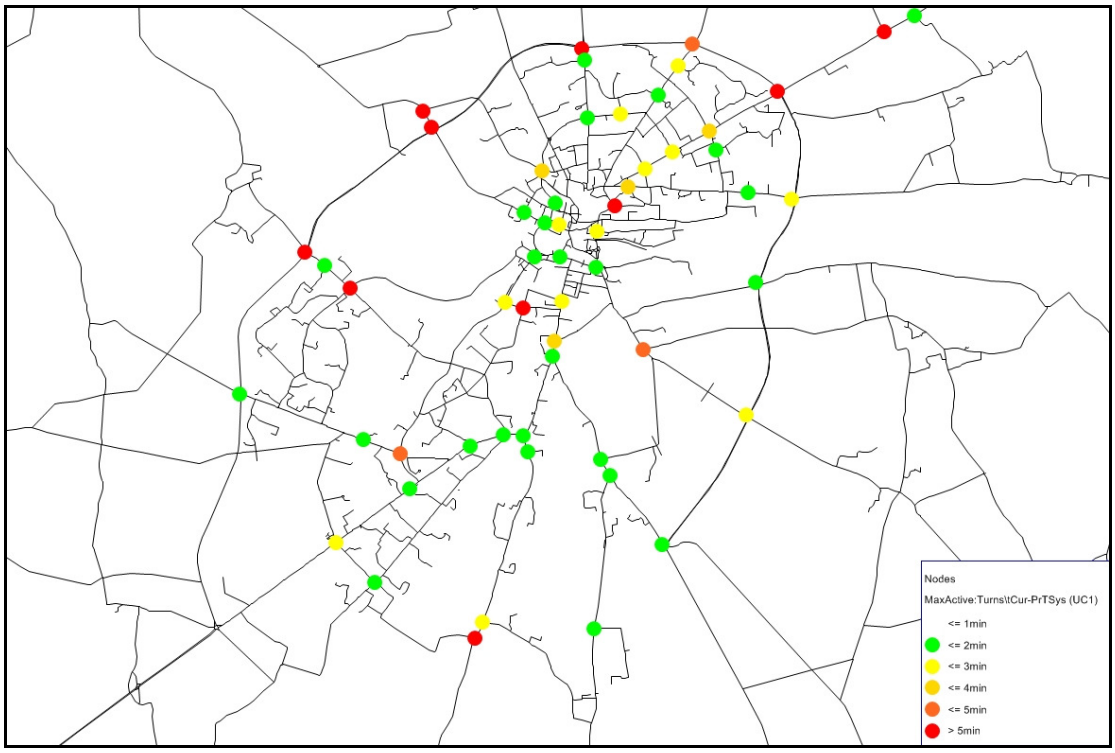


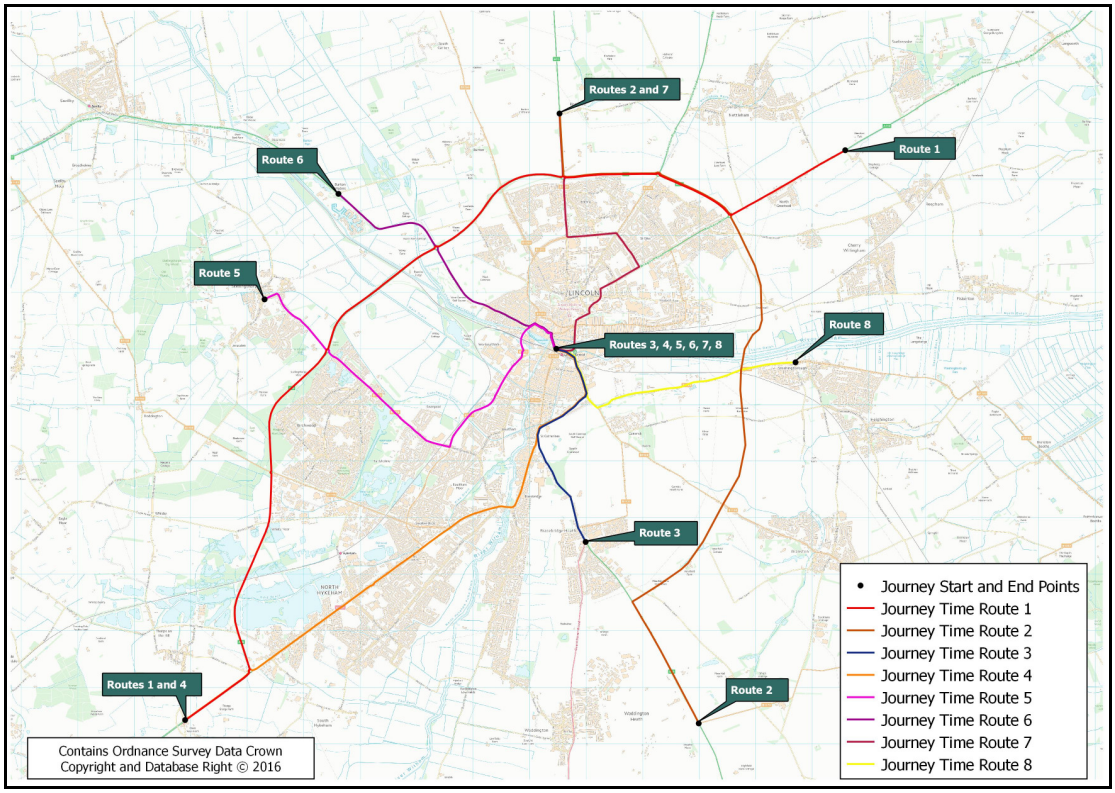
Figure 6-10 – Junctions with Turning Movement Delays – Do-Som 15: Mode Shift 1 – 2036 – PM



6.6 Journey times

The Do-Something journeys times have been calculated for the eight routes, with the map repeated below for ease of reference.

Figure 6-11 – Journey Time Routes 1 to 4



As would be expected, the journeys times on a number of the routes decrease to reflect the reduction in overall trips on the network (increased journey times are highlighted in red text and grey shading while changes of 5% or more are highlighted in bold). However, this is not the case on many of the routes and whilst this may appear counter-intuitive, there may be good reasons for this. Broadly, options 19 and 20, which combine infrastructure and mode shift perform better than mode shift alone, but not uniformly so.

On an uncongested network and with a uniform discount applied to take account of mode shift it is more likely that a uniform decrease in journey times would occur. However, the Lincoln highway network is congested and the discount has not been applied uniformly. The discount has only been applied for existing trips wholly within the urban area of Lincoln and to trips from new developments, also wholly within the urban area of Lincoln. Within the model, this may lead to a rebalancing of flows with, for example, traffic to and from the urban area being less constrained, due to the lower level of traffic wholly within Lincoln, and therefore affecting junctions differently. In effect, one of the results of modal shift may be traffic reassigning to take advantage of newly released capacity and perversely causing additional delays at some locations.

Table 6-7 – Selected Journey Times (MM:SS) – Do-Som Options 15, 16, 19 and 20 – AM

Route		Length	Path	2018 DM	2031 DM	2036 DM	15	16	19	20
1	A46 – A158 via LWRR/LNRR	11.3 mile (18.1km)	Northbound	25:18	32:03	32:46	**34:24**	32:33	33:25	32:45
			Southbound	27:42	41:55	45:03	44:39	44:57	**39:15**	43:52
2	A15 – A15 via LEB	9.6 miles (15.4km)	Northbound	16:08	22:54	28:04	26:48	27:34	27:42	28:39
			Southbound	21:28	28:21	30:34	30:55	30:17	31:17	30:39
3	Bracebridge Heath – City Centre	2.8 miles (4.5km)	Northbound	08:49	10:22	10:58	10:32	10:40	10:59	**12:46**
			Southbound	09:08	14:28	17:21	17:02	17:11	17:13	16:52
4	A46/A1434 – City Centre	6.8 miles (10.9km)	Northbound	31:39	36:22	36:42	35:44	36:20	**32:01**	**33:42**
			Southbound	24:59	33:46	38:04	37:30	37:54	**36:04**	**34:48**
5	Skellingthorpe – City Centre	5.3 miles (8.5km)	Eastbound	29:18	26:59	27:50	27:41	27:32	27:41	**25:09**
			Westbound	20:22	24:07	25:12	25:00	25:04	25:13	**19:42**
6	Burton Waters – City Centre	4.5 miles (7.2km)	Eastbound	12:54	15:40	15:16	**16:02**	15:05	**16:10**	14:57
			Westbound	09:09	12:18	13:30	13:58	13:30	**11:35**	**10:24**
7	Riseholme – City Centre	3.9 miles (8.2km)	Southbound	22:22	27:16	29:17	29:26	28:52	**30:48**	**30:57**
			Northbound	12:27	14:44	17:13	16:29	16:47	**15:45**	**14:55**
8	Washingborough – City Centre	3.3 miles (5.3km)	Westbound	10:32	18:34	20:07	**19:03**	19:36	**18:34**	20:52
			Eastbound	08:38	13:36	16:17	15:56	16:11	16:39	16:27

Table 6-8 – Selected Journey Times (MM:SS) – Do-Som Options 15, 16, 19 and 20 – PM

Route		Length	Path	2018 DM	2031 DM	2036 DM	15	16	19	20
1	A46 – A158 via LWRR/LNRR	11.3 mile (18.1km)	Northbound	35:58	37:13	36:39	37:05	**39:22**	34:52	**33:58**
			Southbound	29:53	43:43	43:27	**47:16**	**49:17**	45:23	42:56
2	A15 – A15 via LEB	9.6 miles (15.4km)	Northbound	19:48	29:23	32:56	32:29	33:22	**29:57**	**30:11**
			Southbound	19:54	24:08	27:37	**25:10**	26:24	27:18	26:43
3	Bracebridge Heath – City Centre	2.8 miles (4.5km)	Northbound	08:41	10:25	15:29	**12:29**	**14:35**	**17:39**	14:57
			Southbound	12:49	17:08	17:16	**15:59**	17:12	17:42	18:02
4	A46/A1434 – City Centre	6.8 miles (10.9km)	Northbound	27:44	30:52	35:12	**32:16**	34:29	**32:58**	**30:11**
			Southbound	32:57	36:48	36:20	35:03	36:21	**34:04**	**33:42**
5	Skellingthorpe – City Centre	5.3 miles (8.5km)	Eastbound	19:48	18:46	19:56	**21:29**	20:22	**17:58**	19:22
			Westbound	27:41	27:52	25:03	26:00	25:30	25:36	24:41
6	Burton Waters – City Centre	4.5 miles (7.2km)	Eastbound	09:51	13:12	16:25	16:57	**13:24**	**12:14**	**14:24**
			Westbound	19:06	23:15	20:21	**22:18**	**22:33**	20:36	**21:42**
7	Riseholme – City Centre	3.9 miles (8.2km)	Southbound	19:46	24:09	26:24	26:54	27:21	26:14	26:25
			Northbound	21:55	24:00	24:08	23:42	**25:52**	23:56	**22:35**
8	Washingborough – City Centre	3.3 miles (5.3km)	Westbound	07:41	09:07	13:16	**11:11**	12:31	**11:47**	**09:45**
			Eastbound	13:12	17:02	16:46	**15:36**	16:44	**17:43**	**18:18**

6.7 Summary

The sensitivity testing in this section has made assumptions on some significant reductions in vehicular trip generation for journeys purely within the urban area of Lincoln, i.e. those most likely to be affected by improvements to sustainable modes of transport. However, the assumptions and analysis has revealed that while improvements that generate this level of mode shift will bring congestion benefits, either higher levels of modes shift or combinations of mode shift and highway capacity improvements would be required to substantially mitigate the traffic growth to be generated over the coming plan period.

It should be noted that the analysis in this section has not identified individual sustainable travel initiatives or their potential to mode shift away from private car travel but identifies what would happen to traffic if such measures were able to achieve different levels of mode shift.

7 Traffic Growth and Responses

7.1 Introduction

The outputs of the LLPT Lower Tier Model show the greatest level of traffic impacts that could be expected given the identified planned growth in housing, employment and other generators of trips, based on the 'Core Scenario' (discussed in Section 2). In all cases, conservative approaches to predictions of traffic growth have been taken, and the model therefore presents a 'worst-case' scenario. However, there are many factors which could, in practice, limit traffic growth to a level below that predicted by the model, and not related to simply reducing the amount of development. These factors in most cases cannot be quantified accurately (and hence no attempt has been to do so in the modelling), but their effects should be considered by policymakers. This section discusses these factors in more detail.

Three broad categories of factors which could in practice limit traffic growth to a level below that predicted by the model are considered:

- Factors which lead to a lower level of vehicle trip growth than forecast
- Demand responses – that is, changes in trip patterns as a result of increased traffic
- Policy responses – actions by policymakers which may have the effect of limiting traffic growth below the level predicted by the model

These are discussed in more detail below.

7.2 Vehicle Trip Growth

7.2.1 Growth in Housing and Employment in the Plan Period

In order to model trip growth across Central Lincolnshire, assumptions had to be made about the level of growth in housing and employment that would take place across the plan period. These assumptions were based upon information supplied from the four Lincolnshire Local Plan teams (Central Lincolnshire, South east Lincolnshire, East Lindsey and South Kesteven) in spring 2015, together with information from adopted and emerging planning documents from the authorities surrounding Lincolnshire. These assumptions are set out in full in the LLPT Upper Tier Tool report and summarised in Section 2 of this report.

The information supplied by the four local plan teams reflected the best information available at the time. However, the authorities were at differing stages in the production of their Local Plans, and there was some uncertainty over the targets for housing and job growth that would be put into Local Plans. Where uncertainty existed, in order to take a conservative but robust approach, the higher level of planned growth was assumed.

Focusing on Central Lincolnshire, at the time the Upper Tier Tool was created, the information provided by the Joint Local Plan Team was that targets for housing and job growth in the period 2011-2036 were likely to be 45,000 dwellings and 17,090 jobs (1,800 dwellings per year and 684 jobs per year). Subsequently, the Central Lincolnshire JPU has published the Further Draft Local Plan, which contains slightly lower target figures for housing and job growth: 36,960 dwellings and 11,894 jobs for the 2012-2036 period (1,540 dwellings per year and 496 jobs per year). If the 2036 figure reflects these new, lower figures, the level of vehicle trip growth will of course be lower.

Moreover, there are other growth forecasts (from DCLG household projections and TEMPRO) which predict a lower level of growth across Central Lincolnshire (and across Lincolnshire as a whole) than that provided by the planning authorities. These are set out in the table below along with the growth contained in the LLPT Core Strategy.

Table 7-1 – Forecasts of Household Growth 2014-2036 (Core Strategy

Local Plan	District	TEMPRO	DCLG HH Projections	LPA/JPU
East Lindsey		**2,994**	**8,949**	**13,333**
Central Lincolnshire	City of Lincoln	15,845	5,391	10,106
	North Kesteven	14,430	8,781	21,344
	West Lindsey	3,431	6,158	10,994
	Total	**33,706**	**20,330**	**42,444**
South East Lincolnshire	Boston	1,031	5,918	8,677
	South Holland	9,845	9,202	13,434
	Total	**10,876**	**15,120**	**22,111**
South Kesteven		**17,303**	**11,661**	**15,316**
Total		**64,878**	**56,060**	**93,205**

It should be emphasised that the figures supplied by the LPAs are targets, and as such there is a level of uncertainty attached to them; it may be that the level of growth ultimately delivered by 2036 falls short of these targets. The targets are nevertheless the best information that is available for the level of planned growth that is expected, and that in order to take a conservative approach, it is appropriate to use these figures as inputs to the model, but the level of uncertainty around planned growth should be recognised.

7.2.2 *Changing Household and Demographic Structures*

In order to take a conservative and robust approach to predicting traffic growth, it has been assumed that the pattern of trips per household remains constant in the future and consistent with those currently occurring. However, there are reasons to suggest that in future, changing household and demographic structures may result in a lower level of trips per household.

The first factor to consider is the potential for household sizes to decrease. The following table shows projected average household sizes for the authorities in Lincolnshire:

Table 7-2 – Projected Change in Average Household Size in Lincolnshire, 2012-2037

Planning Unit	District	2012	2017	2022	2027	2032	2037	Change (2012-2037)
Central Lincolnshire	City of Lincoln	2.22	2.20	2.17	2.16	2.14	2.12	-0.10
	North Kesteven	2.30	2.28	2.27	2.26	2.23	2.21	-0.09
	West Lindsey	2.28	2.26	2.24	2.23	2.20	2.18	-0.10
East Lindsey		2.19	2.17	2.16	2.15	2.12	2.10	-0.09
South East Lincolnshire	Boston	2.33	2.33	2.31	2.29	2.26	2.24	-0.09
	South Holland	2.34	2.32	2.30	2.27	2.24	2.22	-0.12
South Kesteven		2.30	2.27	2.25	2.23	2.21	2.19	-0.11
Lincolnshire		**2.27**	**2.25**	**2.24**	**2.22**	**2.20**	**2.17**	**-0.10**

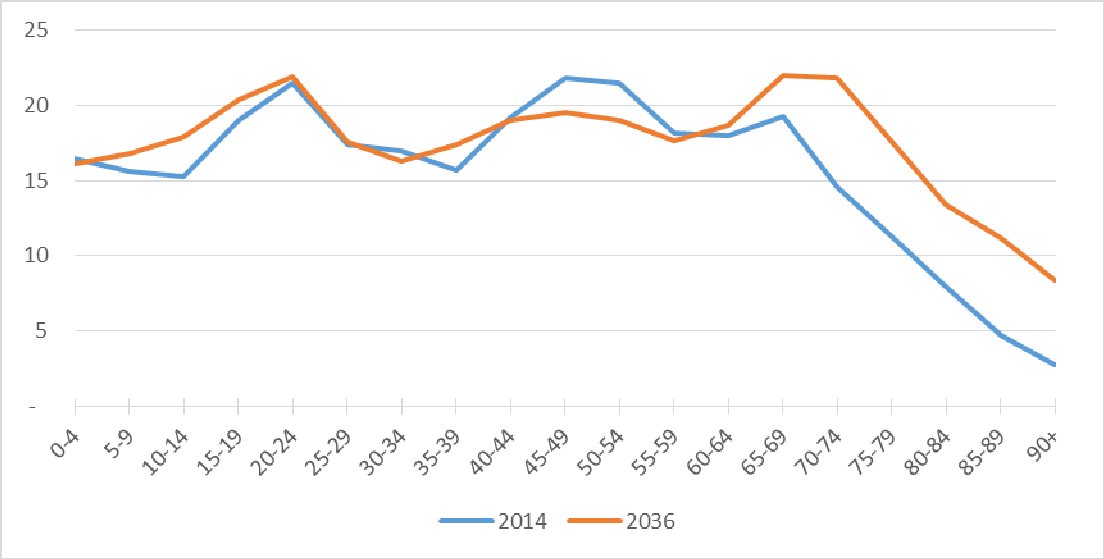
Source: 2012-based Household Projections (Published February 2015), DCLG

Note: forecasts provided in five year intervals from 2012, therefore, LLPT forecast year of 2036 is not available.

The data in the table above clearly indicate forecasts for average household sizes to become slightly smaller over the period to 2037. The nature of the relationship between household size and associated vehicle trips is subject to many factors (such as age structure of the household, number of drivers within a home, and tendency to share vehicle journeys), but a reduction in average household size could lead to lower numbers of vehicle trips per household – and therefore a lower level of growth in traffic than the forecasts used in the model.

Secondly, no allowance is made in the model for changes in trip rates resulting from changing demographic structures. The figure below shows projected changes to the population and age structure of Central Lincolnshire.

Figure 7-1 – Population ('000s) of Central Lincolnshire by Age Group



Source: 2012-based Sub-national Population Projections for Local Authorities in England (published 2014), ONS

It can be seen in the figure above that the bulk of the population growth from 2014-2036 will be in that part of the population aged 60 and above, and, to a lesser extent, 24 and below. Conversely, there is forecast to be a small decrease in the population aged 25-59. The impact of changing age structures on travel patterns is difficult to quantify precisely, and factors such as average retirement ages may well be different in 20 years' time. Nevertheless, in general terms, it can be seen that the much of the population growth is likely to be made up of those parts of the population that have either not yet entered the work force or have retired (and who may be too young to drive or have given up driving). The impact of the growth in population (and by implication in growth in housing) on future levels of traffic – and, in particular, on future levels of peak hour traffic – may again therefore be less than those forecast by the model.

7.2.3 Mode Choice

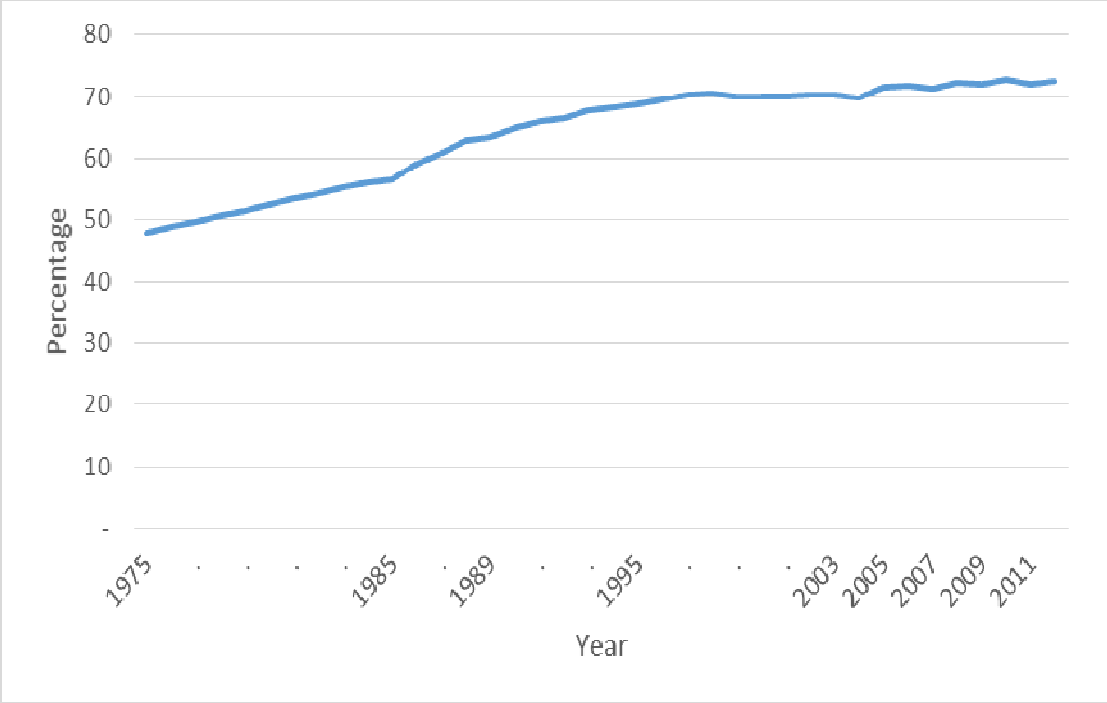
In constructing the model, it has been assumed that mode share (i.e. the proportion of journeys made by private car, as well as other modes of transport) will remain constant. However, there are several reasons to expect that in future, mode share will to some extent shift away from the private car.

Firstly, with Greater Lincoln expected to grow significantly, travel patterns can be expected to change to those more typical of a larger city, with the increased offer (e.g. shops and services) available in Greater Lincoln leading to shorter average trips as the need to travel to larger centres is reduced. Secondly, through the Lincoln Integrated Transport Strategy (discussed in more detail below) and the Local Plan process, LCC is putting in place the policies and investment to further support mode shift away from the private car. Finally, as congestion increases, some element of behavioural change can be expected, as private car becomes a relatively

less attractive mode. All these factors could be expected to limit the projected rise in traffic levels.

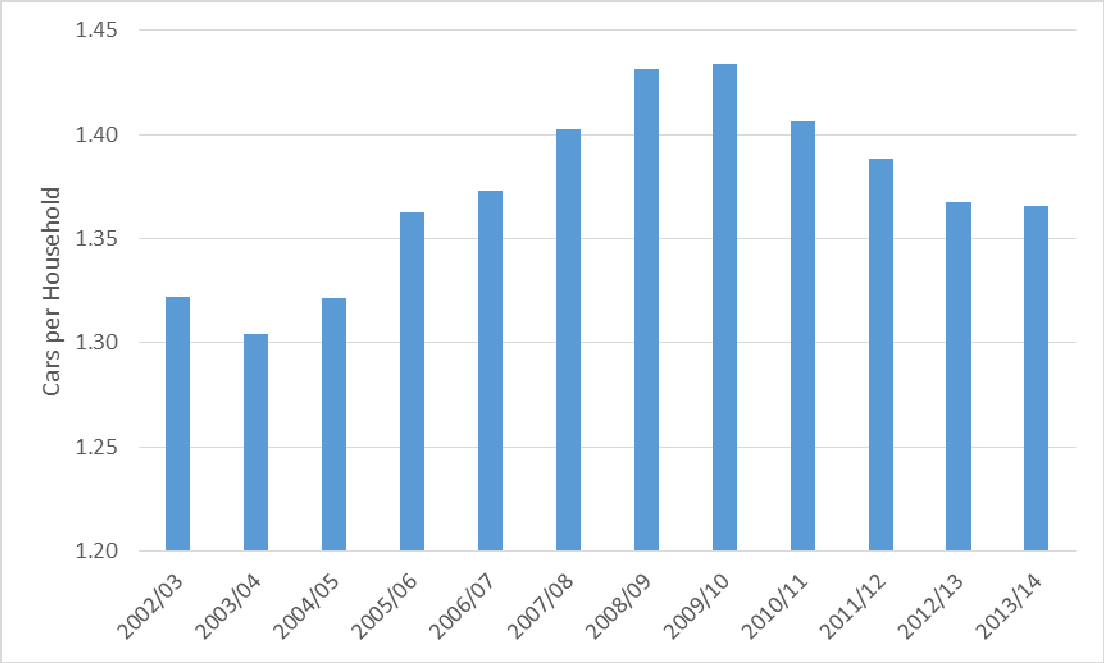
Furthermore, it should be borne in mind that the projection of previous traffic growth forward in the model is based on proportions of drivers and of car owners within the total population continuing to increase. However, while growth in population will continue to account for increases in number of vehicles, there is some evidence to suggest that the proportions of the population who drive may have started to saturate, especially in rural areas. The graphs below illustrate these points. If saturation is being reached, this could result in fewer cars in the forecast year than is predicted by the model.

Figure 7-2 – Percentage of the Population aged 17+ with a Driving License (England)



Source: Department for Transport Vehicle Statistics (published 2015)

Figure 7-3 – Cars/Vans per Household, Rural Towns and Fringe, 2002-2014



Source: Department for Transport Vehicle Statistics (published 2015)

7.2.4 *Relationship between Economic Growth and Travel Demand*

In the development of the model, it has been assumed that travel demand – and hence traffic – will grow in relation to economic growth. However, although in the past these two factors have been related, this will not necessarily be the case in the future. Growth in telecommuting may result in economic growth being possible without a corresponding increase in traffic levels. Similarly, more efficient logistics patterns, making better use of data and technology, could result in a greater number of deliveries in the same number of trips, again de-coupling the link between economic growth and trip growth. These changes can be supported by policy initiatives to manage the demand for travel. There is therefore the potential to see economic growth without necessarily seeing an associated growth in vehicle trips.

7.3 Demand Responses

The LLPT lower tier model takes into account the way in which drivers respond to congestion by finding alternative routes, if these would be quicker (although it should be noted that the upper tier tool does not). However, the model does not take into account other behavioural change. It is likely that an increase in congestion would lead to a degree of behavioural change amongst drivers which would limit growth in traffic below that predicted by the model.

The morning and evening peaks in Lincolnshire are relatively short. In the event of increased congestion at peak times, it is likely that some drivers would respond by travelling at different times – for example, by starting and finishing work half an hour earlier or later. Clearly this is not an option for those working fixed hours; but many workers have the flexibility to change their working pattern, and many peak hour trips are for discretionary purposes (such as shopping) which can be undertaken at

slightly different times. Experience from elsewhere in the country shows that peak spreading (the lengthening of peak periods) is a common response to increased congestion, mitigating some of the impacts of traffic growth.

Alternatively, increased congestion could lead to drivers choosing alternative modes, or in some circumstances choosing not to travel (for example, by making arrangements to work from home or by choosing to shop online). Again, this will limit the growth in congestion below that forecast by the model.

7.4 Policy Responses

7.4.1 Lincoln Integrated Transport Strategy

The Lincoln Integrated Transport Strategy (LITS) was first published in 2006 and revised in 2008, with the broad aim of providing a vision for improving the infrastructure for users of all modes of transport in the Greater Lincoln area, recognising that a good transport network can provide the conditions to support economic growth and a better environment. LITS takes into account the significant growth in housing and employment expected across the Greater Lincoln area, and sets out some measures to support this growth and mitigate any negative impacts.

When first published, LITS included the following proposals:

- Sustainable Travel Initiatives
- Small Scale Walking/Cycling/Public Transport Schemes
- Quality Bus Corridors
- Real-time Passenger Transport Information
- Public Transport Interchange
- Park & Ride
- Parking Strategy
- Rail Service Improvements
- Lincoln Eastern Bypass
- Traffic Management Measures
- East-West Link (Rope Walk to South Park Avenue)
- City Centre Pedestrian Improvements
- Swanpool Link (now the Western Growth Corridor Link)
- Lincoln Southern Bypass

- Relief Road Improvement

As mentioned previously, a progress review of LITS was undertaken in 2008, and the following measures were added to the Strategy:

- Lincoln Eastern Bypass Dualling
- Coach Parking Facility
- Pinch-Point Schemes
- Access LN6
- Bus Network Review
- Lincoln Cycle Strategy
- Parking Standards

The highway schemes set out in LITS (such as the Lincoln Eastern Bypass) have been incorporated into the model and are therefore accounted for in the outputs of the model. However, many of the other interventions identified in LITS can be expected to have impacts which limit traffic growth to levels below the levels forecast by the model, as shown in the mode shift modelling discussed earlier. These are discussed in more detail below.

Parking Policy
LITS contains plans for a new Park & Ride system and use of this facility could limit the growth in traffic levels within the Lincoln urban area below that projected by the model (though of course could also lead to increases in flows on the links adjacent to the Park & Ride site/s).

Public Transport Measures
LITS contains plans for the implementation of a number of measures to improve public transport for Greater Lincoln, including the provision of further Quality Bus Corridors, bus telematics, the provision of a new transport interchange, and improved rail services. These measures will all serve to make public transport a more attractive option and therefore promote mode shift and limit growth in private vehicle trips below the level forecast by the model.

Sustainable Transport
LITS contains a number of Sustainable Transport measures which could limit the level growth in traffic. These include:

- Car share schemes
- Travel planning for schools, businesses and community groups

- Small scale walking and cycling schemes such as cycle training and provision of cycle lockers

- Lincolnshire Cycle Strategy

Cumulatively, these schemes can be expected to have an impact on limiting the growth of vehicle traffic; with the impacts of these schemes becoming greater as congestion increases (and motivates individual drivers to try other modes or to car share).

7.4.2 Sustainable Urban Extensions

Much of the planned growth in housing in Greater Lincoln is expected to come forward in a number of Sustainable Urban Extensions (the North East Quadrant, South East Quadrant, South West Quadrant and Western Growth Corridor). These developments will be planned in such a way that the need for vehicle trips is minimised as far as possible, with essential services such as schools, public transport and local shops within walking distance of housing; and designed to encourage travel by walking and cycling. This approach is set out in Policy LP29 of the emerging Local Plan, which states that each new urban extension must, inter alia, '*meet balanced transport objectives by encouraging walking, cycling and public transport use, through appropriate infrastructure improvements, and the provision of high quality bus services, bus priority corridors and, where appropriate, park and ride*'. In this way, growth in vehicle trips resulting from new housing on these sites can be reduced.

8 Summary and Conclusions

This report describes that Lower Tier phase of work of the Lincolnshire Local Planning Tool project and focusses on the Greater Lincoln area. Due to the shorter timescales to develop the draft Local Plan for Central Lincolnshire, Lower Tier work for Greater Lincoln has been prioritised and equivalent work for other areas and plans will be undertaken as and when required.

The lower tier modelling is based on the Core Scenario of growth developed in the first, upper tier, phase of the project. Due to the four local plans in Lincolnshire being at different stages of development, worst case (in a traffic growth sense) high growth development quantities, for both housing and employment, have been assumed for each local plan area in the Core Scenario. The traffic growth forecasts resulting from the upper tier phase are therefore robust but likely to be higher than the growth result from the four local plans when they are formally adopted.

The Core Scenario includes growth across the four Lincolnshire Local Plan areas amounting to increases in housing of 30% and employment of 13.2%. In the Lincoln area, this level of development is forecast to generate increases in peak hour traffic of 3% by 2021, 12% by 2026, up to 20% in 2031 and up to 28% in 2036.

Overall, the traffic modelling and analysis shows some significant impacts of that level of traffic growth on the operation of the highway network. Whilst some of the highway infrastructure included in the Do-Minimum modelling (e.g. Lincoln Eastern Bypass, East-West Link and the link through the Western Growth Corridor from Skellingthorpe Road to Tritton Road) will generate significant benefits in their own right, they will not alone mitigate some of those significant impacts.

Using the Lincoln Integrated Transport Strategy as a base for identifying mitigation, a number of link capacity improvements have been modelled. These 'Do-Something' options include widening of existing carriageways and the construction of entirely new sections of carriageway. A 'Do-Maximum' scenario has also been modelled, which has used a number of the Do-Something options and combined them into the development of a full, dual-carriageway ring-road of Lincoln, in addition to some more minor schemes.

Of the Do-Something options, the construction of a full Lincoln Southern Bypass, dualled between the A46 and A15, will deliver the greatest benefits of any individual scheme. The Do-Maximum scenario would generate the greatest benefits but this is unlikely to be deliverable during the plan period. This combination of schemes, starting with the Lincoln Southern Bypass could potentially deliver traffic relief sufficient to reduce levels of congestion in 2036 close to projected Do-Minimum levels for 2031.

Modal shift sensitivity testing has been undertaken to assess the potential impact of significant reductions in vehicular trip generation for journeys purely within the urban

area of Lincoln, i.e. those most likely to be affected by improvements to sustainable modes of transport. This analysis has revealed that while improvements that generate mode shift would bring congestion benefits, either higher levels of mode shift or combinations of mode shift and highway capacity improvements would be required to substantially mitigate the traffic growth to be generated over the coming plan period.

As stated above, the level of traffic growth modelled has been based on the LLPT Core Scenario, which represents a worst case. Alongside the likely inclusion in the four local plans of projections for housing and employment growth that are lower than those contained in the Core Scenario, there are a number of reasons why the growth in the AM and PM peak hour traffic identified in this report may be somewhat lower. The application of policy to encourage modal shift away from private cars, changes in household composition and demand responses to increased congestion (such as changes in travel times), may reduce level of impact identified in this report. Notwithstanding the mode shift sensitivity testing undertaken in this report, the traffic modelling undertaken has assumed a static share of travel by car, therefore, the application of robust policies on sustainable transport will reduce the projected level of traffic growth.

The conclusion of this report is that the Lincoln Southern Bypass scheme should be prioritised as part of Central Lincolnshire Local Plan (route protected, including ability for it to be dualled) to provide mitigation of some of the impacts of projected housing and employment growth and resulting impacts on the highway network. This should be implemented alongside robust policies on sustainable transport. The delivery of further elements of additional highway capacity on the existing Lincoln relief roads would provide benefits but are lower priority than Lincoln Southern Bypass.

Further, more detailed analysis is also required on the impacts on traffic growth on key junctions within the highway network, to robustly assess the likely impacts and identify mitigation sufficient to resolve the issues found.

We have used our reasonable endeavours to provide information that is correct and accurate and have discussed above the reasonable conclusions that can be reached on the basis of the information available. Having issued the range of conclusions it is for the client to decide how to proceed with this project.

9 Glossary of Terms

Do-Minimum – the Do-Minimum (Do-Min) scenarios used in traffic modelling relate to the circumstances without the implementation of additional infrastructure schemes or policies to resolve future issues. These scenarios, however, do include infrastructure schemes and policies that are already committed for delivery.

Do-Something – the Do-Something (Do-Som) scenarios used in traffic modelling relate to circumstances similar to the Do-Minimum but with the implementation of additional infrastructure schemes or policies to resolve issues identified through the modelling of the Do-Minimum.

Do-Maximum – in the case of this report, the Do-Maximum (Do-Max) scenarios relate to the implementation of packages of measures that include the most significant version of each individual scheme e.g. the dualled rather than single carriageway versions of schemes.

GLTM – Greater Lincoln Traffic Model – A traffic model of the Lincoln area using the VISUM modelling software package. The GLTM has been used in the lower tier modelling.

LLPT – Lincolnshire Local Plan Tool

LLPT Project – The project to assess the impact of growth predicted in the four Lincolnshire local Plans through the use of an upper tier tool and lower tier traffic model.

Upper Tier – The first of two phases in the LLPT project. This delivered a modelling tool to assess across the whole county the impact of traffic growth on the demand for traffic flows on individual highway links on A and B roads.

Lower Tier – The second of two phases in the LLPT project. This has involved the application of traffic forecasts from the Upper Tier tool to the traffic in the Greater Lincoln Traffic Model.

Link – a section of highway between two junctions.

SUE – Sustainable Urban Extension; in Lincoln these are the North East Quadrant, South East Quadrant, South West Quadrant and Western Growth Corridor.

Vehicle hours – the total duration of all journeys made by vehicles during a modelled time period.