5. Model Outputs and Checks

5.1 Trip Matrix Comparison

Trip totals for the base year and the three forecast years, for all time periods are presented below in Table 5-A for both Do Minimum and Do Something scenarios.

The percentage growth is also given to provide an overall sense check of the levels of growth forecast and applied within models.

Table 5-A: Forecast Car Trip Matrix Totals

Scenario	Base	2022 Forecast	2037 Forecast	2042 Forecast	% Change 2022	% Change 2037	% Change 2042
AM							
DM	430,510	447,243	491,779	508,701	4%	14%	18%
DS	430,510	447,263	491,779	508,738	4%	14%	18%
IP							
DM	302,310	317,222	352,090	364,774	5%	16%	21%
DS	302,310	317,240	352,123	364,811	5%	16%	21%
PM							
DM	481,604	500,147	548,932	566,980	4%	14%	18%
DS	481,604	500,189	548,989	567,038	4%	14%	18%

Appendix B details the total forecast matrices on a sector to sector basis, used in economic assessment. This is important for the economic appraisal of the scheme and is discussed in more detail within the Economic Assessment Report.

5.2 Convergence Statistics

5.2.1 SATURN Convergence

Convergence is the measurement of the stability of the traffic model, whereby the spread (or "distribution") of trips does not vary significantly between iterations and so the model is said to be in "equilibrium". A converged model is therefore stable and produces results that are consistent and robust.

Achieving convergence in the future year forecasts is just as critical as the base year, and is particularly important for economic appraisal purposes.

The acceptability values for convergence (TAG Unit M3.1) are less than 0.1% for %GAP and 4 consecutive iterations where the percentage of links with flow changes less than <1% is greater than 98%.

As demonstrated in Table 5-B and Table 5-C all the forecast models converge to an acceptable level.

Table 5-B: SATURN Assignment Convergence Statistics for Do Minimum Scenarios

Year	Time Period	Iteration	%GAP	% Flow (Link Flows Differing by < 1% Between Assignment & Simulation)	% Delays (Turn Delays Differing by < 1% Between Assignment & Simulation)
2022	AM	22	0.0012	98.2	99.6
		23	0.00062	98.5	99.5
		24	0.0011	98.5	99.6
		25	0.00043	98.8	99.6
	IP	15	0.00014	98.5	99.8
		16	0.0001	98.9	99.8
		17	0.0001	99.4	99.8
		18	0.00017	99.3	99.9
	PM	29	0.0035	98.7	99.3
		30	0.0042	98.5	99.2
		31	0.003	98.5	99.3
		32	0.0029	98.7	99.4
2037	AM	33	0.0017	98.8	99.3
		34	0.0029	98.5	99.4
		35	0.0013	98.3	99.4
		36	0.0023	99.1	99.4
	IP	24	0.00072	98.4	99.6
		25	0.00025	98.1	99.7
		26	0.00037	99.1	99.8
		27	0.00027	99.1	99.7
	PM	44	0.0036	98.4	99.1
		45	0.0042	98.4	98.9
		46	0.0037	98.6	98.9
		47	0.0037	98.7	99
2042	AM	51	0.0031	98.6	99.2
		52	0.0014	98.6	99.3
		53	0.0023	99.3	99.4
		54	0.0014	99.3	99.4
	IP	25	0.00087	98.8	99.5
		26	0.00054	98	99.5
		27	0.00076	98.9	99.5
		28	0.00049	98.3	99.6
	PM	54	0.0044	98.8	98.9
		55	0.0026	98.3	99.3
		56	0.0036	99.4	99.4
		57	0.0023	98.5	99.3

Table 5-C: SATURN Assignment Convergence Statistics for Do Something Scenarios

Year	Time Period	Iteration	%GAP	% Flow (Link Flows Differing by < 1% Between Assignment & Simulation)	% Delays (Turn Delays Differing by < 1% Between Assignment & Simulation)
2022	AM	21	0.00062	98.2	99.7
		22	0.00055	98.4	99.7
		23	0.0004	98.7	99.7
		24	0.0004	99.1	99.7
	IP	12	0.00031	98.4	99.8
		13	0.00021	98.7	99.8
		14	0.00027	98.7	99.9
		15	0.00016	99.1	99.9
	PM	51	0.0027	98.3	99.4
		52	0.0028	98.5	99.3
		53	0.0026	98.7	99.5
		54	0.0032	99	99.4
2037	AM	29	0.00095	98.7	99.5
		30	0.002	98.5	99.3
		31	0.00083	98.1	99.4
		32	0.0012	98.9	99.6
	IP	18	0.00027	98.6	99.7
		19	0.00032	98.8	99.6
		20	0.00037	98.8	99.6
		21	0.0001	98.5	99.8
	PM	46	0.0036	98.4	99.2
		47	0.0049	98.8	99.1
		48	0.0044	98.1	99
		49	0.004	98.7	99.1
2042	AM	33	0.0015	98.3	99.1
		34	0.0013	98.2	99.3
		35	0.0015	98.6	99.1
		36	0.0011	98.2	99.3
	IP	23	0.00048	99.1	99.6
		24	0.00027	98.7	99.7
		25	0.00041	99	99.7
		26	0.00024	99	99.7
	PM	43	0.0041	98.7	99.1
		44	0.0047	98.3	98.9
		45	0.003	98.7	99
		46	0.0053	98.5	98.9

5.2.2 DIADEM Convergence

Based on the lambda and theta parameters derived in the realism tests, the forecast models have been run through DIADEM. In assessing the outputs of the model runs, the main parameter of importance is the 'relative gap', which is the measure of convergence between demand and supply. Current WebTAG guidance recommends a relative gap of at least 0.2%. However, to further increase the robustness of the modelling of the PWD scheme, the DIADEM criterion has been set to achieve a relative gap of 0.145%.

Consequently, the DIADEM models achieved a relative gap convergence level of 0.14% or less in all cases, which suggests the demand - supply convergence of the variable demand traffic model is acceptable. As presented in Table 5-D, it has therefore been shown that the traffic model is stable and has converged to an acceptable standard.

Table 5-D: DIADEM Convergence Statistics

Model Scenario	Measurement	2022 DM	2037 DM	2042 DM	2022 DS	2037 DS	2042 DS
AM	Final Iteration	8	11	12	8	10	9
	%GAP	0.12%	0.12%	0.10%	0.11%	0.12%	0.12%
IP	Final Iteration	8	8	8	8	8	8
	%GAP	0.11%	0.13%	0.13%	0.10%	0.11%	0.10%
PM	Final Iteration	8	23	9	8	12	10
	%GAP	0.13%	0.12%	0.14%	0.12%	0.12%	0.12%

5.3 Highway Traffic Model Performance

Table 5-E below presents high level assignment statistics for forecast years 2022, 2037 and 2042. The statistics have been extracted for the simulation area only of the SATURN model. The results presented are for all vehicle types and journey purposes combined.

Table 5-E: Simulation Area Assignment Statistics

Model Scenario	Measurement	Base	2022 DM	2037 DM	2042 DM	2022 DS	2037 DS	2042 DS
AM	Distance Travelled (PCU km)	1,290,825	1,473,036	1,679,410	1,738,284	1,484,775	1,691,898	1,751,110
	Travel Time (PCU Hrs)	23,889	26,985	32,908	34,815	26,818	32,625	34,484
	Average Speed (Km/Hr)	54	54.6	51	49.9	55.4	51.9	50.8
IP	Distance Travelled (PCU km)	995,327	1,153,312	1,356,563	1,414,535	1,160,557	1,365,930	1,423,992
	Travel Time (PCU Hrs)	17,036	19,402	23,374	24,710	19,315	23,247	24,559
	Average Speed (Km/Hr)	58.4	59.4	58	57.2	60.1	58.8	58
PM	Distance Travelled (PCU km)	1,349,397	1,558,043	1,775,327	1,835,263	1,572,056	1,790,717	1,852,394
	Travel Time (PCU Hrs)	25,394	29,231	35,842	37,957	29,094	35,620	37,717
	Average Speed (Km/Hr)	53.1	53.3	49.5	48.4	54	50.3	49.1

The total travel time is a summation of cruise time, transient queued time (e.g. waiting at a red light at signals) and overcapacity queued time. The total travel distance is summed over full journey lengths for all modelled trips. The average speed is determined based upon the total travel time and total travel distance.

The Do Minimum and Do Something results show a general deterioration in highway conditions over time. Additionally, total travel time is increasing faster than travel distance indicating increasing levels of congestion in all time periods. Reductions in speed are greatest in the AM and PM peak periods. The Do Something scenario which includes the proposed link road mitigation improves the highway conditions.

The introduction of the scheme (Do Something scenario) has the impact of reducing travel times through the area and increasing the distance travelled, resulting in an increase of average vehicle speeds in all time periods in each forecast year.

5.4 Impacts of Variable Demand Modelling

5.4.1 Impact of Variable Demand Modelling – Matrix Total Analysis

Following the completion of the VDM runs, the matrix totals between the pre and post VDM runs were compared to understand the impacts of variable demand responses. Table 5-F presents the comparison of demand for the 2022 DM scenario. The comparisons for all other scenarios, years and time periods are provided in Appendix C.

The comparison of pre and post VDM results indicates that there is induced traffic in Do Minimum UC3 (Other) as a result of VDM. There is also more intra zonal trips and fewer inter zonal trips in all demand segments, indicating that there is induced traffic as a result of VDM.

Table 5-F: Comparison of pre-VDM vs post-VDM Matrices – 2022 Do minimum Scenario

Time Period	UC	Pre VDM - 2022			Post VDM DM - 2022			Difference			% Difference		
		Intra Zonal	Inter Zonal	Grand Total	Intra Zonal	Inter Zonal	Grand Total	Intra Zonal	Inter Zonal	Grand Total	Intra Zonal	Inter Zonal	Grand Total
AM	1	111,978	124,103	236,082	111,882	124,200	236,082	-96	96	0	-0.09%	0.08%	0.00%
	2	14,083	20,659	34,742	14,071	20,670	34,742	-11	11	0	-0.08%	0.06%	0.00%
	3	101,214	74,482	175,696	100,974	75,445	176,419	-240	963	723	-0.24%	1.29%	0.41%
	Total	227,275	219,245	446,520	226,928	220,315	447,243	-347	1,070	723	-0.15%	0.49%	0.16%
IP	1	25,126	28,352	53,478	25,099	28,379	53,478	-27	27	0	-0.11%	0.10%	0.00%
	2	11,949	19,068	31,017	11,937	19,080	31,017	-12	12	0	-0.10%	0.07%	0.00%
	3	123,758	107,935	231,694	123,408	109,320	232,727	-351	1,385	1,034	-0.28%	1.28%	0.45%
	Total	160,834	155,355	316,188	160,443	156,779	317,222	-390	1,424	1,034	-0.24%	0.92%	0.33%
PM	1	98,451	105,391	203,841	98,332	105,509	203,841	-118	118	0	-0.12%	0.11%	0.00%
	2	14,495	20,116	34,611	14,481	20,130	34,611	-14	14	0	-0.10%	0.07%	0.00%
	3	143,531	116,891	260,422	143,141	118,554	261,695	-390	1,663	1,273	-0.27%	1.42%	0.49%
	Total	256,476	242,398	498,874	255,955	244,193	500,147	-522	1,795	1,273	-0.20%	0.74%	0.26%

The trip length distributions (TLD) for the pre and post VDM were also compared in order to further understand the effect of the VDM. Figure 5-1 compares the TLD of the pre and post VDM demand (excluding external to external trips) across all user classes for the AM peak in the 2022 Do Minimum scenario. The green and blue represent pre-VDM and post-VDM, respectively.

The post-VDM bars are lower than the pre-VDM bars for the distance travelled of up to 10mile, after which the opposite pattern occurs. From 10mile band onwards, the proportion of post-VDM trips travelling longer distance becomes higher than the pre-VDM trip proportions.

It should be noted that TLD comparison is provided only for the 2022 DM AM scenario. Other scenarios are available upon request.

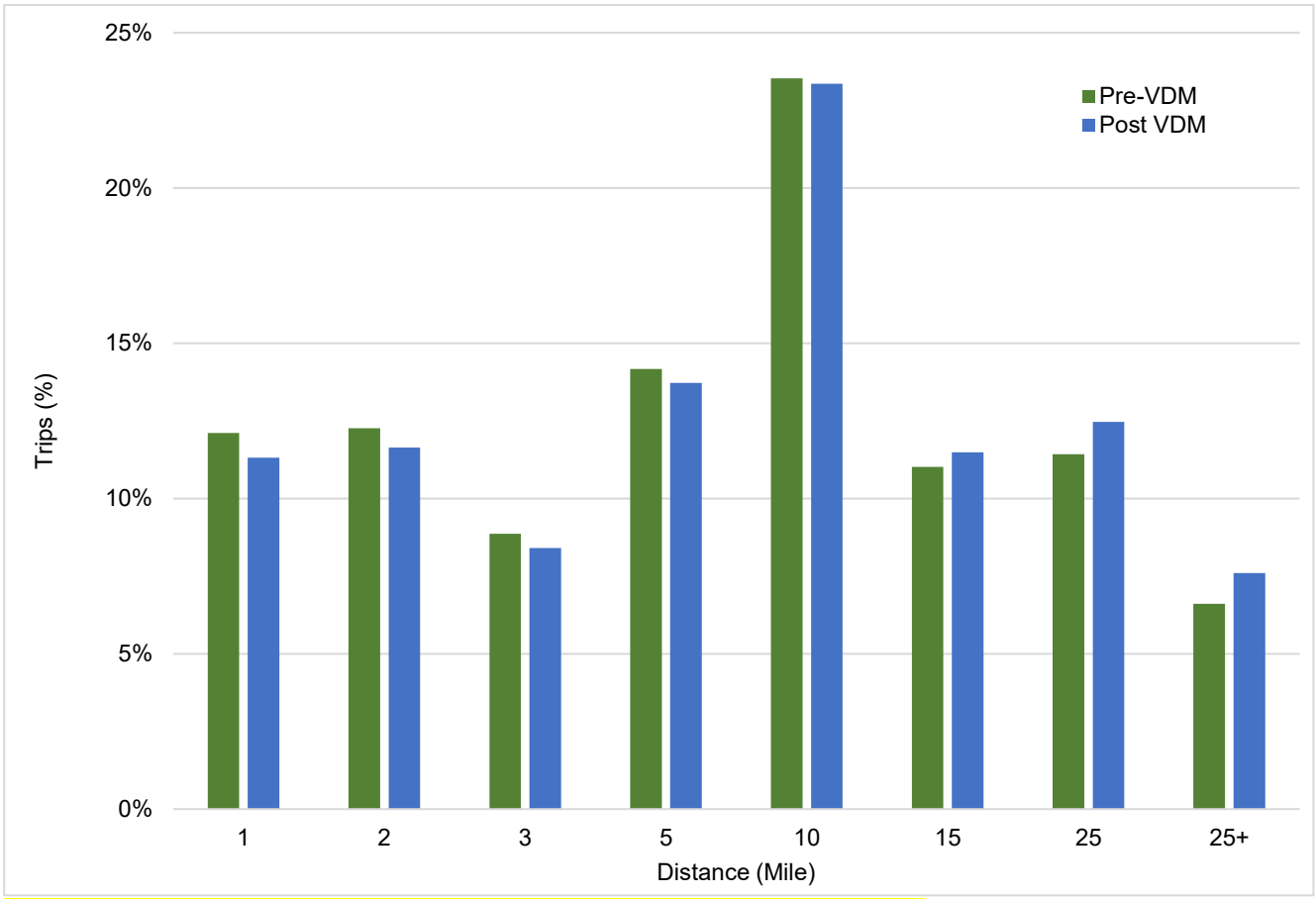

Figure 5-1: Comparison of pre-VDM and post-VDM Trip Length Distribution – DM 2022 AM

The induced traffic impact in Do Minimum can be explained through comparison of the vehicle operating cost element of the generalised cost in the base year (2013) to other forecast years. Figure 5-2 is a graph of fuel prices based on the data from Table A1.3.7 of TAG data book December 2017 and shows that fuel prices were relatively high in 2013 compared to the other years. Given that the forecast scenarios were pivoted off the 2013 base year skim costs (i.e. the reference case scenario in DIADEM), the cost of traveling decreases in the forecast years and consequently there are fewer intra-zonal trips and more longer trips compared to the base.

This is despite the higher congestion and higher VOT in the future year networks when compared to the base year. The tables in Section 5.3 show that on average the speeds in the simulation area decrease between the Base and Do Minimum due to background traffic growth, particularly in 2037 and 2042. The map of junction delays and journey routes comparison, in the subsequent Section 5.6, also demonstrate that the delays generally increase except where the committed schemes are coded into the Do Minimum network.

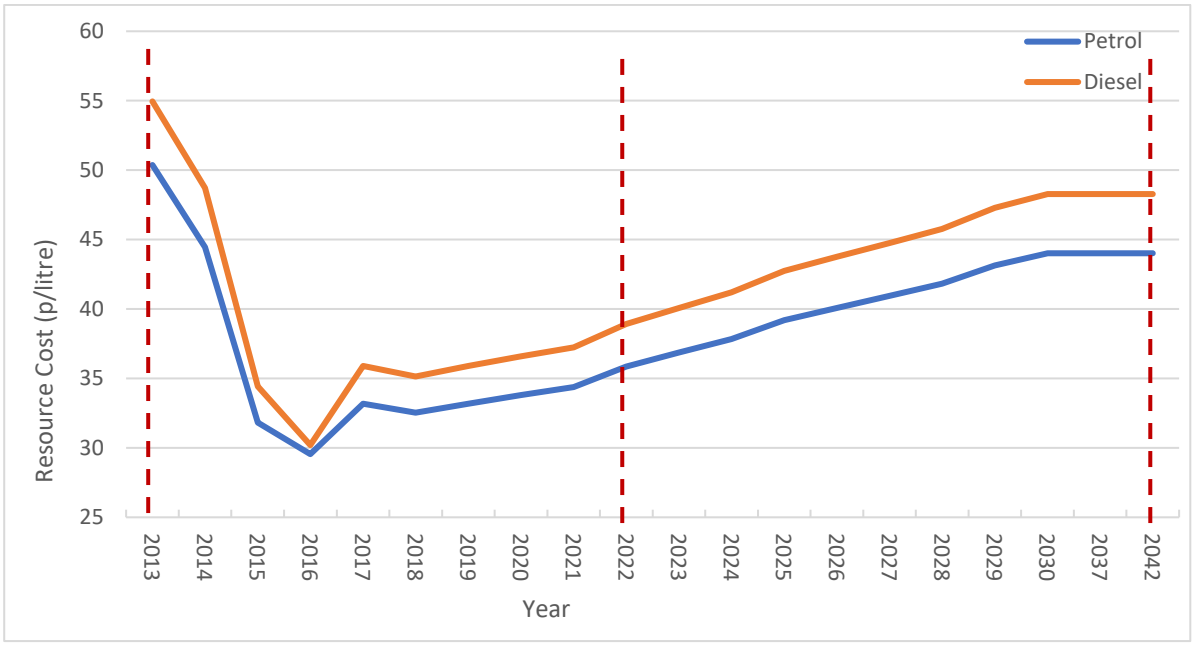

Figure 5-2: Fuel Prices (2010 Prices – Resource Cost, Table A1.3.7 TAG databook Dec. 2017)

5.4.2 Impact of Variable Demand Modelling – Sector Analysis

In order to further understand the effect of VDM, the fixed demand forecast matrices have been compared against the post VDM matrices, as presented in Appendix D for all modelled time periods and years.

To facilitate this comparison, the sector system shown in Figure 5-3 has been used, which consists of 33 sectors. For this comparison, only the car user classes have been assessed as the LGV and HGV user classes are excluded from the VDM process.

For the purpose of discussing the results, Table 5-G is provided below. The table highlights the changes which are more or less than 100 PCUs. The comparison exercise concludes that the main changes in demand between the fixed demand and post-VDM demand matrices are focused on sectors around the edge of the study area, such as sectors 20, 21 and 23. These changes were mainly centred on the far east and far west of the model around Blackburn, Wigan, Blackpool, Manchester, and Wales sectors, and other more distant sectors such as Midlands. For several of these sectors there are decreases in intra-sector flow, with more trips to/from neighbouring sectors, or external sectors further away from the PWD. The decreases in intra-sector demand are proportionately small, with some counter-balancing increases to/from neighbouring sectors; which are due to changes in journey times and routeings arising from changes at modelled junctions around the edge of the main study area.

The impact of VDM on changes in trip movements to / from / between PWD sectors (Sectors 4 and 30) are much smaller in scale, with generally low levels of trip induced and re-distribution in the urban areas. This pattern is present for all time periods (but with smaller changes in inter-peak, due to lower traffic intensity) and increases in size for more distant forecast years (i.e. as traffic growth increases).

Figure 5-3: 33x33 Sector System Preston

Table 5-G: Comparison of pre-VDM vs post-VDM Demand at Sector Level– 2022 Do Minimum AM

Sector	1	2	3	4	5	6	7	8	9	10	11	12	13	20	21	22	23	24	27	28	29	30	31	32	33	14	15	16	17	18	19	25	26
1	-35	-8	-1	-1	2	0	0	1	1	1	8	2	2	14	0	0	4	1	0	0	-1	-1	-4	-4	0	11	2	3	1	0	8	1	2
2	-13	-30	2	-7	0	3	0	1	1	0	10	6	1	22	0	0	2	1	-8	0	-3	-6	0	-2	0	15	0	0	6	4	4	0	3
3	-5	2	-28	1	1	-14	-3	0	2	1	16	2	4	17	-1	1	2	1	1	-4	3	0	-3	-1	-8	6	5	0	2	0	8	2	3
4	-1	-6	0	-13	1	2	0	1	0	2	11	8	2	3	2	1	2	1	-1	0	0	-31	-1	-6	0	10	1	0	2	6	6	2	5
5	3	1	-2	0	-30	-15	-2	-24	-15	5	4	3	1	24	4	2	3	-14	0	0	-3	1	0	1	0	32	2	2	6	1	15	2	5
6	7	1	-1	1	-9	-69	-32	-12	1	7	9	6	1	18	4	4	9	-7	-1	1	-5	3	0	0	-1	27	3	3	13	3	25	3	3
7	2	0	1	0	-1	-11	-6	-4	0	1	1	2	0	2	1	1	2	-1	0	1	-1	0	0	1	1	6	0	0	1	1	3	0	0
8	4	1	1	2	-12	-17	-4	-45	-26	3	4	3	1	27	3	1	2	-1	0	1	-1	1	1	1	1	25	2	3	8	2	18	3	2
9	2	0	1	1	-5	1	0	-17	-27	2	1	0	0	10	4	1	0	0	0	0	0	0	1	1	1	17	1	0	1	0	7	0	0
10	-3	4	0	0	1	2	0	1	1	-86	19	15	8	8	2	0	1	2	1	0	1	2	0	2	0	19	1	0	3	2	5	1	3
11	14	11	1	6	2	10	4	2	1	-31	-151	-48	9	34	10	1	7	2	6	0	3	5	5	6	0	22	7	6	29	4	23	16	9
12	17	18	2	16	3	9	0	4	1	18	-171	-114	4	47	6	3	17	4	3	0	8	11	10	6	1	73	26	0	2	6	45	-41	7
13	5	-3	0	0	2	4	0	2	1	5	5	0	-20	-28	2	1	3	1	-6	0	2	-1	1	1	0	19	1	1	3	1	13	1	-7
20	33	12	1	1	3	4	4	30	9	9	42	31	-30	-309	21	24	76	0	2	2	-1	6	3	6	0	-362	44	20	75	134	259	28	-27
21	-5	0	-4	0	7	1	0	1	5	0	8	3	4	17	-120	-21	16	2	4	-3	1	0	-1	0	-5	23	12	2	16	3	51	6	3
22	4	1	1	0	1	1	0	0	2	1	5	3	1	19	-9	-98	-3	0	0	0	0	0	0	0	0	19	3	3	10	1	44	4	1
23	1	3	0	1	-3	0	0	-11	-17	5	15	14	2	74	23	-7	-279	0	1	1	0	2	1	1	0	91	7	8	25	12	68	11	3
24	0	-1	3	-1	-5	-13	-1	0	1	3	6	5	-1	0	5	1	2	-21	-2	1	-15	0	1	-1	4	16	1	1	6	1	7	3	3
27	-1	-5	0	-2	1	1	1	0	0	0	1	1	-3	0	1	0	1	0	-3	0	0	-3	0	0	0	4	0	1	2	0	3	1	2
28	-3	0	-4	1	0	0	1	1	0	1	0	1	0	2	-1	0	0	0	0	-1	2	0	-1	0	-2	0	0	2	0	0	1	0	2
29	-4	-6	9	-1	-2	-8	-6	0	-1	15	8	4	-1	8	3	0	0	-17	-1	2	-24	-1	5	0	10	5	0	2	7	0	3	0	3
30	-5	-8	0	-29	1	3	1	1	0	1	13	6	2	3	2	1	2	1	-2	0	1	-9	-2	-4	2	12	1	0	2	1	6	1	5
31	-11	-1	0	-2	0	0	0	0	1	0	12	5	0	1	0	0	1	1	-1	0	0	-1	-12	-4	1	2	1	0	0	7	1	1	2
32	-9	-5	-1	-8	2	1	0	1	0	4	6	4	4	2	0	1	1	1	0	0	0	-5	-3	-7	1	8	0	0	0	1	1	3	4
33	-3	0	-6	0	1	-6	-1	0	1	0	4	1	1	5	-5	0	1	3	0	-2	5	0	-1	0	-16	5	3	0	4	2	4	0	3
14	17	10	3	3	15	15	3	38	18	12	16	54	7	-356	20	9	34	6	5	0	3	7	2	3	0	0	19	12	10	77	1	2	3
15	6	0	0	1	0	1	0	0	0	0	3	2	1	1	1	0	0	0	0	0	10	0	0	0	0	1	-38	24	8	2	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	-1	1	1	0	0
17	-3	0	0	-1	0	0	0	0	0	1	1	-1	0	1	0	0	1	0	0	1	-1	0	0	0	0	0	20	-2	1	2	2	-3	0
18	22	0	0	0	0	21	0	0	0	0	1	1	0	25	1	0	4	11	0	0	12	0	0	0	10	19	31	12	6	-139	15	0	0
19	7	1	1	4	4	6	1	8	8	3	30	46	6	88	9	6	18	2	4	0	0	6	0	0	1	-21	24	14	9	53	-272	2	2
25	-2	-4	1	-5	2	2	0	3	1	3	25	-56	0	25	2	2	7	1	-1	0	0	-6	-1	-2	0	7	7	1	-17	3	14	0	0
26	16	5	1	2	7	3	1	5	3	2	3	2	-20	-26	1	1	4	3	0	0	2	2	1	1	1	18	3	1	3	1	6	1	-33

5.5 Flow Changes from Base Year

The increases in traffic flows on the key roads expected in the future are presented in Appendix E.

Figures 5-4 to Figure 5-12 below show forecast flow changes (over 50 PCUs) from the base year to 2022, 2037 and 2042. Green (Dark to Light) bars represent increase in traffic while Red (Dark Red to Amber) bars represent decreases.

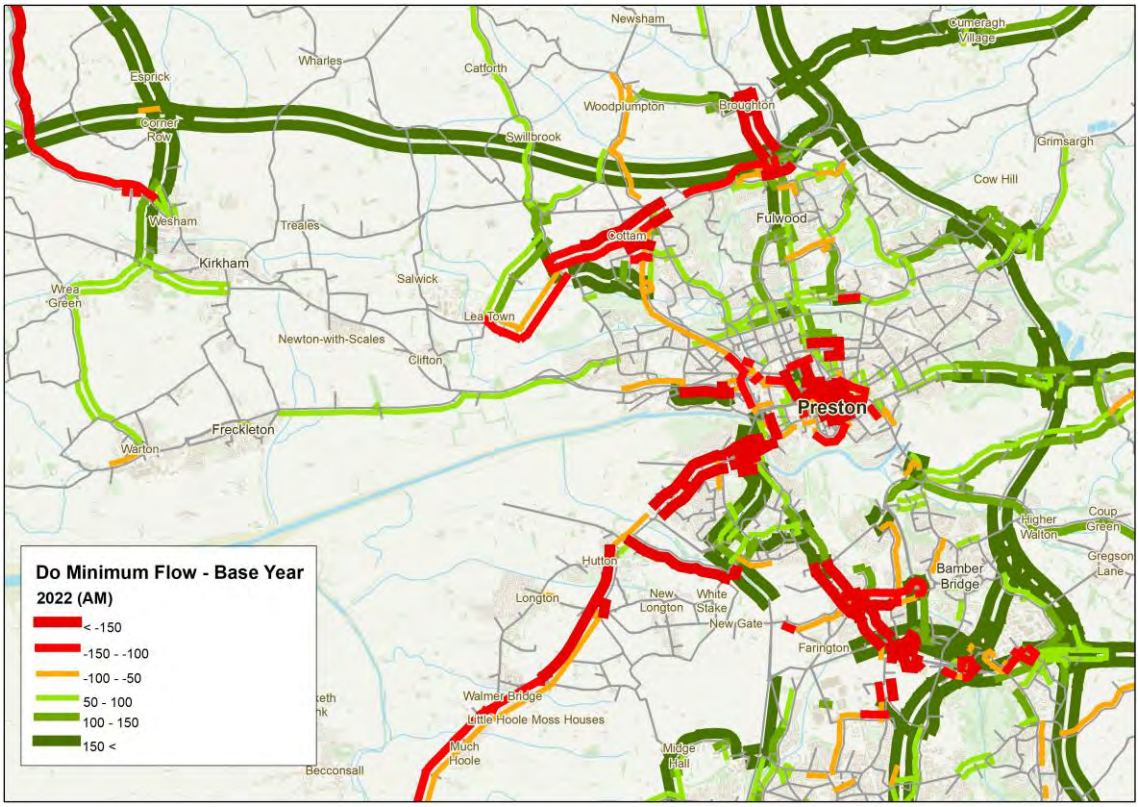

Figure 5-4: Traffic Flow Changes 2022 Do Minimum vs Base Year (AM)

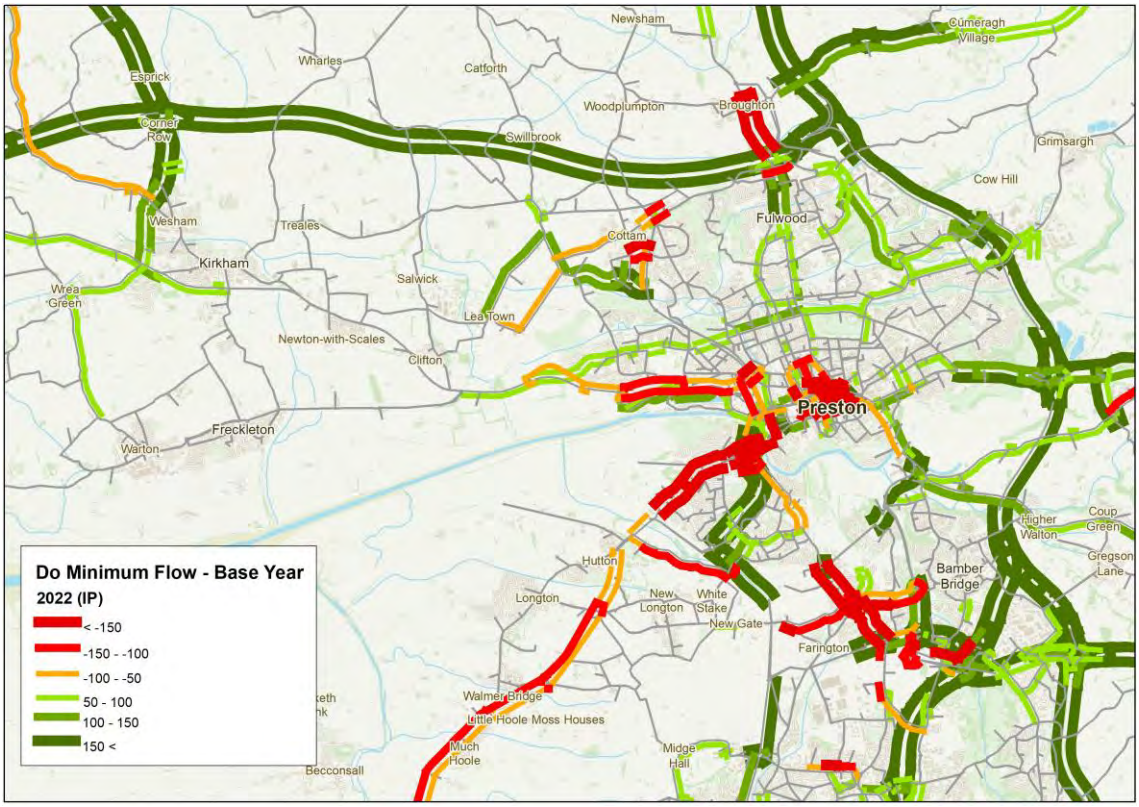

Figure 5-5: Traffic Flow Changes 2022 Do Minimum vs Base Year (IP)

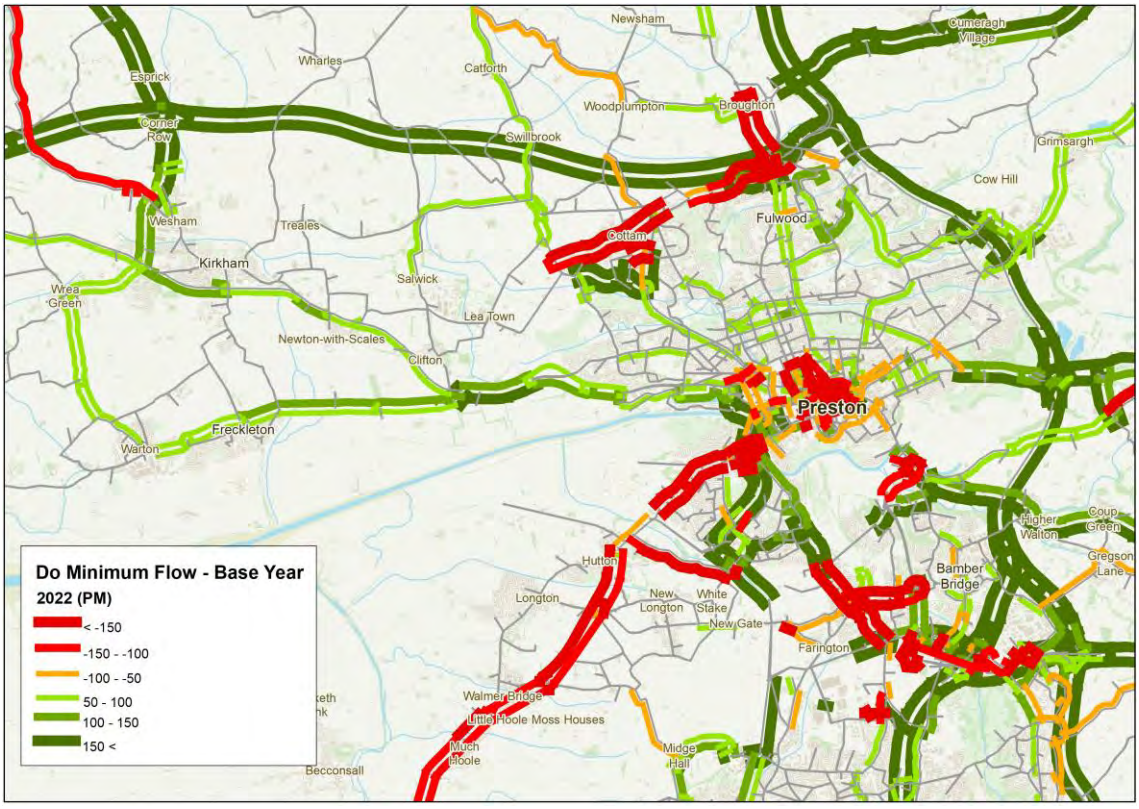

Figure 5-6: Traffic Flow Changes 2022 Do Minimum vs Base Year (PM)

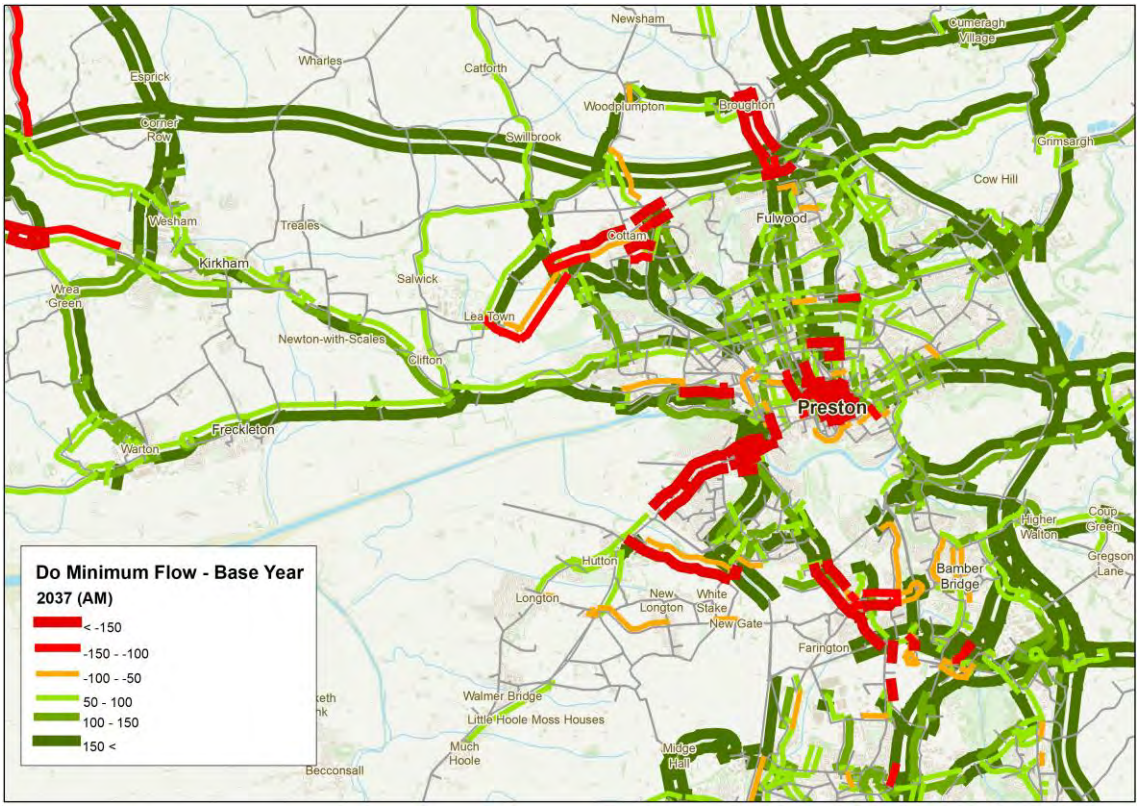

Figure 5-7: Traffic Flow Changes 2037 Do Minimum vs Base Year (AM)

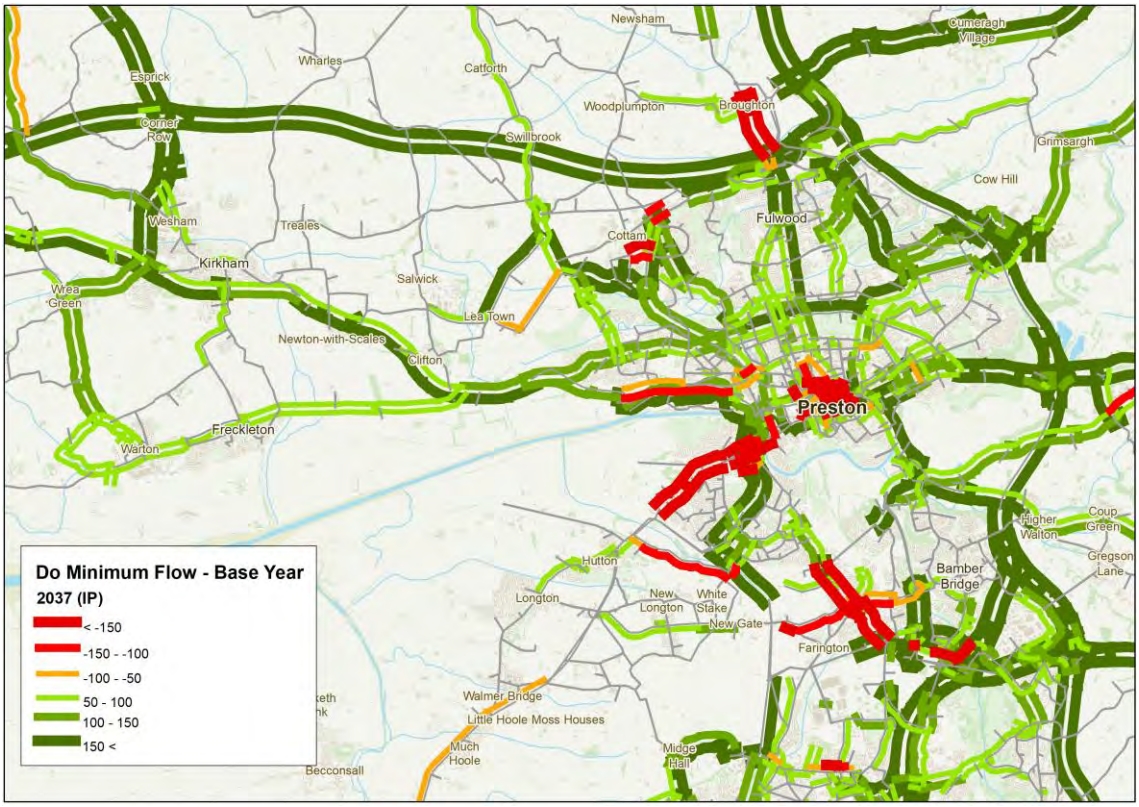

Figure 5-8: Traffic Flow Changes 2037 Do Minimum vs Base Year (IP)

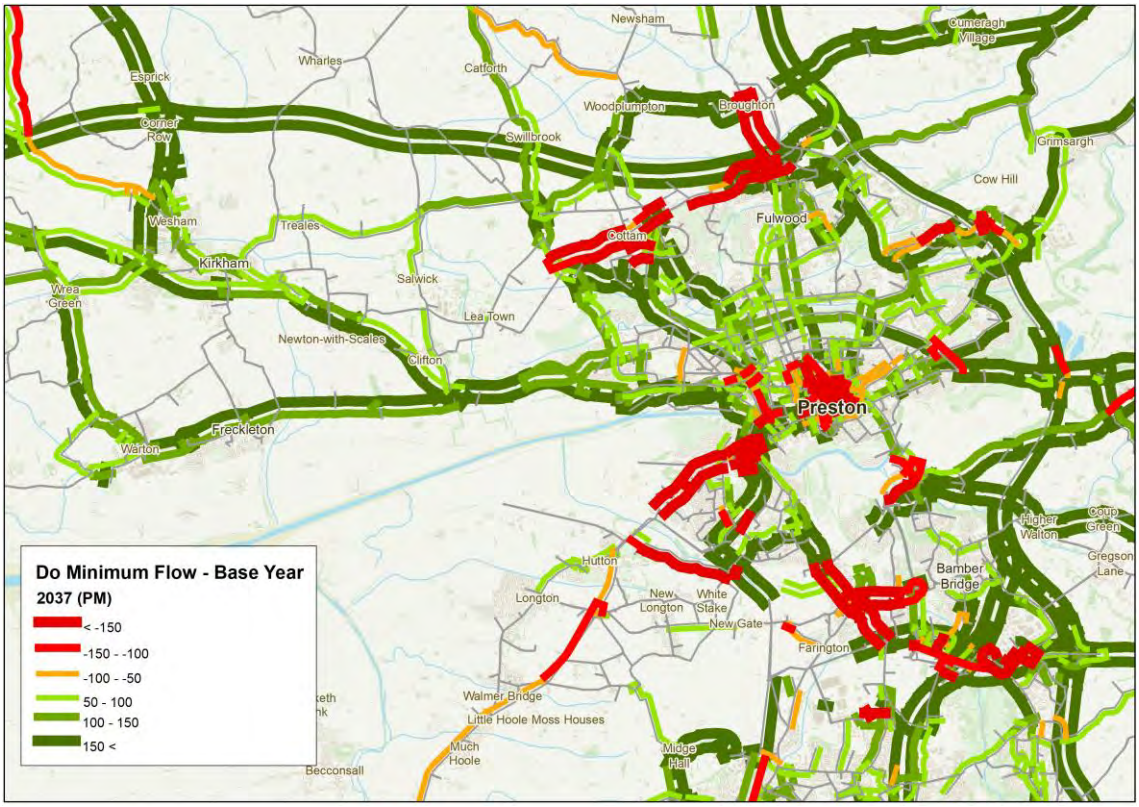

Figure 5-9: Traffic Flow Changes 2037 Do Minimum vs Base Year (PM)

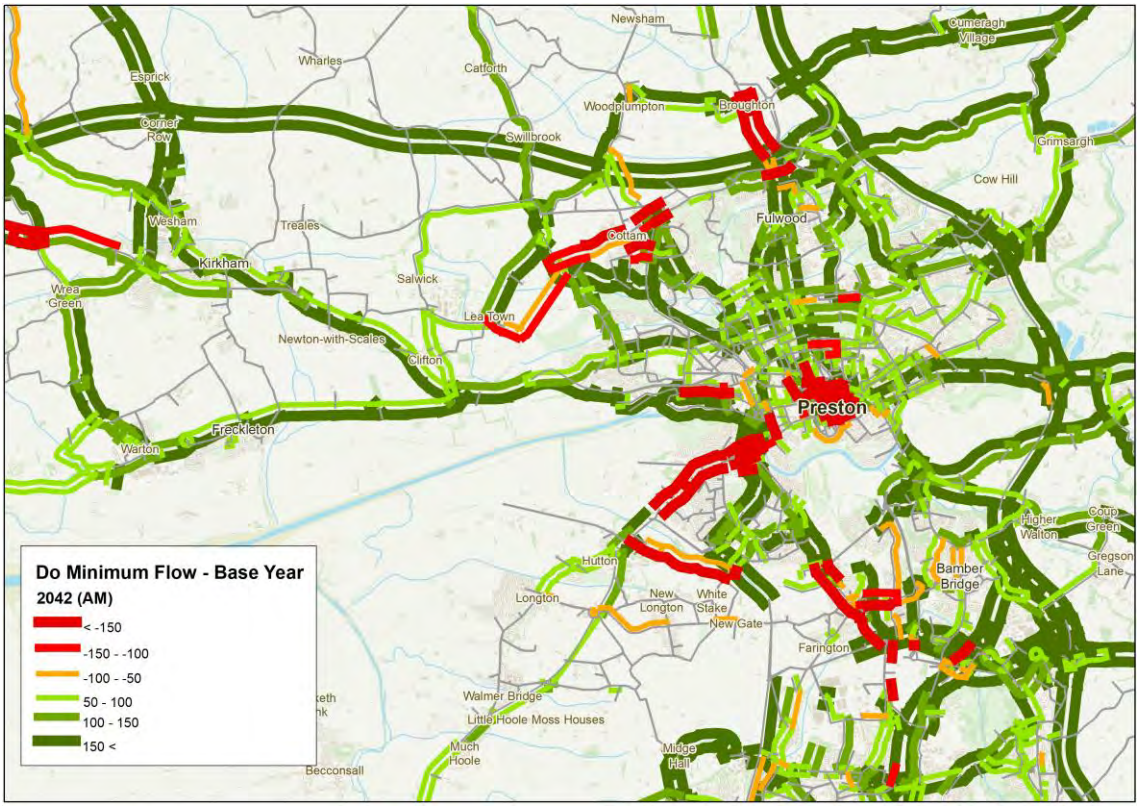

Figure 5-10: Traffic Flow Changes 2042 Do Minimum vs Base Year (AM)