Appendix A

Appendix A – Multi-Modal Model Validation

Introduction

1.1.1 MVA Consultancy has been commissioned by Charnwood Borough Council to model the impacts of a series of development options and proposed multi-modal mitigation schemes within the Loughborough area as part of the 2026 Charnwood LDF. The work has involved the development of a TRIPS based public transport model for Loughborough, and associated mode choice model in order to inform the analysis and results of the comparative scenarios.

1.1.2 This appendix details the validation procedures and results for both the highway and public transport models developed for the testing of the development scenarios and mitigation options, at both a global and local scale.

Network Checking and Updating

2.1.1 The latest version of the Loughborough Traffic Model (LTM), utilised for the Inner Relief Road Business Case, has been obtained from Leicestershire County Council. Roadside counts previously utilised to validate the model were also obtained as part of the model definition, along with the Local Model Validation Report, produced by Scott Wilson.

2.1.2 The previous model validation showed that:

- 86% of counts had a GEH <5 or a flow within ±15% of the count for the AM Peak;
- 78% of counts had a GEH <5 or a flow within ±15% of the count for the PM Peak; and that,
- 88% of screenlines validated with a GEH <4 in each peak.

2.1.3 This represents a level of validation at the model scale which exceeds relevant DfT and TAG guidance for the AM peak and for screenlines, and is close to these guidelines within the PM peak.

2.1.4 The LTM has also been checked in terms of its journey times assumed within the model. Whilst the majority of journey times validate, a number of journey times have been updated and corrected, particularly for external zone connection journey times in order to reach the edge of the model. This has been undertaken in order to make the journey times more reliable when compared against public transport journey times, and is particularly important in a mode choice context.

2.1.5 However, where two or more connections exist from an external zone onto the network, care has been applied to ensure that the relative balance of journey times along multiple centroid connections remains the same, so that flow changes do not result, and that model validation in other parts of the model is not affected.

2.1.6 Junction and link capacities in the vicinity of development options have also been checked, with only minor revisions being made. However, significant changes have been made to parts of the A60 corridor, in the vicinity north of Cotes where capacities were previously unduly low.

2.1.7 Analysis of the previous model screenline validation has also shown that whilst aggregate model validation typically meets DfT and TAG guidance, certain screenlines within the vicinity of the development options do not. As the Scott Wilson LMVR points out, both the Loughbough East and Loughborough West screenlines are the least well validated in both the AM and PM peaks, with traffic substantially below the observed count data by up to 32% in the AM peak and by up to 13% in the PM peak. This equates to the model being more than 200 vehicles low in the AM peak and by 188 vehicles for the worst affected links, which are typically on the eastern side of the town.

2.1.8 As a result, neither screenline validates to a GEH of less than 4, as required by TAG/ DfT.

2.1.9 The previous model screenline validation information is reproduced from the Scott Wilson LMVR below in Table 1 for the AM peak and Table 2 for the PM peak respectively. Values with a GEH of greater than 4, or a flow difference of greater than 25%, are highlighted in red.

Table 1 AM Peak Scott Wilson LMVR Screenline Results

AM Peak	East and North-bound					West and South-bound				
	Count	Model	Diff	%Diff	GEH	Count	Model	Diff	%Diff	GEH
Loughborough West										
New Ashby Rd	1685	1677	-8	0%	0.2	1054	845	-209	-20%	6.8
Nanpantan Rd	630	600	-30	-5%	1.2	417	446	29	7%	1.4
Total	**2315**	**2277**	**-38**	**-2%**	**0.8**	**1471**	**1291**	**-180**	**-12%**	**4.8**
Central/ North East										
Toothill Rd	277	333	56	20%	3.2	369	337	-32	-9%	1.7
Meadow La	179	133	-46	-26%	3.7	222	167	-55	-25%	3.9
Nottingham Rd	318	282	-36	-11%	2.1	417	285	-132	-32%	7.0
Total	**774**	**748**	**-26**	**-3%**	**0.9**	**1008**	**789**	**-219**	**-22%**	**7.3**

Table 2 PM Peak Scott Wilson LMVR Screenline Results

PM Peak	East and North-bound					West and South-bound				
	Count	Model	Diff	%Diff	GEH	Count	Model	Diff	%Diff	GEH
Loughborough West										
New Ashby Rd	1225	1166	-59	-5%	1.7	1369	1304	-65	-5%	1.8
Nanpantan Rd	383	334	-49	-13%	2.6	552	554	-2	0%	0.1
Total	**1608**	**1500**	**-108**	**-7%**	**2.7**	**1921**	**1858**	**-63**	**-3%**	**1.4**
Loughborough East										
Meadow Lane	679	618	-61	-9%	2.4	316	316	0	0%	0
Nottingham Rd	1007	880	-127	-13%	4.1	540	518	-22	-4%	1.0
Total	**1686**	**1498**	**-188**	**-11%**	**4.7**	**856**	**834**	**-22**	**-3%**	**0.8**

2.1.10 It is important to note that these links and screenlines with the lowest level of validation are the areas within which the developments and mitigation option testing to be analysed are likely to have their largest traffic impacts.

2.1.11 As a result, MVA have undertaken a number of matrix enhancements in order to improve the validation of the model in these areas, without affecting the validation of other screenlines and routes within the town centre. These updates have included the addition of previously unobserved movements, mainly within Eastern quadrant of the model, where route analysis showed that there was systematic tendency of the model to under-reflect observed flow levels for through movements within the quadrant, for example between Barrow and Wymeswold and Hoton to Barrow. This has been confirmed with Leicestershire County Council; the reason for which is that this area of the model lay outside the original RSI cordon when the model was developed. As a result, very limited observations were undertaken for these routes.

2.1.12 Whilst this is likely to be of marginal importance for schemes within the town centre such as the Inner Relief Road, making sure that the model has the correct flow levels in the vicinity of the development options being tested for this study is very important. Previous tests utilising the Loughborough traffic model are therefore flawed in this regard; especially on the eastern side of the town.

2.1.13 In order to resolve this issue within the multi-modal model, a number of select link analyses for routes in these areas have been undertaken in order to identify routes and zone pairings with the lowest levels of validation when compared to the count data within the screenlines and quadrants of the model previously identified. Where parallel routes and screenlines are over-represented when compared to counts, demand has been transferred between assigned routes.

2.1.14 Where this is not the case matrices have been enhanced has been using select link analysis for the route or screenline in question. However, demand has only been enhanced across screenlines, where the neighbouring quadrant of the model is also under-represented in terms of flow level (such as between Loughborough East and Loughborough Central-East) in both time periods. No other changes have been made to the model demand matrices, as validation for the central parts of the town is otherwise sufficient.

Revised Validation

2.1.15 The model has been revalidated after the application of these checks and updates. A comparison of the previous model and the revalidated model in terms of flows in the vicinity of the proposed development options against the roadside counts has been undertaken. Table 2 and Figure 1 show these count locations on the network.

2.1.16 For simplicity, the previous and the revalidated models are called 'Previous' and 'Current' respectively.

2.1.17 The DMRB Highway Criteria have been used to check flows for validation against the counts. The criteria are shown in Table 3.

2.1.18 The comparison of 'Previous' and 'Current' modelled flows at locations in the vicinity of the options under assessment are shown in Tables 4 and 5 for AM and PM peak respectively. The flows are compared for both inbound and outbound directions. The validated flows are highlighted in green.

2.1.19 It can be seen that the revised validation has resulted in greater levels of validation being achieved:

- For AM peak outbound flow, the 'Previous' model validates at 63% of the selected locations. This figure is 100% for the 'Current' model;
- For AM peak inbound flow, the 'Previous' model shows 54% validation compared with 100% validation in the 'Current' revalidated model;
- The outbound flow comparison during the PM peak shows 72% validation for the 'Previous' model while this percentage increases to 91% in the 'Current model; and,
- For PM peak inbound flow, the validation achieved is 54% for the 'Previous' model, which increases to 72% for the 'Current' model.

2.1.20 Special attention is required for the East Loughborough locations (5, 6, 7 and 8) where the model did not validate particularly well in the 'Previous' scenario. This is particularly true for the inbound flow in AM peak and the outbound flow in PM peak. These locations are in the vicinity of the proposed Eastern development options and the proposed Eastern Distributor Road (EDR). Not only is the model now validated in these locations, but the flows are almost identical to the counts, which is important for areas with currently low levels of traffic flow. This is therefore also important in terms of correctly forecasting future year traffic impacts of the proposed East Loughborough development and the mitigation impacts of the proposed Eastern Distributor Road (EDR).

2.1.21 The revised model validation shows that at an aggregate scale:

- 94% of counts have a GEH <5 for the AM Peak;
- 83% of counts have a GEH <5 for the PM Peak; and that,
- 94% of screenlines validate with a GEH <4 in each peak.

2.1.22 As a result, the model is considered fit for purpose for analysis within each part of the model required for robust development and mitigation scheme analysis, as well as at the overall scale. The model is also suited to, and has been developed to be comparable with, the public transport model that has also been developed for Loughborough.

Table 2 Roadside Count Locations

Location	Description
1	A512 New Ashby Road
2	A6 Derby Road
3	Meadow Lane
4	A60 Loughborough Road
5	B676 Loughborough Road
6	Barrow Road
7	Nottingham Road
8	Cotes Road
9	A6 Loughborough Road
10	A6004
11	Nanpantan Road

Figure 1 Highway Validation – Count Locations

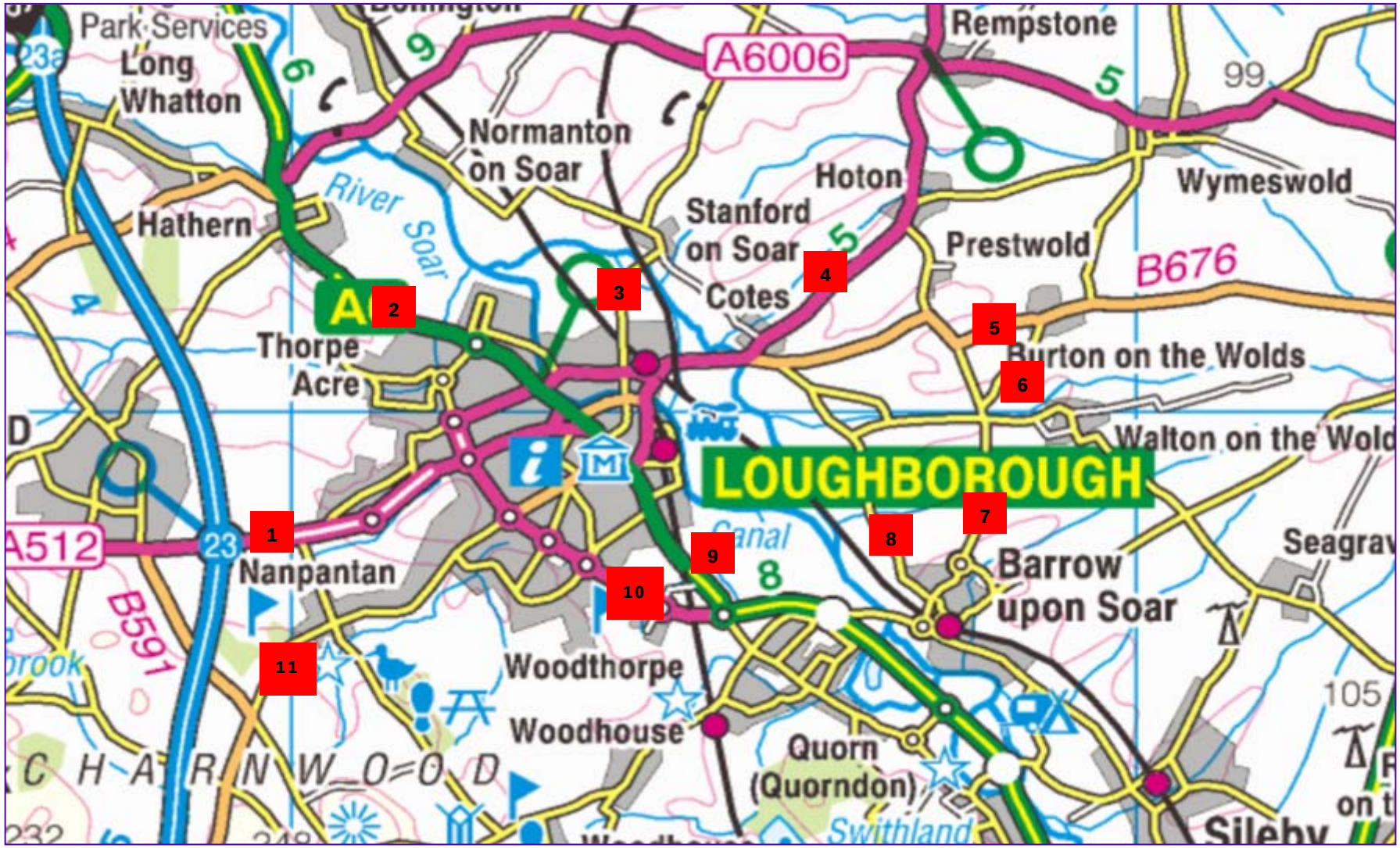

Table 3 DMRB Highway Validation Criteria

Assigned hourly Flows compared with observed flows	Guidelines
Individual Flows	
1. Individual flows within 15% for flows 700-2,700 vehicles per hour (vph)	>85%
2. Individual flows within 100 vph for flows < 700vph	>85%
3. Individual flows within 400vph for flows >2,700 vph	>85%
4. Total screenline flows (normally > 5 links) to be within 5%	All (or nearly all) screenlines
5. GEH statistic	
Individual Flows: GEH < 5	>85% of cases
Screenline totals: GEH < 4	All (or nearly all) screenlines
Journey Times	
Times within 15% (or 1 minute, if higher)	>85%

Table 4 AM Highway Validation

	Outbound			Inbound		
Location	Count	Previous	Current	Count	Previous	Current
1	996	843	909	1682	1675	1674
2	499	673	520	1407	1348	1396
3	135	68	99	542	662	564
4	285	310	311	555	445	527
5	177	52	177	319	107	309
6	68	34	67	74	48	76
7	266	81	259	293	131	299
8	79	33	30	233	207	274
9	887	873	882	957	930	915
10	1037	1183	1185	771	589	649
11	365	446	456	537	600	604

Table 5 PM Highway Validation

	Outbound			Inbound		
Location	Count	Previous	Current	Count	Previous	Current
1	1336	1302	1211	1077	1164	995
2	1280	1193	1253	600	702	741
3	516	598	603	155	167	194
4	451	470	510	214	326	418
5	360	126	331	219	52	218
6	65	67	100	80	42	70
7	263	117	258	205	78	195
8	261	130	246	78	6	28
9	1028	1076	1047	699	556	554
10	903	829	1005	933	835	951
11	466	555	580	383	333	376

Public Transport Model Validation- DfT Guidance

2.1.23 The validation of a public transport model should involve three types of checks:

- Network and service validation;
- Assignment validation; and,
- Validation of the trip matrix.

2.1.24 The network validation involves checks on the accuracy of the coded geometry and routes.

2.1.25 Validation of services involves comparing the modelled flows of public transport vehicles with roadside counts.

2.1.26 Validation of the assignment should involve comparing modelled and observed:

- Passenger flows across cordons, usually by public transport mode and sometimes at the level of individual bus or train services; and,
- Passenger boardings and alightings in urban centres.

2.1.27 Across routes, modelled flows should, in total, be within ±15% of the observed values.

2.1.28 On individual links in the network, modelled flows should be within ±25% of the counts.

Network and Service Validation

2.1.29 All AM and PM peak services have been incorporated into the public transport model. These include all bus and train services stopping within Loughborough.

2.1.30 Counts of public transport patronage, passenger boardings and alightings have been obtained from the bus operators, including Kinchbus, Arriva and Trent Barton. Total boarding and alightings at the rail station have been sourced from Network Rail patronage statistics, whilst Leicestershire County Council have provided a series of bus stops counts for all services and time periods at each of the main bus stops within the town centre, rail station and university. Journey times have been obtained from timetable data and have been incorporated into the model.

2.1.31 Fare tables, interchange penalties and wait curves have also been incorporated into the model, which have initially been taken from the CLTM and then calibrated to better reflect the overall levels of public transport patronage within Loughborough.

2.1.32 For the services with a headway of 60 minutes, wait curves have been calibrated in order to model them correctly in TRIPS, which assumes a wait time of half-the headway by default. Wait time curves have been calibrated using a minimum value of 5 minutes to a maximum of 15 minutes for services with only hourly frequencies.

2.1.33 To ensure accuracy of the services, the timetables, frequencies and routes of the incorporated lines have been verified by Charnwood Borough Council.

2.1.34 A thorough check of the geometry and network layout of the model has been conducted, including a number of additional zone connectors and city centre walk links which have been

added to the public transport network in order to better represent loading patterns and town centre bus interchange.

Assignment Validation – Bus Routes

2.1.35 Tables 6 and 7 show the bus routes validation statistics for the AM and PM period respectively, aggregated to a weekly period, which have been provided directly by the bus operators. The last column shows whether the validation has been achieved against the ±15% confidence interval criteria, as set by DfT and TAG guidance.

2.1.36 The validation results show that:

- 90% of the routes validate against the observed values of AM peak period boarding. The only route which is not validated is Service 99 westbound;
- 100% validation has been achieved for bus routes boarding during the PM peak period; and therefore,
- Overall validation at a route level is 95%.

Assignment Validation – Central Bus Stops

2.1.37 Tables 8 and 9 show the validation results for the Loughborough Town Centre bus stops for the AM and PM peaks respectively. The stops surveyed include Baxter Gate, Market Place, High Street, University and the Railway Station, for all stopping services.

2.1.38 A confidence interval of ±25% has been used to define the validation, as per TAG requirements for public transport validation at individual bus stops.

2.1.39 The validation results show that:

- 100% bus stops validate for passenger boarding and alighting during AM period;
- 90% validation has been achieved for individual bus stops for passenger boarding and alighting during PM period; and therefore that,
- 100% validation is achieved for total of boarding and alighting for both AM and PM periods.

Assignment Validation – Specific Services Bus Stop Counts

2.1.40 Validation checks have also been made for specific services at the Baxter Gate bus stops in the town centre. The counts were provided by the bus operators for the following services:

- Service 1 (Loughborough – East Leake – Clifton – Nottingham);
- Service 8 (Loughborough – Grantham);
- Service 13 (Baxter Gate – Tuckers Road – Market Place); and,
- Service 54 (Leicester – Loughborough).

2.1.41 As per TAG requirements, a validation criterion of ±25% has been used.

2.1.42 The validation results can be seen in Tables 10 and 11 for the AM and PM periods respectively.

2.1.43 The results show that:

- 100% validation has been achieved in terms of passenger boarding and alighting during the AM period for all services stopping at Baxter Gate;
- 88% services have been validated for passenger boarding and alighting during the PM period; and,
- 100% validation has been achieved for total of passenger boarding and alighting during both AM and PM periods.

Trip Matrix Validation

2.1.44 Table 12 shows levels of public transport patronage and percentage mode share for Loughborough and Leicester.

2.1.45 It can be seen that overall mode share in Loughborough is lower than that in Leicester, in both AM and PM periods. This is in line with annual patronage statistics for both areas.

2.1.46 This suggests that at an aggregate level the trip matrix is suitable for use in future year forecasting and assessment.

2.1.47 However, further segmentation has been applied within the matrix for more accurate future year forecasting. Table 12 shows the demand segmentation applied within the demand matrices for 'Car-Available' and 'Non-Car-Available' trips in the mode choice model. This is particularly important for reliably and accurately testing the future year public transport and Park-and-Ride schemes.

2.1.48 The matrices have been further segmented into work, commute and other purposes, and this allows for value of time variations to be incorporated into the mode choice model responses for future scheme testing.

Table 6 AM PT Validation - Bus Routes Passenger Boardings

Route No.	Description	Observed	Modelled	Validated
2	Leicester – Loughborough – Leicester	855	731	Yes
5	Ravensthorpe Drive – Hazel Road	712	672	Yes
11, 12	Thorpacre – Shelthorpe	1522	1637	Yes
99	Nottingham – Loughborough – Shepshed	270	335	No
99	Shepshed – Loughborough – Nottingham	435	371	Yes
127	Loughborough – Leicester	1695	1940	Yes
127	Leicester – Loughborough	3389	3053	Yes
IGO	Trent Barton Indigo	655	635	Yes
SKY	Kinchbus Skylink	813	798	Yes
SPR	Belton Road – University – Belton Road	1521	1721	Yes

Table 7 PM PT Validation - Bus Routes Passenger Boardings

Route No.	Description	Observed	Modelled	Validated
2	Leicester – Loughborough – Leicester	660	650	Yes
5	Ravensthorpe Drive – Hazel Road	701	756	Yes
11, 12	Thorpacre – Shelthorpe	2346	2199	Yes
99	Nottingham – Loughborough – Shepshed	570	536	Yes
99	Shepshed – Loughborough – Nottingham	432	368	Yes
127	Loughborough – Leicester	1935	2109	Yes
127	Leicester – Loughborough	1590	1757	Yes
IGO	Trent Barton Indigo	795	698	Yes
SKY	Kinchbus Skylink	1195	1050	Yes
SPR	Belton Road – University – Belton Road	2436	2372	Yes

Table 8 AM PT Validation - Central Bus Stops

	Observed			Modelled			Validated		
Stop	**Boarders**	**Alighters**	**Total**	**Boarders**	**Alighters**	**Total**	**Boarders**	**Alighters**	**Total**
High Street	36	61	97	31	75	106	Yes	Yes	Yes
Baxter Gate	18	103	121	28	88	116	Yes	Yes	Yes
University	10	7	17	4	10	14	Yes	Yes	Yes
Railway Station	97	12	109	75	11	86	Yes	Yes	Yes
Market Place	43	50	93	44	55	99	Yes	Yes	Yes
Total	204	233	437	182	239	421	Yes	Yes	Yes

Table 9 PM PT Validation - Central Bus Stops

	Observed			Modelled			Validated		
Stop	**Boarders**	**Alighters**	**Total**	**Boarders**	**Alighters**	**Total**	**Boarders**	**Alighters**	**Total**
High Street	67	17	84	54	42	96	Yes	No	Yes
Baxter Gate	112	13	125	105	12	117	Yes	Yes	Yes
University	14	15	29	13	15	28	Yes	Yes	Yes
Railway Station	39	79	118	32	69	101	Yes	Yes	Yes
Market Place	78	30	108	70	36	106	Yes	Yes	Yes
Total	310	154	464	274	174	448	Yes	Yes	Yes

Table10 AM PT Validation - Specific Services Bus Stop Counts

	Observed			Modelled			Validated		
Service	Boarders	Alighters	Total	Boarders	Alighters	Total	Boarders	Alighters	Total
13	1	11	12	2	11	13	Yes	Yes	Yes
1	5	12	17	6	8	14	Yes	Yes	Yes
8	8	32	40	4	26	30	Yes	Yes	Yes
54	2	3	5	0	6	6	Yes	Yes	Yes

Table 11 PM PT Validation - Specific Services Bus Stop Counts

	Observed			Modelled			Validated		
Service	Boarders	Alighters	Total	Boarders	Alighters	Total	Boarders	Alighters	Total
13	3	0	3	7	1	8	Yes	Yes	Yes
1	29	4	31	35	0	35	Yes	Yes	Yes
8	10	2	12	13	0	13	Yes	Yes	Yes
54	16	0	16	9	3	12	No	Yes	Yes

Table 12 PT Patronage and Mode Share

		Loughborough	Leicester
AM peak	Total Patronage	1,178	11,661
	Mode Share	6.5%	9.7%
PM peak	Total Patronage	1,289	10,045
	Mode Share	7.2%	8.0%

Table 13 Mode Choice Model Segmentation

		Percentage of Demand
Car Available	Work	5%
	Commute	31%
	Other	32%
Non-Car Available	Work	1%
	Commute	11%
	Other	20%

Conclusions

2.1.49 The validation statistics for both highway and public transport networks show that the model is validated to the required standards as set by the DfT and TAG, and can be reliably used for future year forecasting and assessments.

2.1.50 Highway validation results show that the model has an improved level of validation than before, especially in the area relating to the proposed Eastern Distributor Road and the new proposed developments. Model validation in the areas of future development and proposed mitigation schemes now meets and exceeds DfT criteria, which previously was not the case. Other areas of the model have not seen significant changes to flow levels, and therefore at an aggregate level, overall model validation has also been improved.

2.1.51 The public transport validation results show that the model is validated across all the criteria set out by TAG. These criteria include:

- Network and Service Validation;
- Assignment Validation; and,
- Trip Matrix Validation.

2.1.52 As a result, the multi-modal model is considered suitable for the purposes of development and mitigation testing within and around Loughborough.

MVA Consultancy provides advice on transport, to central, regional and local government, agencies, developers, operators and financiers.
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