Inverness West Link Assessment:

Transport Modelling and Economic Assessment Report

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Introduction

1 Introduction

1.1 Background

In September 2010 AECOM delivered the Moray Firth Transport Model (MFTM) to The Highland Council (THC), fulfilling phases one and two of their three phase commission. This contract involved the development of a 2009 Base multi-modal transport model for the 'travel to work' catchment area of the City of Inverness. Phase three of the commission involves the ongoing use and support for the model. The modelled area is shown in Figure 1.

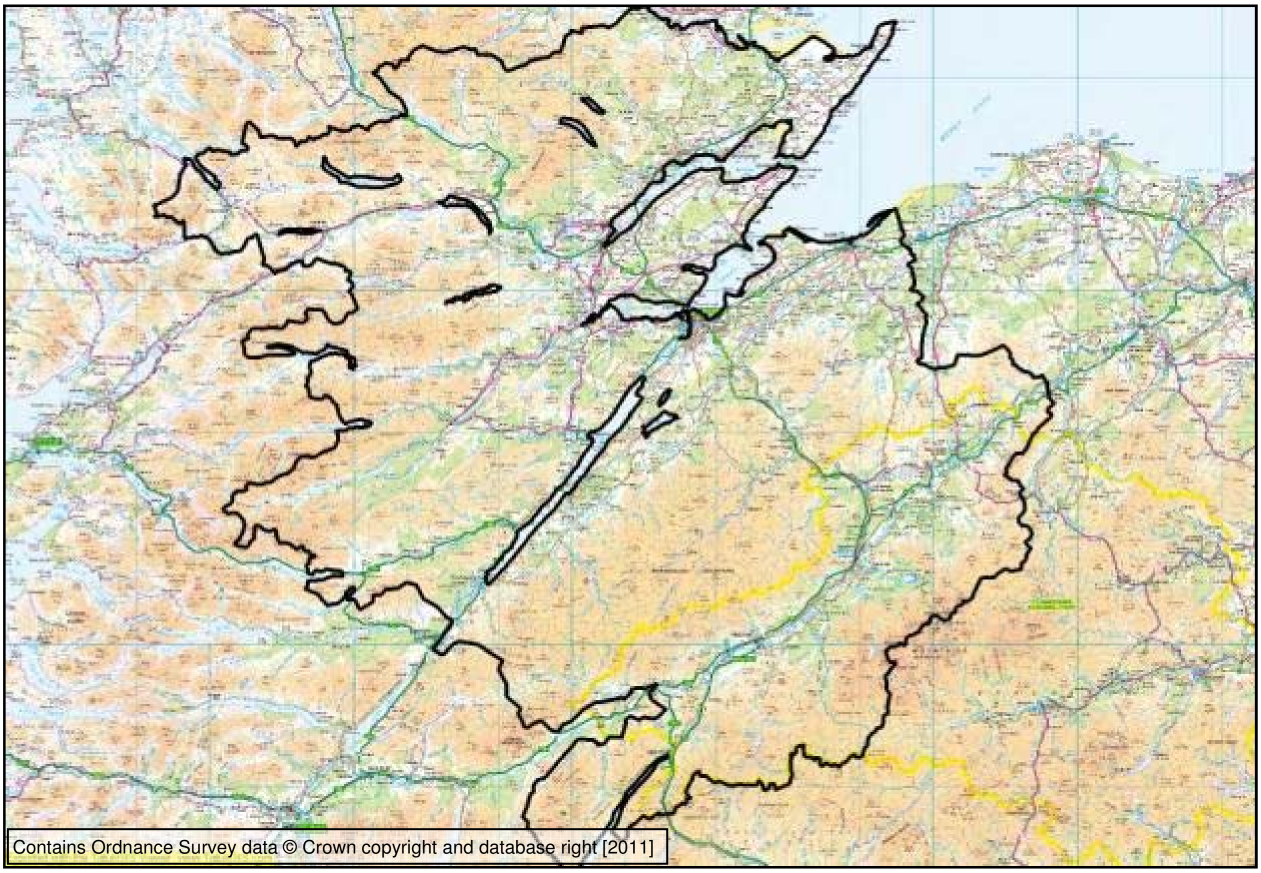


Figure 1 MFTM Modelled Area

THC has been examining options for connecting the area to the south west of the city adjacent to the Dores roundabout and the A82 at Torvean, which will involve crossing the River Ness and the Caledonian Canal. Five options were taken to public consultation in December 2010.

In June 2011 THC commissioned AECOM to undertake an appraisal of the Inverness Western Link project using the MFTM. This Report documents the steps undertaken to provide inputs from the transport model to the Appraisal Summary Table THC developed for the Scottish Transport Appraisal Guidance (STAG) assessment of this proposal.

1.2 Moray Firth Transport Model

The MFTM uses PTV Vision software VISUM, version 11.52-08, supplemented by software scripts written in Python produced by AECOM. It is structured as a variable demand and assignment model, following WebTAG guidance and models the following behavioural responses:

- Trip Generation;
- Trip Frequency;
- Mode Choice;
- Trip Distribution; and
- Route Choice.

The model has two distinct time periods for its assignment models:

- Morning peak hour (08:00 to 09:00); and
- Evening peak hour (17:00 to 18:00).

It should be noted that, as specified in the Brief originally issued for the MFTM, there is no explicit representation of the Inter Peak or Off Peak periods.

In running the model, the 'trip generation' stage is run only once, and uses forecast changes in development to calculate the amount of trip making from each area of the model. In producing a forecast scenario, the Trip Frequency, Mode Choice and Trip Distribution (collectively called the 'demand model') runs iteratively with the Route Choice. The demand model then forecasts changes in the amount, mode, and pattern of trip making as a result of changes in travel times and costs.

The demand model segments the trip demand in the following manner:

- Home Based Work;
- Home Based Educate;
- Home Based Other;
- Home Based Employers Business;
- Non Home Based Employers Business; and
- Non Home Based Other.

The 'multi-modal' element of the model includes the road and public transport modes. Freight (light and heavy goods vehicles) is also included. The model takes inputs from the Transport Model for Scotland, Transport Scotland's national transport model, to ensure that forecasts for trip making to and from areas outwith the area covered by the model (as well as trips through the area) are represented.

The route choice represents traffic flows for three main vehicle types, with car split by the purpose of travel:

- Car – Commute;
- Car – In Work;
- Car – Other;
- Light Goods Vehicles; and
- Heavy Goods Vehicles.

With regard to public transport, this assignment is undertaken as combined person trips rather than vehicle flow.

The model was developed to represent an average weekday in the three month period of September to November in 2009, with the demand and supply (network, public transport lines etc) developed to represent that period of time. Any forecasts that are made are based on this foundation. The model was developed following Government guidance, and as previously reported, adequately reproduces observed flows. In addition, sensitivity tests were undertaken, and demonstrated that the model responded within acceptable limits to changes in travel costs.

1.3 Western Link Proposal

In addition to the five options submitted for public consultation, THC requested AECOM assess a variant of option 1 (called option 6) and two additional scheme options. THC supplied schematics for each option which are included in Appendix A.

1.4 Structure of Report

In addition to this Introduction, this Report contains the following Chapters:

- Chapter 2 details the validation of the MFTM in the area of interest to the Western Link proposal;
- The recalibration and validation of the model is discussed in Chapter 3;
- Chapter 4 presents details of the network coding for the forecast scenarios;
- Chapter 5 discusses the preparation of forecast demand; and
- Finally, the results of the economic assessment are presented in Chapter 6.

Area Wide Model Validation

2 Area Wide Model Validation

2.1 Introduction

The MFTM was developed to cover the ‘travel to work’ catchment area of Inverness. As such, it concentrated on trips to and from Inverness, not within the city itself. The quality of transport model forecasting work depends upon the quality of its base model. Therefore, before any assessment of the Western Link could be undertaken, the representation of road traffic in the area relevant to the project needed to be checked against observed counts, to ensure that the model was a fair representation of observed data in the area. If the representation is not found to be adequate, then additional work would be required. This chapter presents this analysis.

2.2 MFTM Development

The development of the MFTM checked the modelled flows of the highway model against surveyed values at the points presented in Figures 2 and 3. These, when taken together, formed two ‘cordons’, through which traffic had to pass.

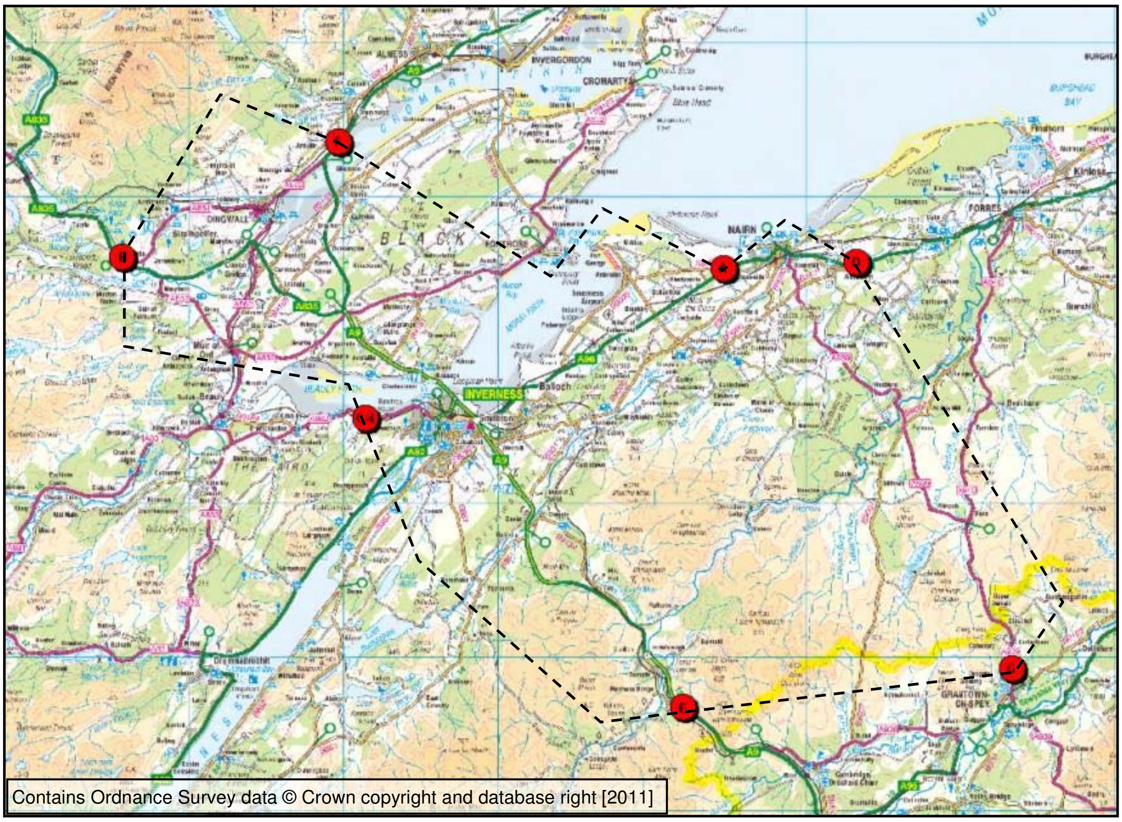


Figure 2 MFTM Outer Screenline

Figure 3 MFTM Inner Screenline

The development of the model had access to other count locations, but concentrated on the points presented above in order to fulfil its Brief. It is clear that only one point, the A82 on the Inner Screenline, is of direct relevance to the Western Link project.

2.3 Data Review

The counts collected as part of the development of MFTM were reviewed, to establish whether additional data points were available to check the suitability of the model for the Western Link appraisal. The area of interest used for this review is presented in Figure 4.

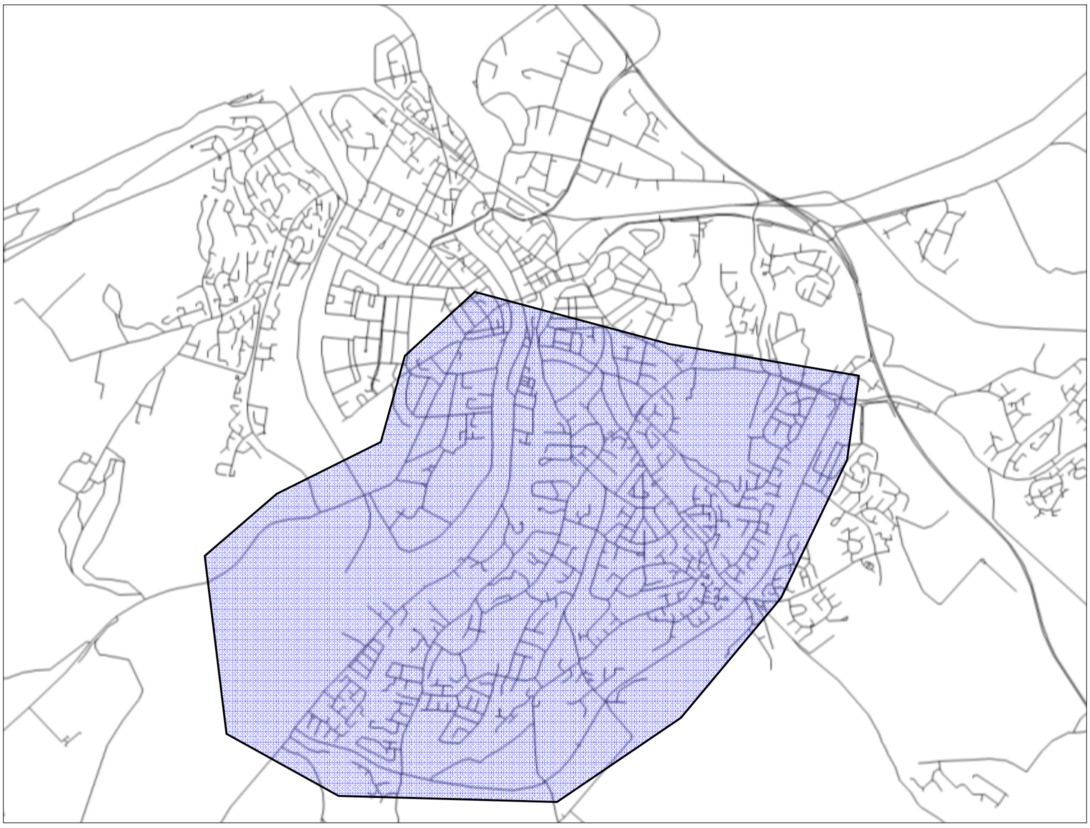


Figure 4 Area of Interest for Data Review

A total of 29 counts were identified as being available for the validation of the MFTM model for the Western Link. The choice of location of the counts was limited to where existing survey data was located; counts were used at various junction approaches on the Southern Distributor Road (SDR) corridor, as well as the A82, B861 and B862. The location of all counts used can be seen below in Figure 5.

Figure 5 Location of Link Counts used for Validation

2.4 Model Performance in Area of Interest

The MFTM was developed in line with Government guidance, as discussed in Chapter 1. In the case of highway models, current guidance and recommendations are outlined in Design Manual for Roads and Bridges (DMRB) Volume 12 Section 2. The process of adjusting the model until the assigned modelled flows meet observed criteria is called model calibration. Model validation follows calibration. The purpose of validation is to provide an independent demonstration that the model truly reflects existing traffic conditions. This analysis is therefore taking a model calibrated to the screenlines shown in Figures 2 and 3, and checking its validation against the counts shown in Figure 5.

The DMRB specifies the acceptable values for modelling and observed traffic flow comparisons and suggests how calibration and validation should relate to the magnitude of the values being compared. A summary of the criteria is included in Table 1.

Table 1 DMRB Guidelines for Screen-line / Link Calibration and Validation

DMRB Criteria and Measures	Acceptability Guideline
Individual flows within 15% for flows 700-2700 vph	> 85% of cases
Individual flows within 100 vph for flows <700 vph	
Individual flows within 100 vph for flows >2700 vph	
Total screen-line flows to be within 5%	All (or nearly all) screen-lines
Individual flows - GEH < 5	> 85% of cases
Screenline totals - GEH < 4	All (or nearly all) screen-lines

The percentage difference between observed and modelled data sets can prove to be misleading given the relative value of the difference. The standard method used to compare modelled values against observations on a link involved the calculation of GEH, which is a form of the Chi-squared statistic, incorporating both relative and absolute errors.

The GEH is a measure of comparability that takes account of, not only the difference between the observed and modelled flows, but also the significance of this difference with respect to the size of the observed flow. For instance, a difference of 50% compared to an observed flow of 10 is of far less significance than a difference of 20% compared with an observed flow of 1000. The GEH is calculated as follows:

$$GEH = \sqrt{\frac{(M-O)^2}{0.5(M+O)}}$$

Where; M is the modelled flow and O is the observed flow.

A low GEH index indicates a good correlation between the observed and modelled flows and it is generally accepted that when comparing assigned volumes with observed volumes: -

- a GEH parameter of 5 or less indicates an acceptable fit;
- a value between 5 and 10 requires review; whilst
- a value of greater than 10 requires closer attention

The MFTM base flows were extracted from the model for the identified links, and compared with the surveyed values using the GEH statistical test. A summary of the findings are presented in Table 2. Detailed findings are presented in Appendix B.

Table 2 Link GEH banding of original MFTM

GEH value	AM %	PM %
Less than 5.0	45	55
Between 5.0 and 10.0	24	17
Between 10.0 and 15.0	14	14
Greater than or equal to 15.0	17	14

The figures below present the relative GEH values for the links used in the local area validation. The size of the bar relates to the magnitude of the GEH value. Green bars indicate a GEH of under five, orange bars indicate a GEH between five and ten, and red bars indicate a GEH of greater than ten.


Figure 6: AM link GEH for original MFTM


Figure 7: PM link GEH for original MFTM

2.5 Conclusions

It is clear from the figures above that many of the validation points within Inverness did not match the surveyed values very closely. The AM average GEH value was 8.2 and the PM value was 6.8. It was therefore decided that an additional calibration task was required in order to develop a version of the MFTM specifically for use on the Western Link appraisal. This is presented in the next Chapter.

Base Year Recalibration

3 Base Year Recalibration

3.1 Introduction

As discussed in the previous Chapter, the road traffic flows in the base MFTM did not match the surveys in our area of interest sufficiently well. Consequently, a version of the MFTM was developed specifically for use on the Western Link appraisal.

The flows of traffic on links in a road traffic assignment model depend on:

- The representation of *demand*, both the amount and pattern of the trip making; and
- The representation of *supply*, which is how the roads and junctions are coded in the model.

This demand and supply are brought together through the use of an algorithm to assign trips to paths between their origin and their destination, which in aggregate make up the traffic flows on the roads.

Having decided that the flows were inadequate for our purposes, there were therefore two stages to developing a more satisfactory model:

- Check the network representation; and
- Improve the representation of demand, which is held in matrices.

This Chapter presents the results of this process.

3.2 Network Review

The development of the MFTM network representation was based on NAVTEQ mapping. It therefore contains all roads in its modelled area. However, not all links are 'active' within the model, as shown in Figure 8 below.

Figure 8 Active (black) and Inactive (grey) Links in the MFTM Network

In the review of the network, therefore, as well as the characteristics of the roads and junctions being checked against reality and modified if necessary, additional links could be activated and opened to traffic.

The network structure was investigated to determine where it could be improved and, as an example, Figure 9 highlights the Culduthel Road junction with Gordon Terrace.

Figure 9: Culduthel Road / Gordon Terrace junction

In this case it was noted that there was a particularly large flow (in both the AM and PM models) on Gordon Terrace for such a narrow, residential road. Traffic would be expected to use Mayfield Road and then turn onto Culduthel Road rather than use Gordon Terrace. A free flow speed of 45kph and capacity of 850 was considered to be too high, as the road is extremely narrow, and has poor forward visibility due to high walls and curvature. These were reduced 22kph and 450 vehicles per hour.

It was also noted that the model flow was almost double that of the survey count in the northbound direction on the A82. In order to correct this several links were opened up to traffic, as shown below.

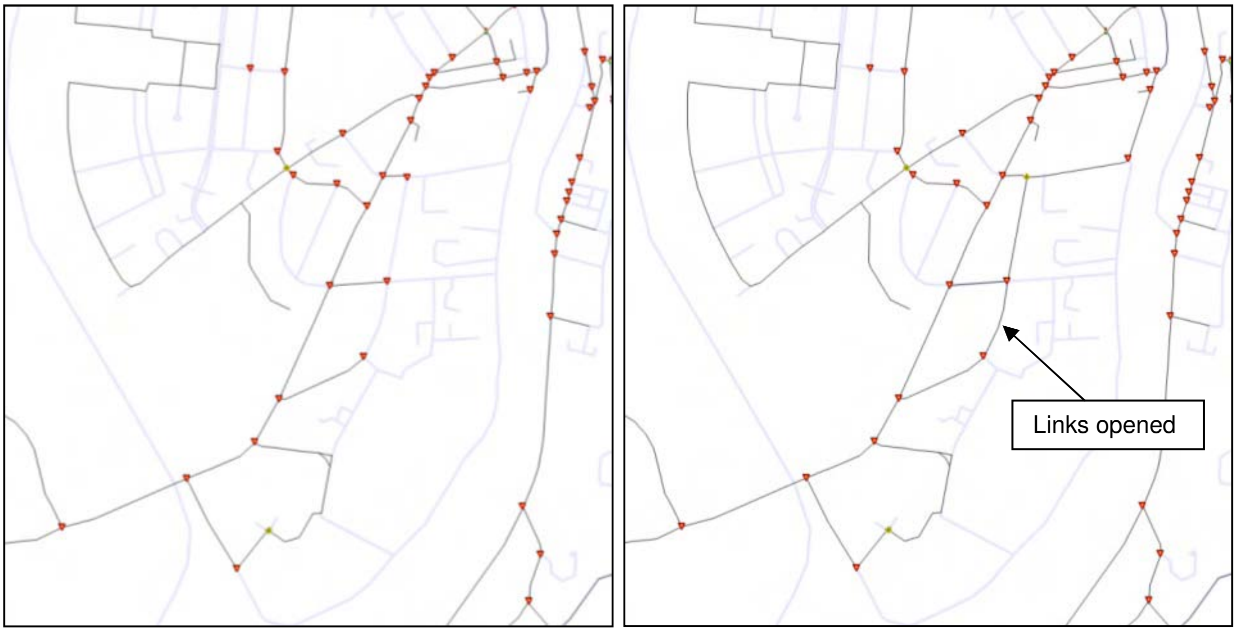


Figure 10: Links opened to vehicular traffic

The opening up of these links did not have as significant an effect as may have been anticipated as a negligible proportion of northbound traffic used the newly opened links. One of the reasons for this is that Ness Walk is closed to northbound traffic, and therefore vehicles cannot bypass the A82 / Kenneth Street signalised junction in this direction. Moreover, because traffic *can* bypass this junction in the opposite direction, some vehicles used these newly available links in order to do so. This was acceptable to a degree, as on-site observations suggest a small amount of traffic does do this, and it resulted in the westbound flow from Young Street to the A82 being more in line with the survey count.

A number of additional modifications were made, as follows:

- Old Edinburgh Road eastbound approach to the Southside Road / Old Edinburgh Road green time was increased from nine to twelve seconds – the proceeding Intergreen time was deemed unnecessarily long;
- Adjustments to Old Perth Road (minor) to minimise rat-running on this link;
- Speed reduction on the western links of Raigmore hospital to encourage more use of the eastern exit as per survey data;
- Minor change to the free flow speed on a short link on Old Perth Road eastbound (just west of Raigmore hospital) in order to maintain consistency with other sections of the road resulting in a slight increase the journey time; and
- A correction to the signal junction at the Culloden Road/Caulfield Road North junction in the PM peak to ensure that the eastbound movement has enough green time.

3.3 Calibration

As discussed in Chapter 1, the development of the MFTM, and its matrices, concentrated on trip making to and from Inverness. Data was collected in the form of Roadside Interviews (RSIs), which were undertaken at the points identified on the Outer and Inner Cordons shown in Figures 2 and 3. Movements that did not pass through the cordons, which includes all movements starting and finishing inside the inner cordon, were synthesised using outputs from the National Trip End Model fitted to observed trip length distributions. As these movements are not based on observed data, it is considered valid to adjust their values, whilst leaving 'observed' values untouched, and ensuring that trip length distributions are not distorted.

Matrix modifications were undertaken by using 'flow bundles', which allow the user to select a link and display the origin and destination of all trips that pass through that link. These O-D pairs were saved as a matrix, and modified by a factor. The observed movements were fixed, and not modified in the recalibration.

The tables below show the matrix totals prior to recalibration, alongside the final recalibrated matrix totals. Note that the totals are *inter*-zonal only, i.e. the *intra*-zonal elements of the matrices have been removed for comparison (these do not affect the assignment results).

Table 3: AM Prior and recalibrated inter-zonal matrix totals

Matrix	Original	Recalibrated	Change
Car Commute	12021	12300	+278
Car In Work	1706	1726	+20
Car Other	4353	4611	+258
LGV	1128	1128	0
HGV	471	471	0

Table 4: PM Prior and recalibrated inter-zonal matrix totals

Matrix	Original	Recalibrated	Change
Car Commute	8457	8281	-176
Car In Work	1507	1661	+154
Car Other	9264	9777	+513
LGV	1000	1000	0
HGV	303	303	0

Comparisons between the original and recalibrated matrices are presented on a sector basis in Appendix C.

The trip length distributions for the commute journey purpose before and after calibration are shown in figures Figure 11 and Figure 12.

Figure 11 AM Commute Trip Length Distribution

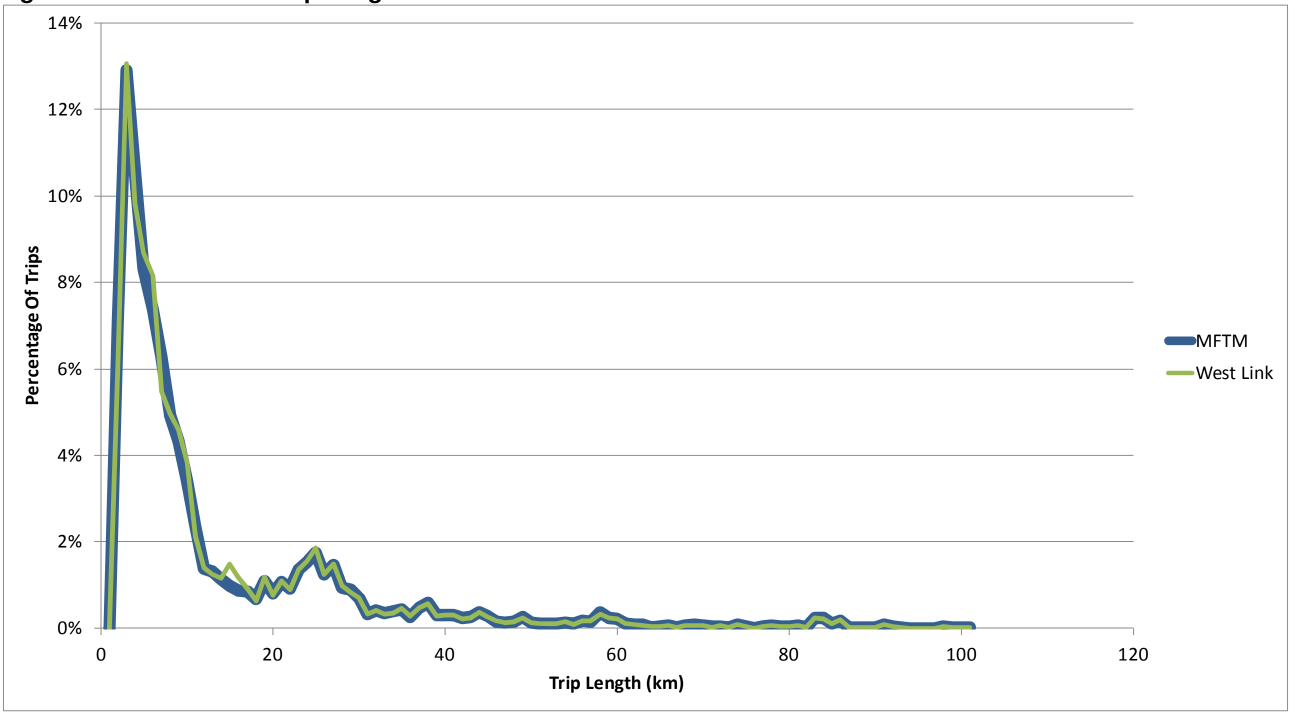
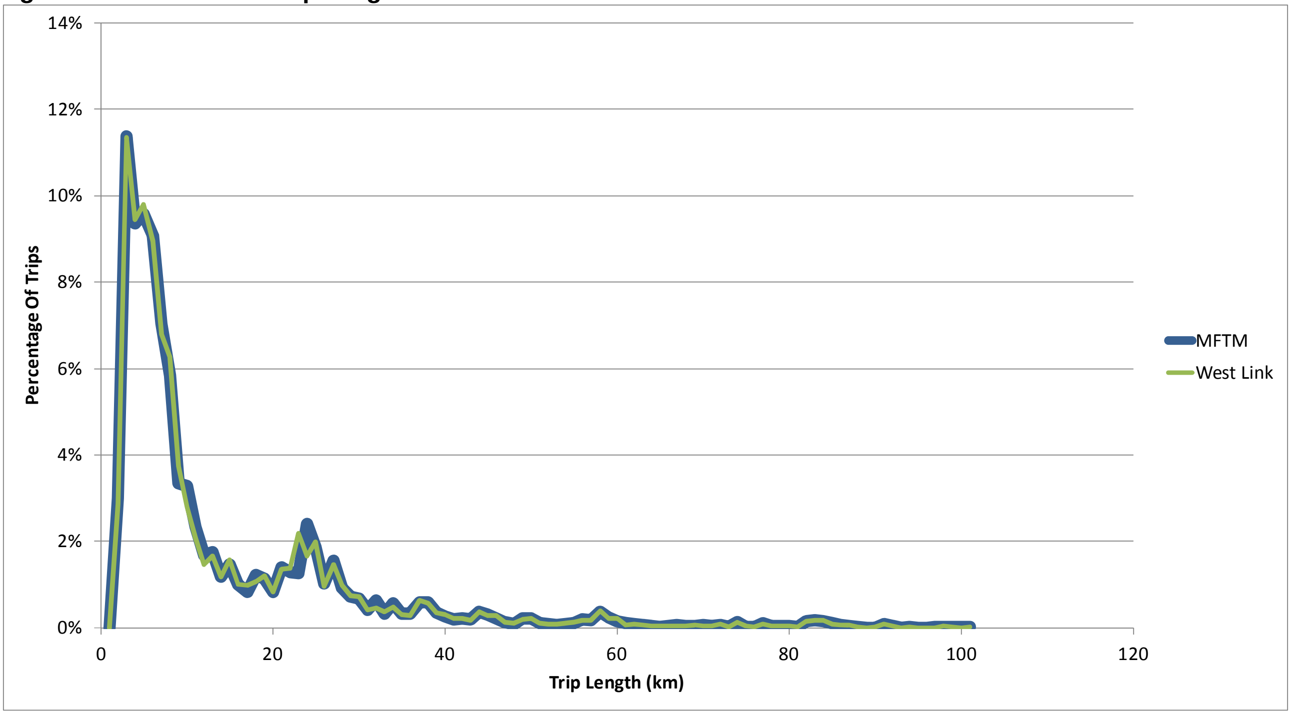


Figure 12 PM Commute Trip Length Distribution



Both AM and PM peak model trip distributions indicate only minor changes due to the additional calibration process undertaken to develop the Western Link version of the MFTM. This shows that the matrix estimation process has not unduly distorted the matrices beyond what would be acceptable. Trip Length Distributions for other purposes are shown in Appendix D.

Following the recalibration of the model, the GEH statistics were as shown below in Table 5. Detailed results are presented in Appendix E.

Table 5: Link GEH banding after recalibration

GEH value	AM %	PM %
Less than 5.0	93	90
Between 5.0 and 10.0	7	10
Between 10.0 and 15.0	0	0
Greater than or equal to 15.0	0	0

The table above shows a significant improvement in the GEH results for both the AM and PM peak. Both models pass the DMRB guidance for GEH (85% of links under five), with 93% of AM links passing and 86% of PM links passing the GEH criterion.

The figures below indicate the relative GEH values for the links after the recalibration process was undertaken. As before, the size of the bar relates to the magnitude of the GEH value. Green bars indicate a GEH of under five, orange bars indicate a GEH between five and ten, and red bars indicate a GEH of greater than ten. It can be seen that there are no GEH values over ten, and the majority of GEH values are under five.

Figure 13: AM link GEH after recalibration

Figure 14: PM link GEH after recalibration

As shown previously in Table 1, in addition to the GEH criterion, DMRB states that for links where the survey flow is under 700 vehicles per hour, the difference between the modelled and survey flow must be within 100 vehicles. Furthermore, if the hourly flow is greater than 700 but less than 2700, the difference must be within 15%. Links must either pass this criterion or the aforementioned GEH criterion. Taking cognisance of this, 97% of the AM link flows pass the DMRB criteria with the average GEH across all links of 2.5. In the PM peak, 100% of the link flows pass the DMRB criteria with an average GEH of 3.0 across all links.

3.4 Validation

The purpose of validation is to provide an independent demonstration that the model truly reflects existing traffic conditions. The validation procedure demonstrates the satisfactory operation of the modelling platform and ensures that the model is both robust, and suitable, for further use and development.

It is important to demonstrate that the calibration procedure, while improving the fit of the model to observed data in the area of interest to the Western Link, has not invalidated the model in other areas. Table 6 presents a summary of the comparison between modelled and surveyed flow on the inner and outer cordons shown in figures Figure 2 and Figure 3, in terms of the DMRB criteria presented in Chapter 2.

Table 6 Inner and Outer Cordon Link Flow Validaton

DMRB Criteria	Result Achieved	
Modelled Flows against Observed Flows satisfying DMRB criteria (DMRB Target > 85%)	**AM Peak Hour**	**PM Peak Hour**
Individual flows within 100 vph for flows <700 vph	100%	95%
Individual flows within 15% for flows 700-2700 vph	100%	100%
Individual flows within 400 vph for flows >2700 vph	N/A	N/A
Average GEH	2.1	2.2
GEH Statistic for individual flows < 5	100%	92%

The table illustrates that the updated model has not adversely affected the model in areas outwith the area of interest to the Western Link project.

An additional measure of the overall performance and robustness of the model is to consider particular journeys through the assigned network and compare the known observed travel times with those predicted by the model. This combines the delays which are simulated along each link and turn along the route presenting a good indication of the comparison between known and actual journey movements.

Guidance in the DMRB is set out in Table 7.

Table 7 Model Validation Journey Time Criterion

DMRB Criteria and Measures	Acceptability Guideline
Modelled journey times Compared with Observed Times:	
Times within 15% (or 1 minute if higher)	> 85% of cases

The journey time routes in the MFTM model were collected for the development of the model from 11 November 2009 to 26 November. Journey time analysis was split into two distinct sectors i) Inner journey routes ii) Outer journey routes. They were carried out over a long period in order to avoid clashing with other surveys (RSIs etc) being carried out as part of the MFTM survey programme. The list of the journey time survey routes is shown below in Table 8. Diagrams of the Journey time route are presented in Appendix F.

Table 8 MFTM Journey Time Routes

Code	Journey Time Route	Survey Date
Route 1 Inner	A862 Delmore to Inshes Roundabout.	16/11/2009
Route 2 Inner	General Booth Road to Longman roundabout.	19/11/2009
Route 3Inner	Telford Street to Raigmore.	11/11/2009
Route 4 Inner	Culloden Rd / A9 slips to Millbank on-ramp.	12/11/2009
Route 1 Outer	A9 / A862 to A9 / B9169.	17/11/20009
Route 2 Outer	A835 / A9 to A835 / A832.	18/11/20009
Route 3 Outer	A862 / A835 to A862 / B9164.	23/11/2009
Route 4 Outer	A831 / A862 to 862 where High Street Ends and becomes Clachnaharry Road.	26/11/2009
Route 5 Outer	Forres Road/A939 to Raigmore via the A96.	16-18/6/2009

Table 9 displays the results of the journey time validation tests for all routes. Full detailed analysis of the journey time routes is shown in Appendix G.

Table 9 Journey Time Validation Statistics

DMRB Criteria	Result Achieved (%)	
Modelled Journey Times within 15% (or 1 minute if higher) of the Observed Times	**AM Peak Hour**	**PM Peak Hour**
	83.3	94.4
(DMRB Target > 85% of routes)	FAIL	PASS

The recalibration of the MFTM for use in the Western Link appraisal has resulted in one AM Peak journey time decreasing from 92.3% of the average journey time to 84.2%, just outside the +-15% limit, resulting in an effective failure against DMRB criteria. However, this journey time (Inner 2, Eastbound) has a 95% confidence interval recorded in the MFTM development report of +-26%, meaning that the modelled journey time is within the range of values that will be valid 95% of the time.

Forecasting: Network Coding

4 Forecasting: Network Coding

4.1 Introduction

The Western Link is not expected to open until 2017. Also, it is common practice to include in an assessment not only the opening year, but opening year plus 15 i.e. 2032. It is therefore necessary to produce models that forecast conditions in that year in order to assess the effect of the proposal. Typically, the road network, patterns of land use, and other factors such as fuel price and wealth in the economy, will change between the base year of the model (2009) and 2017, and then 2032. We therefore need to take account of these changes when developing a forecast model.

This Chapter discusses the development of the road networks intended to represent these changes. Discussion of the representation of land use changes, such as housing developments, new shops, jobs etc, are dealt with in the next chapter.

4.2 Do Minimum

In the appraisal of a transport intervention, it is not adequate to simply compare a scheme scenario with the current network situation. In order the isolate the effect of the intervention we must develop a 'Do-minimum' scenario that best represents the network situation in the assessment years with the scheme. This 'Do Minimum' contains all changes from the base that are expected to be built by the time the scheme opens.

The basis for the Do Minimum was taken as the schemes included in Transport Scotland's work to on the A96 between Inverness and Nairn. In discussion with THC the Do Minimum was defined as the current year situation, plus:

- Modifications to Culloden Road, including the introduction of a new arm to the Culloden Road / A9 slip road junction to serve the new Beechwood Campus;
- Dalcross rail station;
- A new circular bus service linking Dalcross rail station and Inverness airport;
- A new Inverness to Nairn rail service; and
- The replacement of Inshes roundabout with a signal controlled junction including left turn bypass lanes.

It was agreed that these networks would be used for the 2017 and 2032 scenarios, as there is no committed scheme after 2017.

4.3 Do Something Scenarios

Eight Do Something scenarios were then created, making changes to the Do Minimum in line with the schematics already presented in Appendix A. The network coding is shown in Figure 15, with the scheme highlighted in red.

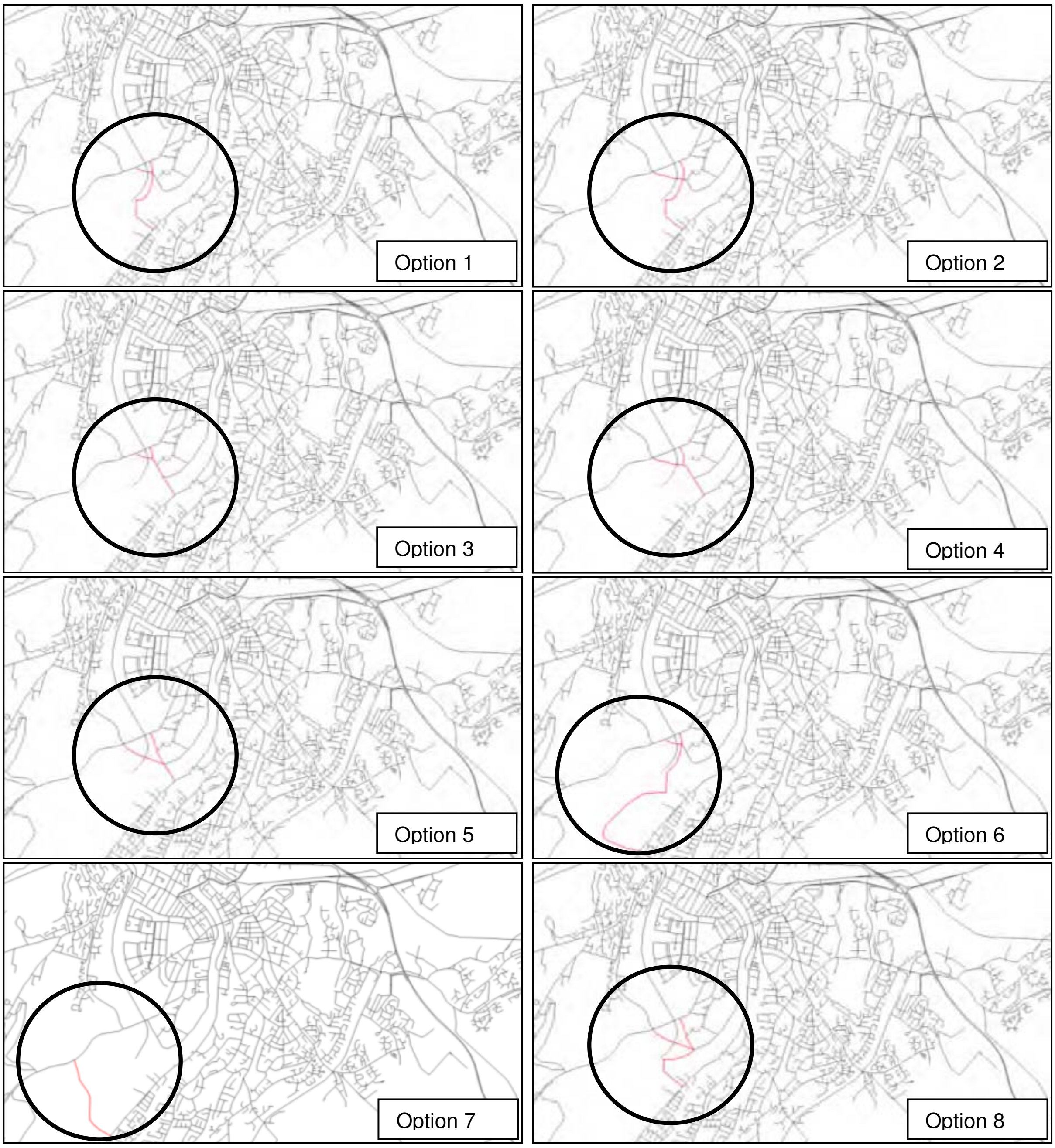


Figure 15 Scheme Coding (highlighted in red)

Forecasting: Trip End Development

5 Forecasting: Trip End Development

5.1 Introduction

This chapter discusses the methods used to represent the changes in patterns of land use between the base year (2009) and the forecast years (2017 and 2032).

5.2 Planning Forecast Scenario

The MFTM uses planning data, providing employment, households, and population levels to forecast changes in trip making over time within, and 'to and from' the internal demand model area. This data was prepared by THC, and supplied as:

- number of jobs split by 12 categories consistent with the National Trip End Model (NTEM);
- number of households and second homes; and
- population split by 11 categories consistent with NTEM.

The data was supplied in the geographic units that make up the MFTM, the zones. These are shown in Figures 16 and17.

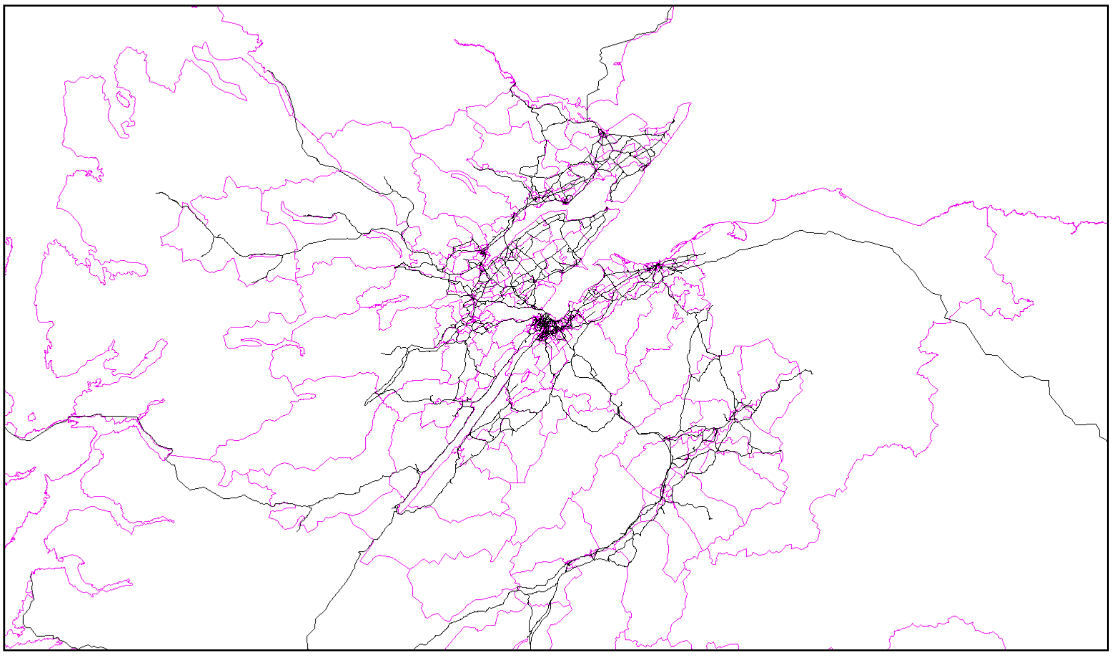


Figure 16 MFTM Zone System - wide area view

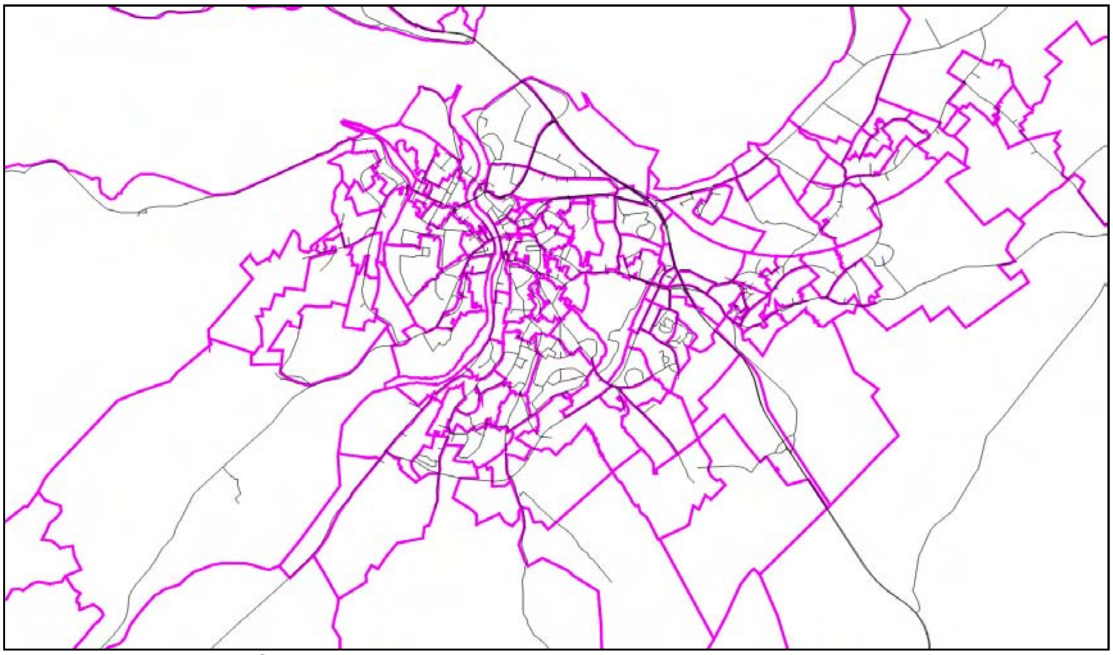


Figure 17 MFTM Zone System - close up of Inverness

The scenario supplied by THC represented a situation with the expected build-out, without development that depends upon non-committed transport schemes. For example, the development at Ness Side that is dependent on the Western Link to be built is not included in this scenario. It does include, for example, developments such as the ASDA supermarket at Slackbuie.

The predicted levels of employment, households, and population across the MFTM modelled area are presented in Table 10

Table 10 Forecast Planning Data Totals

	Employment	Households	Population
2009	74,146	65,886	143,392
Opening Year (2017)	79,641	72,854	154,825
% Change from Opening Year	+7	+11	+8
Opening Year +15 (2032)	86,884	82,793	164,244
% Change from Opening Year	+17	+26	+15

5.3 Demand

The planning data is used to develop growth factors that are applied the 2009 base demand matrices in order to generate an initial set of demand matrices. As discussed in Chapter 1, these are then input into each scenario's demand model, and are modified in response to changes in transport cost. The demand matrix totals are presented in the following tables:

Table 11 AM Peak Hour Travel Demand (vehicles)

Mode:	Car		
Purpose:	Commute	In Work	Other
2009	12,300	1,726	4,611
Opening Year (2017)	13,307	1,904	5,271
% Change from Opening Year	+8	+10	+14
Opening Year +15 (2032)	14,538	2,099	6,090
% Change from Opening Year	+18	+22	+32

Table 12 PM Peak Hour Travel Demand (vehicles)

Mode:	Car		
Purpose:	Commute	In Work	Other
2009	8,281	1,661	9,777
Opening Year (2017)	9,937	1,986	11,808
% Change from Opening Year	+20	+20	+21
Opening Year +15 (2032)	10,987	2,200	13,779
% Change from Opening Year	+33	+32	+41

Economic Assessment / Scenario Results

6 Economic Assessment / Scenario Results

6.1 Introduction

This Chapter describes the development of the Transport Economic Efficiency (TEE) part of the Economy objective of the Scottish Transport Appraisal Guidance (STAG)[1]. It describes the key issues in the calculation of the TEE outcomes and then provides the outcomes themselves.

6.2 Key Issues

The methodology adopted follows the guidance given in STAG sections 9.2, which describes the TEE as assessing "…the contribution which a transport option may have on economic welfare through consideration of the resultant transport costs and benefits". It makes use of the standard HM Government guidance contained in WebTAG[2] section 3.5.6, and of the Department for Transport (DfT) software TUBA (Transport User Benefits Appraisal)[3], which was developed by the DfT for undertaking economic appraisals for transport schemes.

The outputs are calculated by comparing the forecast outcome with each scheme in place with the forecast outcome without the scheme. The transport benefits and disbenefits identified are then, therefore, only due to the effects of the scheme implementation.

Not all benefits to transport users have been quantified in this assessment. For example, it was not possible to monetise the quality or reliability benefits. The quantified benefits are presented in 2002 prices, with values discounted to 2002 values as required by STAG. They are assessed over a period of 60 years from the opening of the link.

6.3 Inputs Supplied by THC

In addition to the option schematics presented in Appendix A, and the planning data previously discussed, THC prepared and supplied estimates of the cost of constructing and maintaining each of the eight options, and spend profiles for the five years of construction. These included periodic major maintenance after opening, allowances for risk and optimism bias, and special costs such as British Waterways charges for temporary closure of the canal to construct an aqueduct structure. Summaries of the costs supplied are presented in Appendix H.

6.4 Critical Assumptions

With no representation of the inter-peak period, or the off peak (overnight) period, it was assumed that no benefits accrue in hours that are outwith the peaks. The costs for provision of the Active Travel Network (Access tracks, Riverside Improvements for Cyclists, and Park and Ride Facilities) are included in the costs, despite the potential net benefits of the investment not being included in the modelled benefits (as the MFTM does not include cycling or walking). As a result of both of these assumptions it is considered that the overall outcomes are conservative, in that they will tend to underestimate the economic benefits.

Construction price inflation is assumed to be 3% for the duration of the build. The RPI target of 2.5% is assumed to be realised, given a real increase in construction prices of 0.5% per annum.

6.5 Network Flow Effects

Appendix I presents diagrams showing the Do Minimum flows, and the change in flows due to the introduction of each West Link option, for each time period (AM and PM) and forecast year (2016 and 2031).

6.6 Economic Assessment Results

The direct economic impacts of a project are captured by a "cost-benefit" analysis which is expressed in monetary terms. The project costs (PVC) to Government and benefits (PVB) to society (such as savings in distance travelled) are combined to produce a Net Present Value (NPV). All values are discounted back to a common base year, which is currently 2002.

A positive NPV implies that the benefits to users are of greater value than the costs, whereas a negative NPV implies the benefits have a lower value than the costs. The benefit cost ratio (BCR) is a simple calculation (PVB divided by PVC) to illustrate the net

[1] http://www.transportscotland.gov.uk/stag/home
[2] http://www.dft.gov.uk/webtag/
[3] http://www.dft.gov.uk/topics/appraisal-evaluation/tools/tuba/

benefit of spending each £1 on the project. In purely economic terms, a BCR greater than 1 suggests that a project is worth undertaking, in the absence of any constraints on funding.

A summary of the results is given in the tables below; Table 13 presents the results in £millions, and Table 14 ranks the options against each other, highest (1) to lowest (8).

Table 13 Monetised Summary of Costs and Benefits (£millions, 2002 values and prices)

Option	1	2	3	4	5	6	7	8
Present Value of Benefits	56.5	59.9	60.0	65.7	65.8	59.7	63.9	58.6
Present Value of Costs	14.4	16.7	18.1	19.7	18.9	16.2	44.3	47.8
Net Present Value	42.1	43.2	41.9	46.1	46.9	43.5	19.7	10.8
Benefit Cost Ratio*	3.931	3.587	3.323	3.341	3.483	3.686	1.444	1.227

* Note: ratio, not monetary value

Table 14 Ranking of Costs and Benefits (1 = highest, 8 = lowest)

Option	1	2	3	4	5	6	7	8
Present Value of Benefits	8	5	4	2	1	6	3	7
Present Value of Costs	1	3	4	6	5	2	7	8
Net Present Value	5	4	6	2	1	3	7	8
Benefit Cost Ratio	1	3	6	5	4	2	7	8

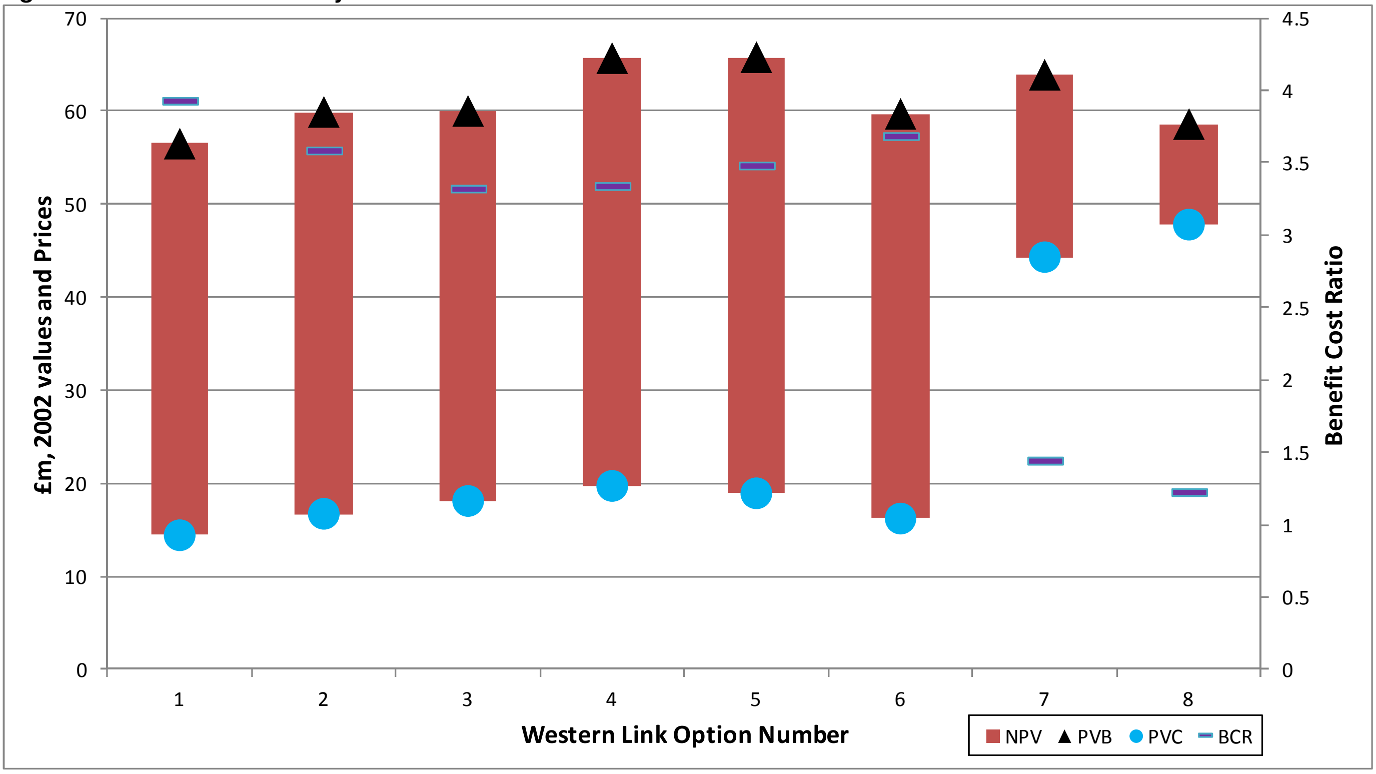
In all the scenarios analysed as part of the appraisal, the benefits were found to be greater than the costs. The benefits of all options are in a relatively narrow band. The option with the lowest PVB gives 86% of the benefit of that with the highest PVB.

As the benefits are so similar, the Net Present Value and Benefit Cost Ratio are largely determined by the cost levels. With regard to costs, the options fall into two camps:

- options 1 to 6 are similar, with a gap of £5.3m between the most expensive (option 4) and least expensive (option 1); and
- options 7 and 8, which are more than three times the cost of the cheapest option.

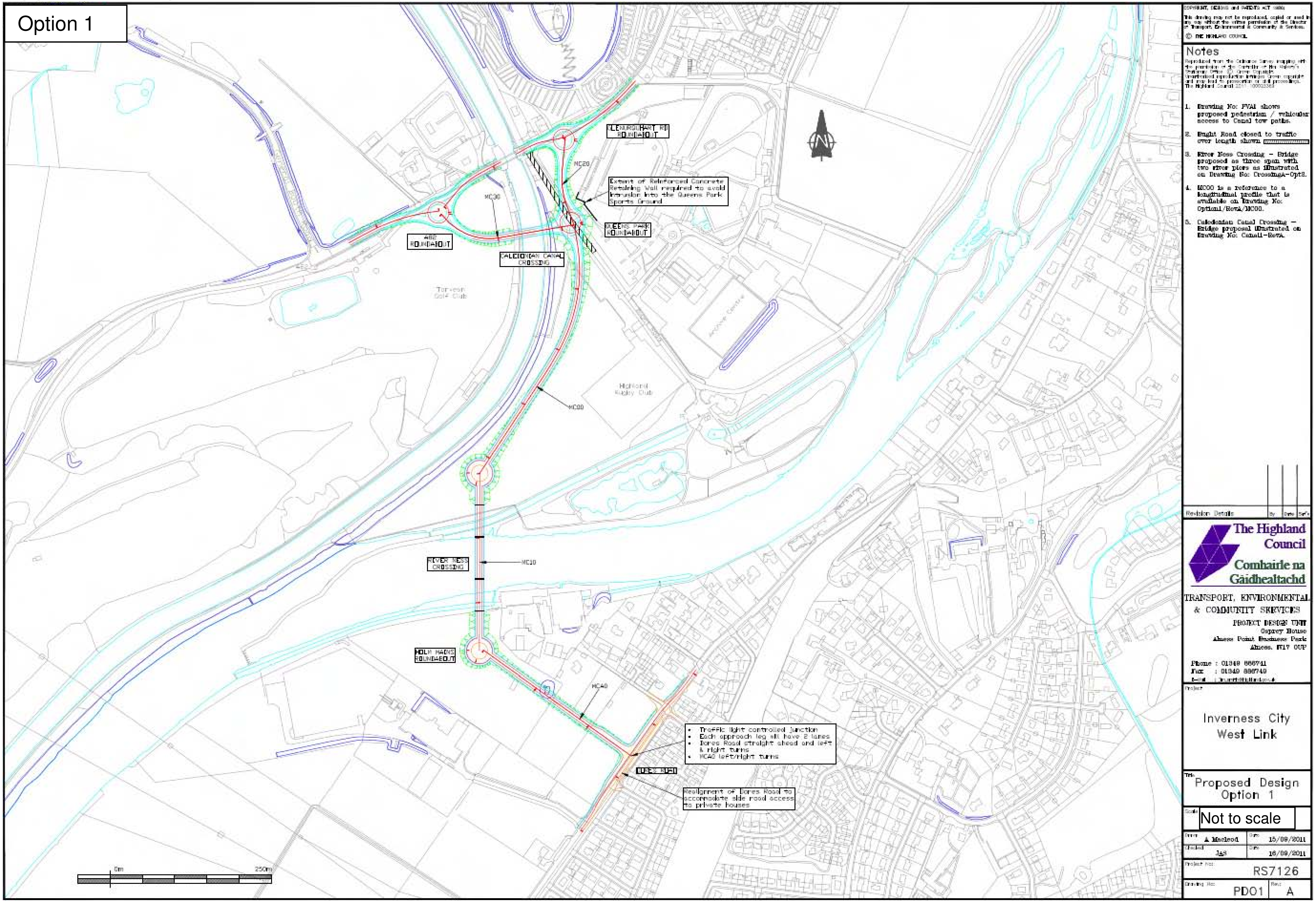
It is unsurprising, therefore, that options 7 and 8 have the lowest net benefit (the NPV) and benefit per pound spent (the BCR). The other options are clustered in a relatively narrow band, as illustrated by Figure 18.

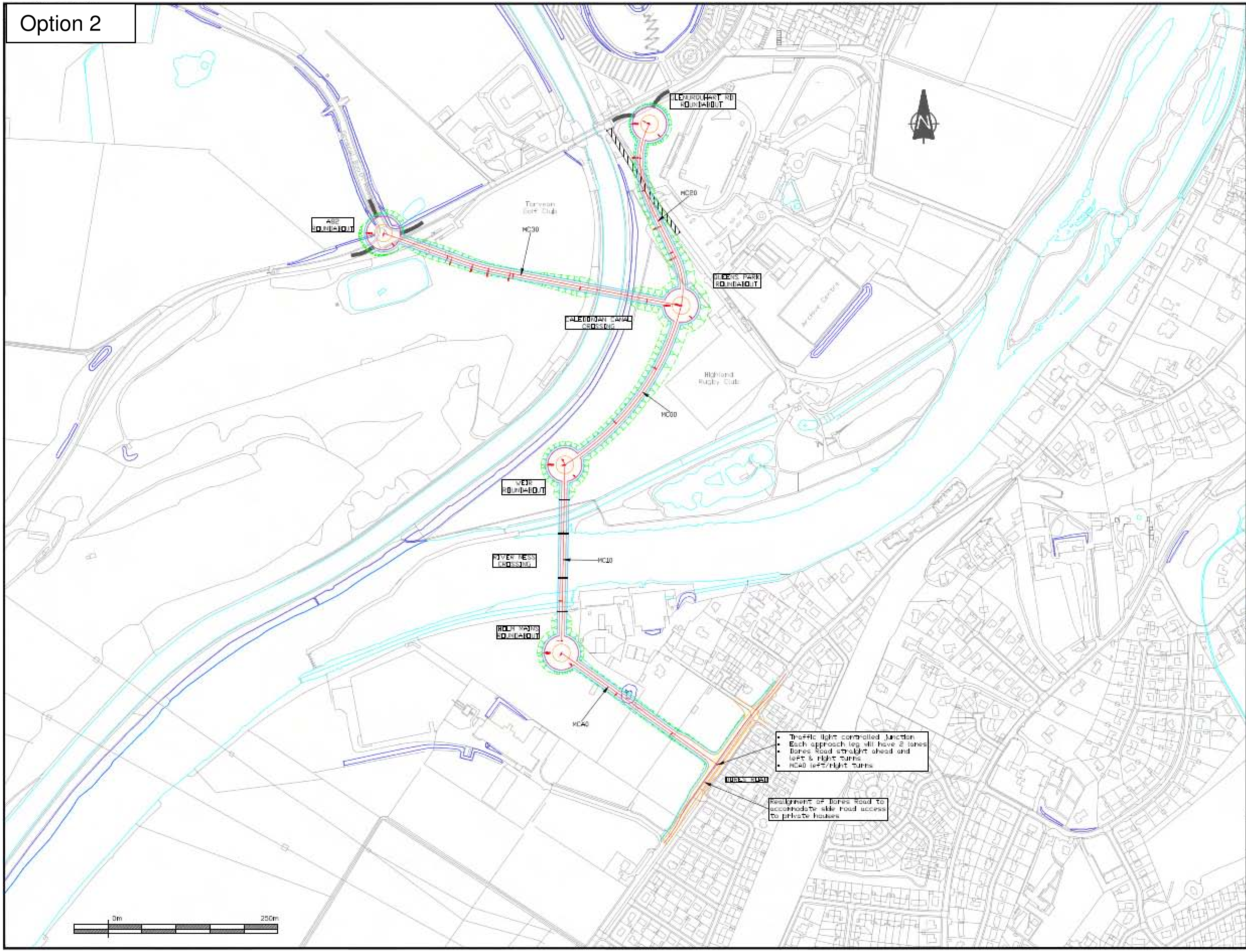
Figure 18 Monetised Summary of Costs and Benefits



Appendix A: Option Schematics

Appendix A: Option Schematics





Notes

1. Drawing No: PVA2 shows proposed pedestrian / vehicular access to Canal tow paths.
2. Bught Road closed to traffic over length shown
3. River Ness Crossing – Bridge proposed as three span with two river piers as illustrated on Drawing No: CrossingA–Opt2.
4. MC00 is a reference to a longitudinal profile that is available on Drawing No: Option2/RevA/MC00.
5. Caledonian Canal Crossing – Bridge proposed illustrated on Drawing No: Canal1–RevA.

Revision Details | By | Date | Suffix

The Highland Council
Comhairle na Gàidhealtachd

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PROJECT DESIGN UNIT
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Alness Point Business Park
Alness, IV17 0UP

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Project

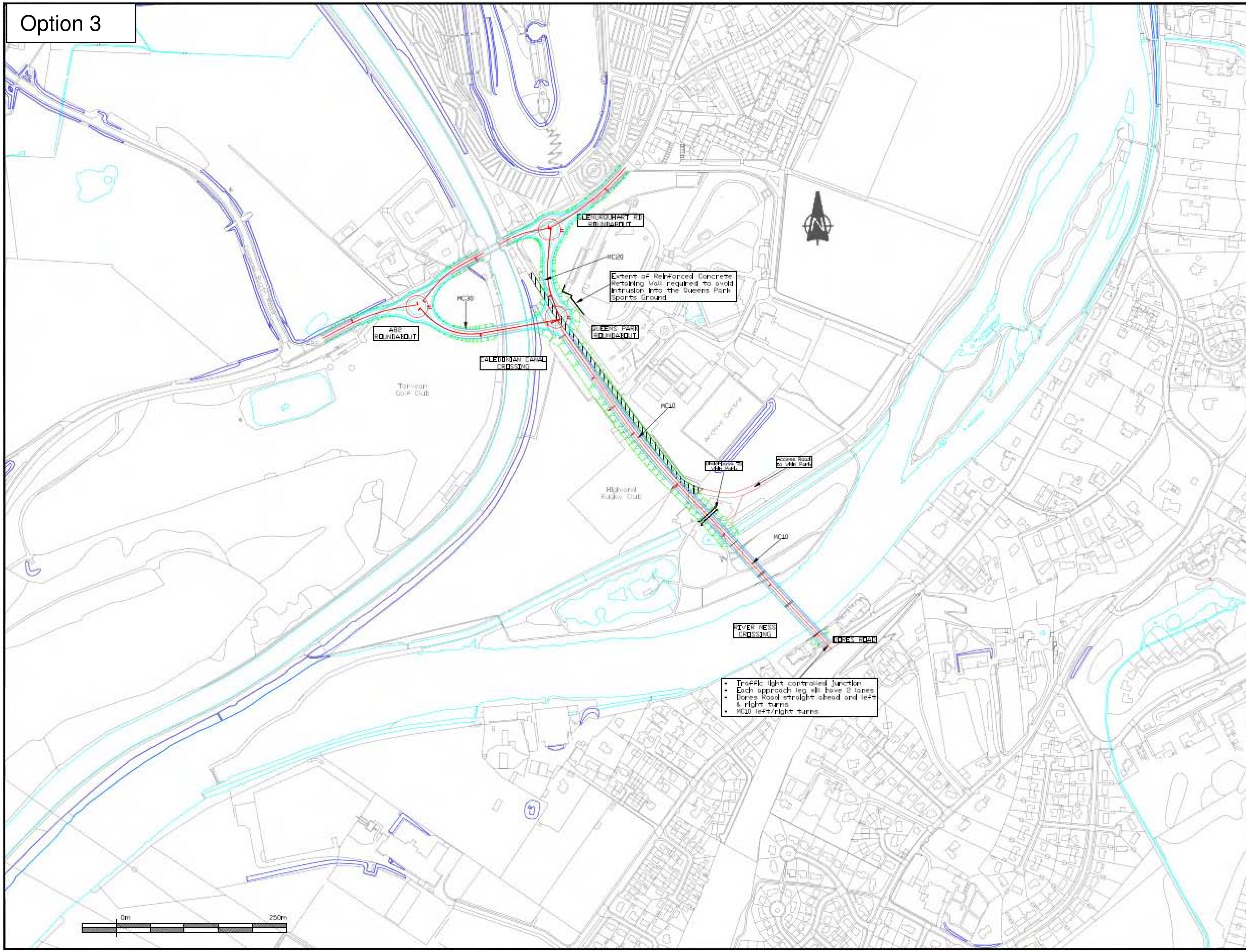
Inverness City West Link

Title

Proposed Design Option 2

Scale	Not to scale		
Drawn	A Macleod	Date	15/09/2011
Checked	JAS	Date	16/09/2011
Project No:	RS7126		
Drawing No:	PD02	Rev:	A

Option 3



Notes

1. Drawing No: PVA3 shows proposed pedestrian / vehicular access to Canal tow paths.
2. Bught Road closed to traffic over length shown
3. River Ness Crossing – Bridge proposed as three span with two river piers as illustrated on Drawing No: Crossing3–Opt6.
4. MC10 is a reference to a longitudinal profile that is available on Drawing No: Option3/RevA/MC10.
5. Caledonian Canal Crossing – Bridge proposal illustrated on Drawing No: Canal1–RevA.

Revision Details	By	Date	Sig's

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E-mail : [illegible]

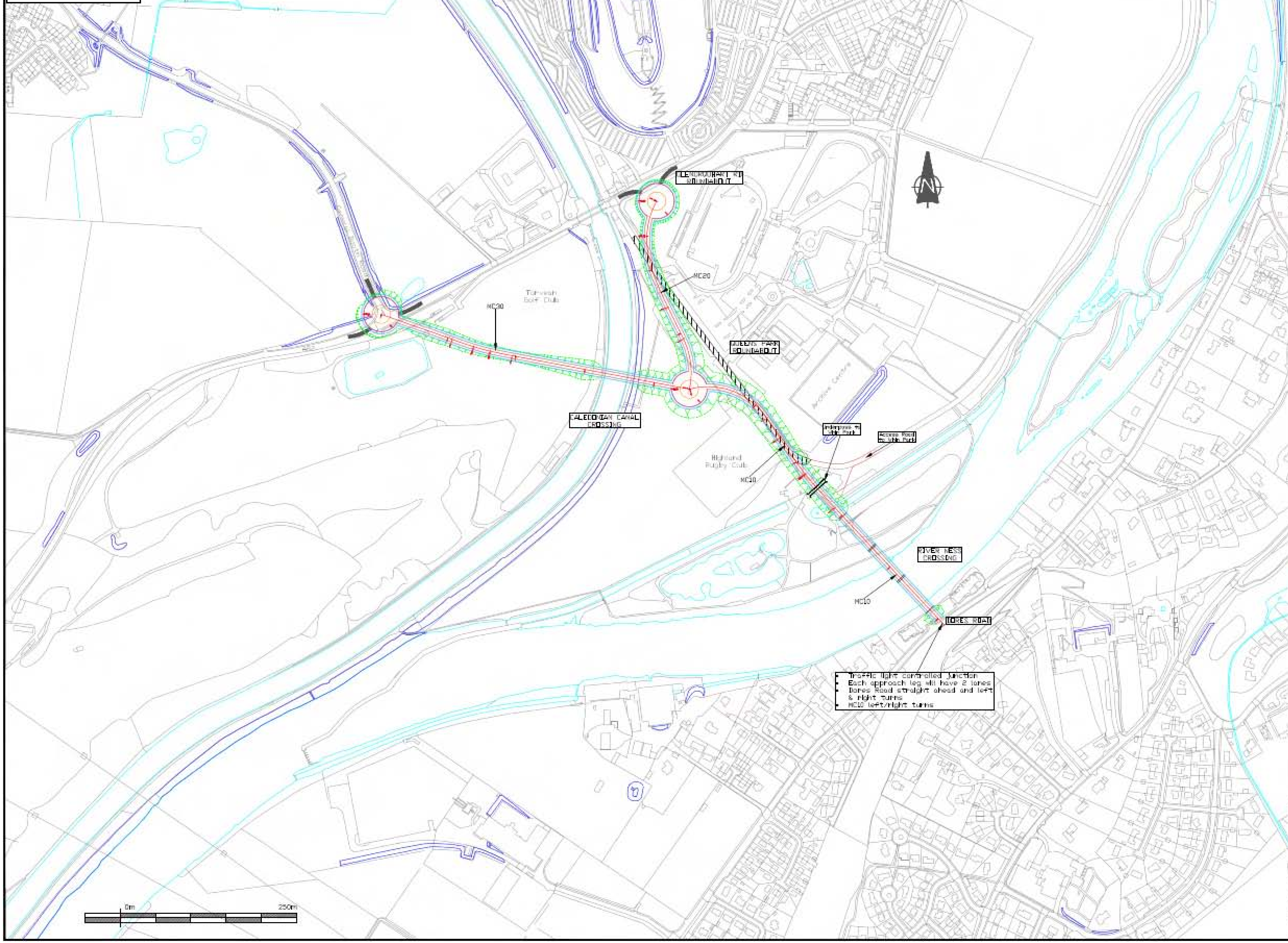
Project: Inverness City West Link

Title: Proposed Design Option 3

Scale: Not to scale

Drawn	A Macleod	Date	15/09/2011
Checked	JAS	Date	16/09/2011
Project No:	RS7126		
Drawing No:	PD03	Rev:	A

Option 4



Notes

1. Drawing No: PVA4 shows proposed pedestrian / vehicular access to Canal tow paths.
2. Bught Road closed to traffic over length shown
3. River Ness Crossing – Bridge proposed as three span with two river piers as illustrated on Drawing No: CrossingB–Opt6.
4. MC10 is a reference to a longitudinal profile that is available on Drawing No: Option4/RevA/MC10.
5. Caledonian Canal Crossing – Bridge proposal illustrated on Drawing No: Canal1–RevA.

Revision Details	By	Date	Sw'd

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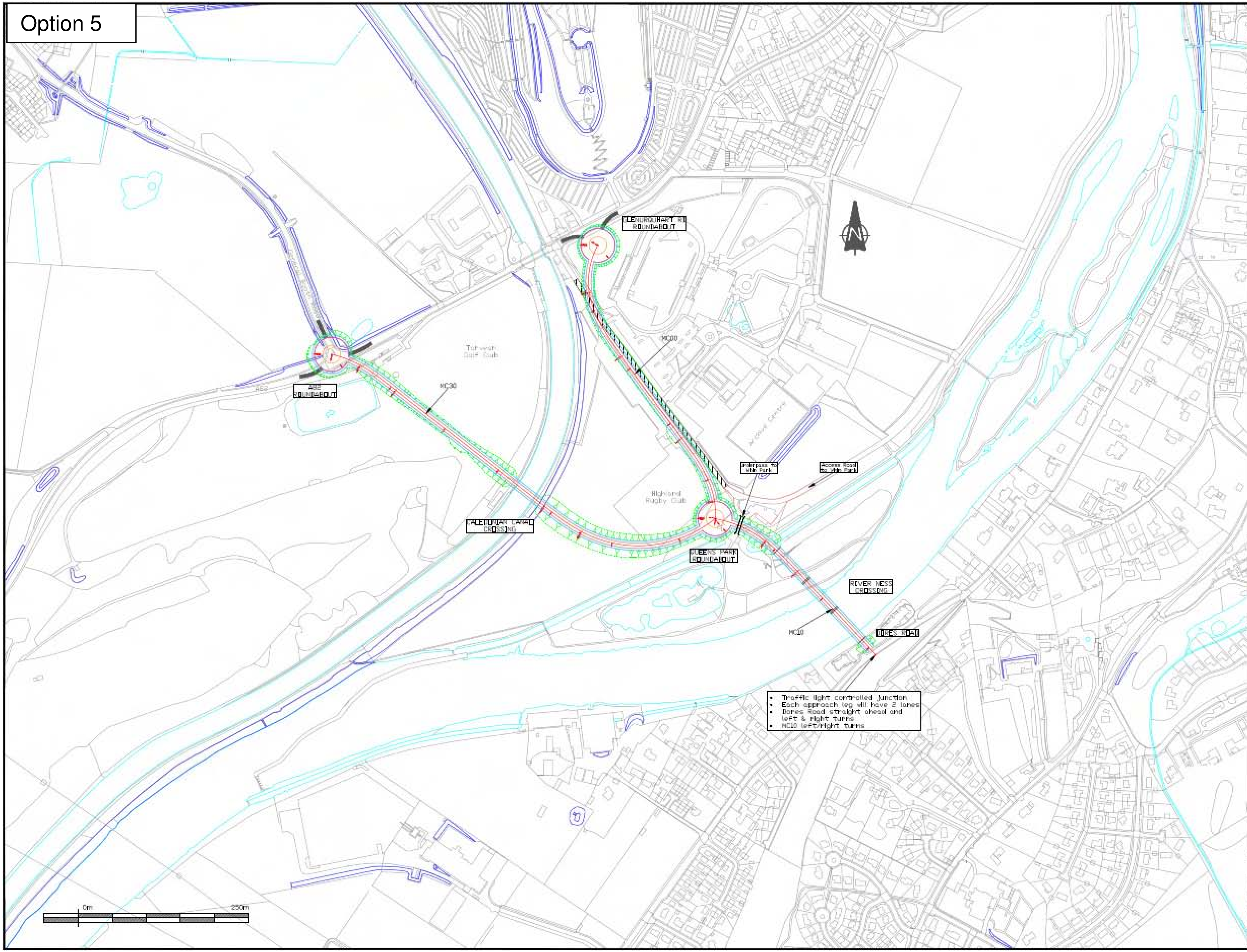
Project: Inverness City West Link

Title: Proposed Design Option 4

Scale: Not to scale

Drawn	A Macleod	Date	15/09/2011
Checked	JAS	Date	16/09/2011
Project No:	RS7126		
Drawing No:	PD04	Rev:	A



Notes

1. Drawing No: PVA5 shows proposed pedestrian / vehicular access to Canal tow paths.
2. Bught Road closed to traffic over length shown
3. River Ness Crossing – Bridge proposed as three span with two river piers as illustrated on Drawing No: Crossing3–Opt6.
4. MC00 is a reference to a longitudinal profile that is available on Drawing No: Option5/RevA/MC00.
5. Caledonian Canal Crossing – Bridge proposed illustrated on Drawing No: Canal1–RevA.

Revision Details	By	Date	Ref's

The Highland Council
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Project

Inverness City West Link

Title

Proposed Design Option 5

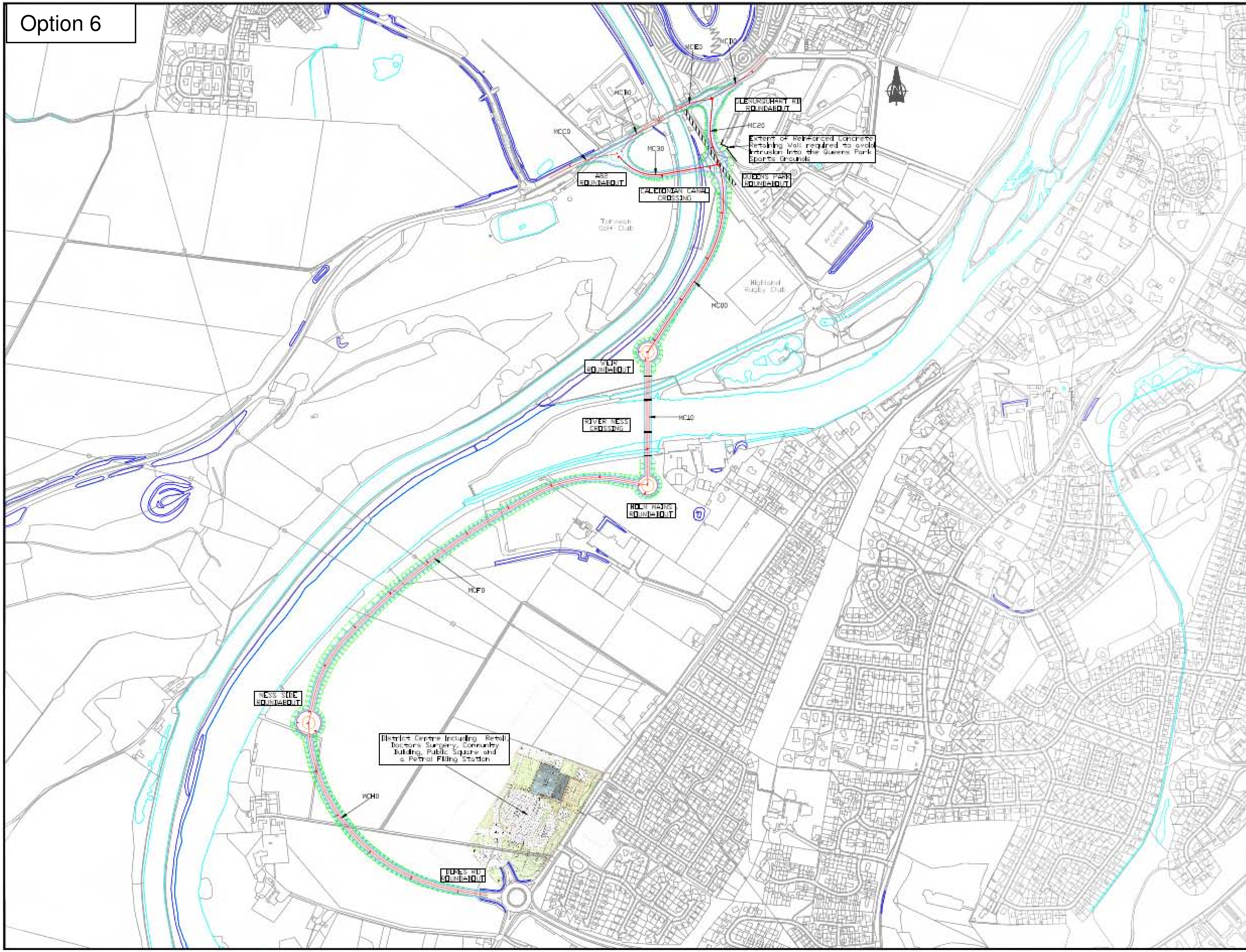
Scale: Not to scale

Drawn	A Macleod	Date	15/09/2011
Checked	JAS	Date	16/09/2011

Project No: RS7126

Drawing No: PD05 | Rev: A

Option 6



Notes

1. Drawing No: PTA6 shows proposed pedestrian / vehicular access to Canal tow paths.
2. Bught Road closed to traffic over length shown
3. River Ness Crossing – Bridge proposed as three span with two river piers as illustrated on Drawing No: CrossingA–Opt2.
4. MC00 is a reference to a longitudinal profile that is available on Drawing No: Option6/RevA/MC00.
5. Caledonian Canal Crossing – Bridge proposal illustrated on Drawing No: Canal1–RevA.

Revision Details | By | Date | Chk'd

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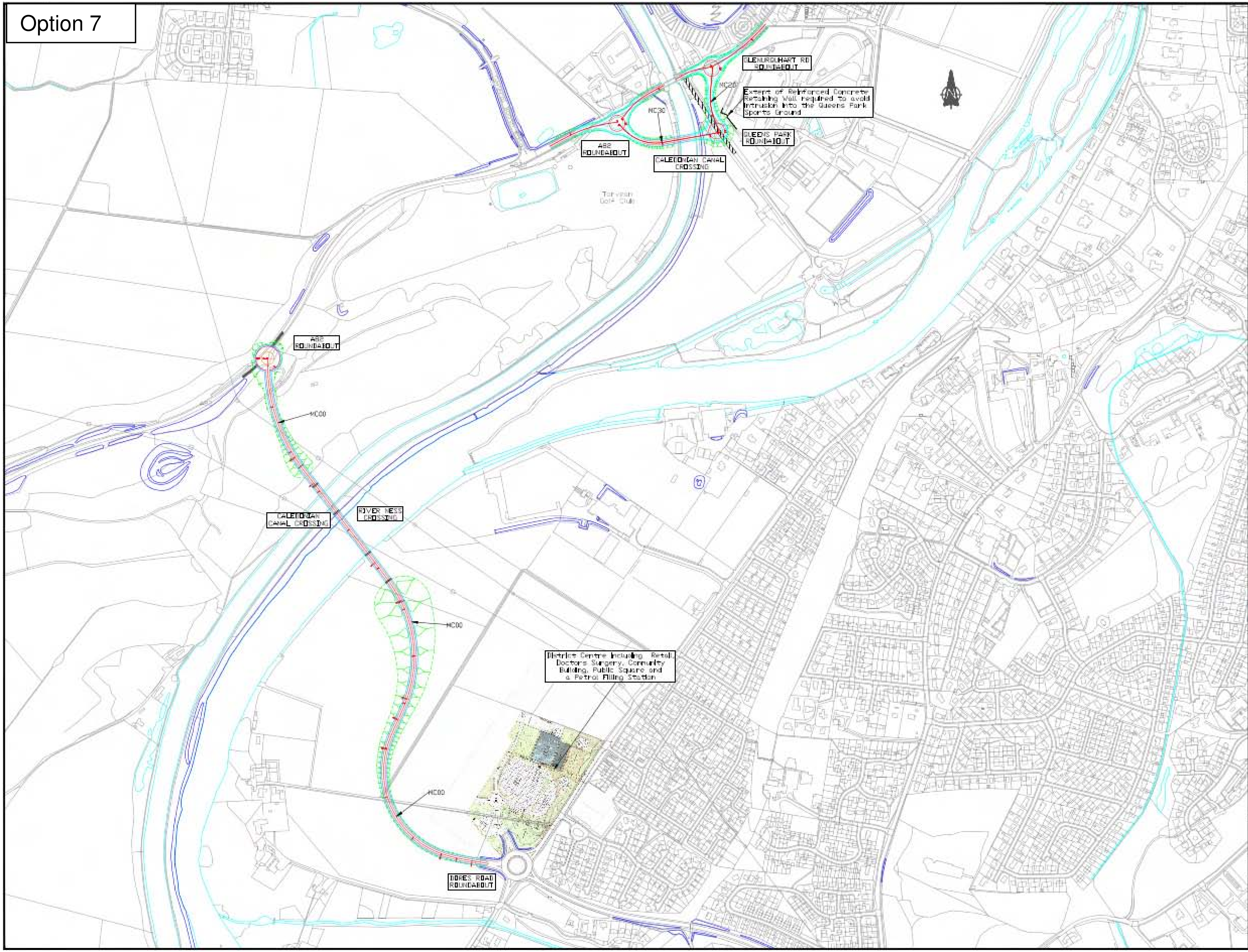
Project: Inverness City West Link

Title: Proposed Design Option 6

Scale: Not to scale

Drawn	A Macleod	Date	15/09/2011
Checked	JAS	Date	16/09/2011
Project No:	RS7126		
Drawing No:	PD06	Rev:	A



Notes

1. Drawing No: PVA7 shows proposed pedestrian / vehicular access to Canal tow paths.
2. Caledonian Canal and River Ness Crossing – Bridge proposed as five span with two river piers as illustrated on Drawing No: Crossing7A.
3. MC00 is a reference to a longitudinal profile that is available on Drawing No: Option7/RevA/MC00.
4. Bught Road closed to traffic over length shown
5. Caledonian Canal Crossing – Bridge proposal illustrated on Drawing No: Canal1-RevA.

Revision Details	By	Date	Ref's
Additional Caledonian Canal Crossing added.	AMK	30/9/11	B
Addition of Tesco Layout at Dores Road Roundabout.	AMK	15/4/11	A

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Project: Inverness City West Link

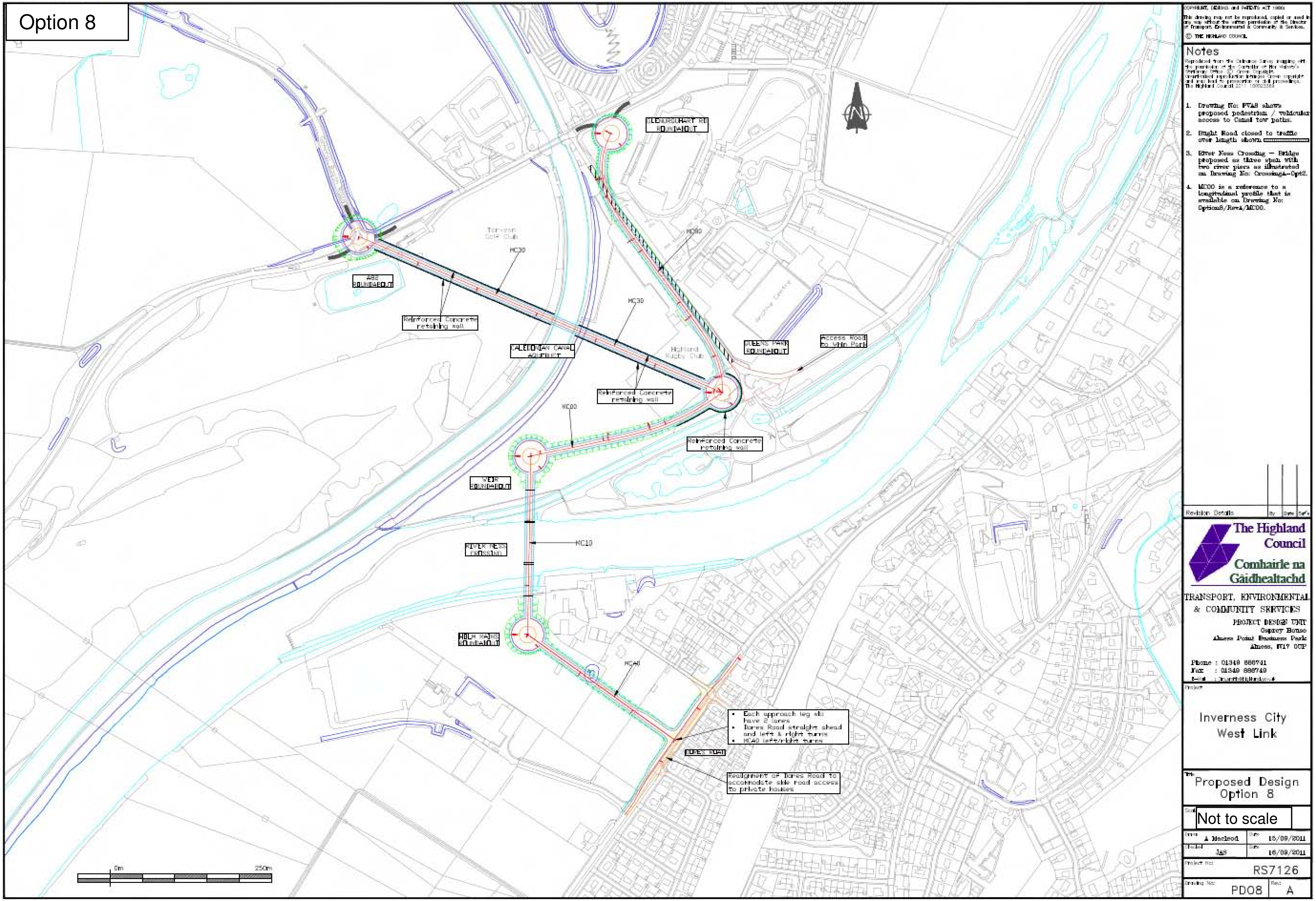
Title: Proposed Design Option 7

Scale: Not to scale

Drawn	A Macleod	Date	30/09/2011
Checked	JAS	Date	30/09/2011

Project No: RS7126

Drawing No: PD07 | Rev: B



Option 8
GLENURQUHART RD ROUNDABOUT
ABB ROUNDABOUT
Torvean Golf Club
MC30
MC80
Reinforced Concrete retaining wall
CALEDONIAN CANAL AQUEDUCT
Highland Rugby Club
QUEENS PARK ROUNDABOUT
Access Road to Whin Park
MC00
WEIR ROUNDABOUT
RIVER NESS CROSSING
MC10
HOLM MAINS ROUNDABOUT
MC40
Each approach leg will have 2 lanes
Dores Road straight ahead and left & right turns
MC40 left/right turns
DORES ROAD
Realignment of Dores Road to accommodate side road access to private houses
0m
250m
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Notes
1. Drawing No: PVA8 shows proposed pedestrian / vehicular access to Canal tow paths.
2. Bught Road closed to traffic over length shown
3. River Ness Crossing – Bridge proposed as three span with two river piers as illustrated on Drawing No: CrossingA-Opt2.
4. MC00 is a reference to a longitudinal profile that is available on Drawing No: Option8/RevA/MC00.
Revision Details
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Inverness City West Link
Proposed Design Option 8
Not to scale
A Macleod
15/08/2011
JAS
16/08/2011
RS7126
PD08
A

Appendix B: Screenline comparison before recalibration

Appendix B: Screenline comparison before recalibration

AM Base Model Western Link Area of Interest Validation Link Results					
Location	**Direction**	**AM Survey Total**	**AM Model Total**	**Difference**	**GEH**
Industrial Exit to B8082	W	169	118	-51	4.3
Industrial Exit to B8082	E	314	39	-275	20.7
A82/ General Booth Rd	SW	286	308	22	1.3
A82/ General Booth Rd	E	206	158	-48	3.6
Sir Walter Scott Dr	NE	573	451	-122	5.4
Sir Walter Scott Dr	SW	487	215	-272	14.5
Sir Walter Scott Dr	S	451	217	-234	12.8
Sir Walter Scott Dr	N	392	531	139	6.5
B862/ Dores Rd south	NE	103	203	100	8.1
B862/ Dores Rd south	SW	45	73	28	3.6
Holm Road	NW	92	40	-52	6.4
Holm Road	SE	153	100	-53	4.7
B862/ Dores Rd North	SW	122	79	-43	4.3
B862/ Dores Rd North	NE	119	148	29	2.5
Sir Walter Scot Drive	NE	511	451	-60	2.7
Sir Walter Scot Drive	SW	513	215	-298	15.6
B9006 Old Perth Road EB	SE	297	363	66	3.6
B8082 Sir Walter Scott Drive	N	405	531	126	5.8
Old Edinburgh Road	NW	348	124	-224	14.6
Old Edinburgh Road	SE	310	161	-149	9.7
B8082/ Old Edinburgh Rd roundabout	SW	816	194	-622	27.7
B8082/ Old Edinburgh Rd roundabout	NE	385	291	-94	5.1
A82 - Glenurquhart Road - West (ATC 01042)	SW	436	360	-76	3.8
A82 - Glenurquhart Road - East (ATC 01042)	NE	326	674	348	15.6
Gordon Terrace	SW	58	283	225	17.2
Culduthel Road/B861 north	S	636	650	14	0.6
Culduthel Road/B861 north	N	704	682	-22	0.8
Culduthel Road/B861 south	S	243	320	77	4.6
Culduthel Road/B861 south	N	690	401	-289	12.4

PM Base Model Western Link Area of Interest Validation Link Results					
Location	Direction	PM Survey Total	PM Model Total	Difference	GEH
Industrial Exit to B8082	W	307	91	-216	15.3
Industrial Exit to B8082	E	351	199	-152	9.2
A82/ General Booth Rd	SW	211	205	-6	0.4
A82/ General Booth Rd	E	288	239	-49	3.0
Sir Walter Scott Dr	NE	650	502	-148	6.2
Sir Walter Scott Dr	SW	732	616	-116	4.5
Sir Walter Scott Dr	S	622	750	128	4.9
Sir Walter Scott Dr	N	496	528	32	1.4
B862/ Dores Rd south	NE	54	195	141	12.6
B862/ Dores Rd south	SW	87	165	78	6.9
Holm Road/	NW	134	89	-45	4.3
Holm Road/	SE	128	96	-32	3.0
B862/ Dores Rd North	SW	149	128	-21	1.8
B862/ Dores Rd North	NE	123	150	27	2.3
Sir Walter Scot Drive	NE	783	502	-281	11.1
Sir Walter Scot Drive	SW	811	616	-195	7.3
B9006 Old Perth Road EB	SE	758	776	18	0.6
B8082 Sir Walter Scott Drive	N	547	528	-19	0.8
Old Edinburgh Road/	NW	432	181	-251	14.3
Old Edinburgh Road/	SE	814	205	-609	27.0
B8082/ Old Edinburgh Rd roundabout	SW	596	333	-263	12.2
B8082/ Old Edinburgh Rd roundabout	NE	349	339	-10	0.5
A82 - Glenurquhart Road - East (ATC 01042)	NE	354	363	9	0.5
A82 - Glenurquhart Road - West (ATC 01042)	SW	588	446	-142	6.2
Gordon Terrace/	SW	61	380	319	21.5
Culduthel Road/B861 north	S	721	704	-17	0.6
Culduthel Road/B861 north	N	558	572	14	0.6
Culduthel Road/B861 south	S	319	285	-34	2.0
Culduthel Road/B861 south	N	541	214	-327	16.8

Appendix C: Demand Matrix Sector Comparison

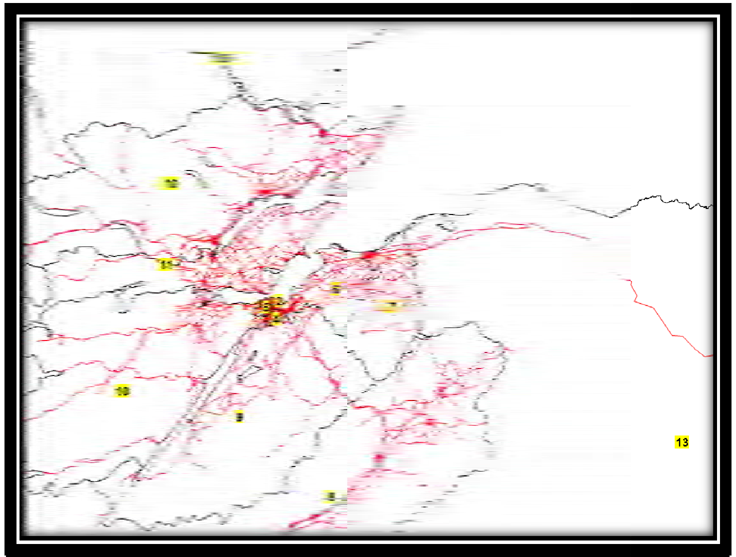
-

Appendix C: Demand Matrix Sector Comparison

The matrix analysis presented in this appendix shows the distribution of trips on a geographic basis using the sector system shown the table and figures below.

Table C1: Sector System

Number	Description
1	Central Inverness
2	North east Inverness
3	East Inverness
4	South Inverness
5	West Inverness
6	Between Inverness and Nairn
7	Nairn and surrounds to south and east
8	Rural south
9	East side of Loch Ness
10	Rural west and southwest
11	Black Isle
12	Rural north
13	Externals: Moray, Aberdeen and Aberdeenshire
14	Externals: South
15	Externals: North and West
16	Externals



MFTM AM Peak Car Commute Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	42	92	55	30	69	33	5	-	1	5	12	13	5	-	3	3	367
2	17	26	34	17	44	15	3	1	-	5	3	1	-	-	-	-	167
3	93	188	170	58	125	55	5	-	4	7	4	1	-	-	1	-	711
4	210	231	246	369	292	92	18	10	16	18	25	83	12	8	7	7	1643
5	243	355	232	165	436	191	5	8	6	12	15	45	7	6	3	3	1733
6	170	282	218	106	155	447	67	8	11	12	22	72	25	4	10	12	1622
7	13	37	47	17	21	56	344	4	-	5	1	5	38	1	-	30	619
8	7	12	23	10	12	31	18	517	10	2	1	4	10	-	-	39	697
9	53	41	53	46	55	26	-	4	31	17	4	27	3	-	-	4	364
10	43	65	49	18	96	15	1	-	4	174	22	51	4	7	3	14	564
11	83	140	142	35	117	52	3	6	7	26	321	319	6	4	21	8	1291
12	31	65	73	18	47	24	3	1	3	13	71	1511	4	1	22	41	1928
13	17	21	17	8	14	19	24	14	3	-	4	6	-	1	1	32	179
14	2	4	6	2	3	2	-	-	-	-	-	2	5	-	1	-	27
15	2	10	3	1	2	2	1	1	-	-	2	7	-	4	-	-	35
16	-	-	-	-	-	-	4	9	2	6	-	53	-	-	-	-	74
Total	1026	1568	1367	899	1488	1060	501	582	98	304	509	2199	121	35	71	194	12021

Changes to AM Peak Car Commute Matrix due to recalibration for Western Link

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	2
2	-	-	-	52	8	-	-	-	1	-	-	-	-	-	-	-	61
3	-	-	-	19	4	-	-	-	-	-	-	-	-	-	-	-	23
4	10	7	4	201	12	2	-	-	1	-	-	-	-	-	-	-	237
5	-44	-29	-36	-33	21	-17	-	-	-1	-	-	-	-	-	-	-	-138
6	-	-	-	13	1	-	-	-	-	-	-	-	-	-	-	-	14
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-1	-4	-7	82	6	-4	-	-	1	6	-	-	-	-	-	-	78
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-35	-26	-39	336	53	-18	-	-	2	6	-	-	-	-	-	-	278

Capabilities on project:
Transportation

MFTM AM Peak Car In Work Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	5	6	4	2	2	7	2	4	13	4	4	2	3	4	6	2	70
2	1	2	20	6	1	30	5	4	15	1	1	6	4	5	5	2	109
3	9	13	17	3	8	13	-	4	13	5	1	1	1	7	4	-	101
4	12	8	20	20	12	12	2	6	11	2	2	8	2	3	1	1	122
5	20	15	40	24	30	45	2	4	16	4	1	4	5	8	9	2	229
6	37	57	21	16	35	42	19	-	1	9	3	7	7	6	2	3	266
7	7	7	4	3	1	2	20	-	-	2	-	2	3	-	-	2	53
8	-	-	-	2	3	28	11	16	-	15	-	5	3	-	3	11	99
9	5	4	6	2	10	11	2	-	1	19	1	1	-	-	1	-	63
10	9	18	10	5	16	3	2	-	1	14	11	17	-	1	4	1	111
11	12	50	25	7	27	10	1	2	3	12	12	18	6	8	2	3	199
12	14	15	11	1	14	9	2	1	4	4	11	58	3	4	2	6	160
13	3	5	3	3	5	4	5	1	-	2	1	3	-	5	2	2	45
14	2	3	-	5	-	-	-	-	-	2	-	3	2	-	4	-	21
15	2	10	2	-	6	2	-	-	1	2	2	14	2	1	-	1	44
16	-	-	-	-	-	-	-	4	-	-	1	9	-	-	-	-	13
Total	139	212	183	98	171	218	72	49	79	98	52	157	42	52	44	38	1706

Changes to AM Peak Car In Work Matrix due to recalibration for Western Link

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	13
3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
4	-	-	-1	11	1	-	-	3	5	-	-	-	-	-	-	-	19
5	-2	-1	-8	-4	2	-4	-	-1	-2	-	-	-	-	-	-	-	-19
6	-	-	-	-	6	-	-	-	1	-	-	-	-	-	-	-	7
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-1	5	-	-3	-	-	-	-1	-	-	-	-	-	-	-1
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-2	-1	-9	24	9	-7	-	2	6	-1	-	-	-	-	-	-	20

MFTM AM Peak Car Other Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	45	42	44	28	45	49	3	1	11	24	7	7	4	8	8	3	327
2	35	29	55	31	39	33	1	-	3	-	2	2	3	1	-	1	235
3	44	45	43	33	56	30	1	2	16	10	8	6	2	8	5	2	310
4	59	34	54	66	81	43	4	3	39	14	12	8	4	5	1	2	429
5	130	68	103	107	141	106	2	1	9	13	13	7	3	10	3	2	717
6	87	42	46	116	46	89	25	7	8	6	8	9	10	8	6	5	517
7	10	5	4	7	2	16	95	1	2	3	-	2	13	1	2	9	173
8	14	5	14	3	4	27	18	160	-	8	2	4	12	1	4	26	301
9	16	14	9	9	24	14	-	3	7	19	2	1	1	5	-	1	127
10	34	10	15	14	29	7	1	3	1	42	15	12	2	-	2	1	188
11	30	24	34	19	11	10	1	1	-	24	44	75	3	5	7	2	290
12	15	12	20	6	23	7	-	-	2	10	56	366	2	6	6	19	552
13	14	6	2	3	3	10	7	3	1	-	2	3	-	10	10	4	78
14	2	3	3	2	1	2	-	1	-	-	5	2	2	-	7	1	32
15	6	4	6	-	9	7	-	2	3	1	3	8	3	10	-	1	64
16	-	-	-	-	-	-	-	4	-	-	1	9	-	-	-	-	13
Total	542	343	453	444	514	449	158	190	100	174	179	521	65	77	64	79	4353

Changes to AM Peak Car Other Matrix due to recalibration for Western Link

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	4
2	-	-	-	22	3	-	-	-	1	-	-	-	-	-	-	-	25
3	-	-	-	16	4	-	-	-	3	-	-	-	-	-	-	-	22
4	27	19	21	89	44	8	-	-	8	-	-	-	-	-	-	-	216
5	-20	-7	-17	-14	7	-10	-	-	-1	-	-	-	-	-	-	-	-62
6	-	-	-	4	2	-	-	-	-	-	-	-	-	-	-	-	7
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3
9	-	-1	-2	37	5	-6	-	-	-	10	-	-	-	-	-	-	43
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	7	10	2	158	69	-9	-	-	10	10	-	-	-	-	-	-	258

MFTM PM Peak Car Commute Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	39	35	63	202	194	59	13	4	77	13	29	12	14	2	1	4	761
2	55	28	81	286	197	97	18	6	61	19	47	24	9	2	4	3	937
3	37	24	96	322	118	40	7	12	200	15	46	26	7	3	5	2	962
4	34	28	43	208	96	48	8	7	70	7	15	19	3	3	-	1	590
5	64	42	75	236	269	53	18	7	55	31	46	26	3	1	3	1	930
6	16	19	42	68	67	295	40	10	12	5	15	18	15	1	1	4	627
7	4	1	3	10	3	24	224	16	-	1	2	1	14	-	-	7	312
8	-	3	-	8	6	6	2	571	3	-	4	-	7	-	-	13	623
9	3	1	4	13	7	6	-	9	34	65	4	8	-	-	-	2	156
10	1	2	2	6	8	4	-	5	41	175	25	13	2	3	1	6	293
11	6	4	6	13	10	11	3	1	2	19	277	67	2	-	2	1	424
12	7	2	4	43	23	31	1	2	14	30	215	1195	3	1	6	44	1621
13	4	1	1	9	4	22	33	7	3	2	5	2	-	4	-	-	97
14	-	-	-	6	2	4	-	-	-	6	3	1	1	-	5	-	27
15	1	-	3	2	3	2	-	-	-	2	6	12	-	1	-	-	32
16	1	-	1	3	1	6	15	4	1	2	3	10	17	-	-	-	65
Total	272	190	424	1434	1006	709	383	660	572	393	743	1434	97	22	29	89	8457

Changes to PM Peak Car Commute Matrix due to recalibration for Western Link

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	-	-	-	18	-4	-	-	-	-3	-1	-	-	-	-	-	-	10
2	-	-	-	-28	-82	-	-	-	-8	-1	-	-	-	-	-	-	-119
3	-	-	-	-50	18	-	-	-	-15	-	-	-	-	-	-	-	-47
4	-	-	1	126	14	-	-	-	22	-	-	-	-	-	-	-	164
5	-2	-7	-4	3	-131	-2	-	-	-9	-1	-	-	-	-	-	-	-154
6	-	-	-	-3	4	-	-	-	-1	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-2	-	-	-	-	-	-21	-	-	-	-	-	-	-23
10	-	-	-	-	-	-	-	-	-2	-4	-	-	-	-	-	-	-6
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-2	-7	-3	63	-182	-2	-	-	-15	-27	-	-	-	-	-	-	-176

MFTM PM Peak Car In Work Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	6	6	9	19	22	26	1	1	7	4	9	8	6	3	3	2	133
2	6	4	12	44	14	49	7	-	8	12	22	6	11	8	9	3	217
3	6	7	11	35	20	18	7	2	20	7	13	7	2	-	4	1	159
4	5	9	4	12	12	13	1	4	7	2	4	4	2	11	1	1	92
5	7	5	13	18	22	19	4	9	7	17	18	12	3	3	8	1	166
6	10	11	12	17	15	26	14	19	5	5	11	6	5	-	2	2	160
7	1	3	-	5	1	6	7	2	1	-	2	1	7	-	-	2	39
8	2	-	-	3	-	2	1	12	-	13	1	2	4	-	-	4	46
9	1	2	2	3	3	12	1	-	-	19	1	4	-	-	1	-	48
10	5	3	2	-	9	2	1	1	1	14	6	2	3	3	3	1	56
11	9	2	2	3	3	2	-	-	2	7	5	10	1	-	1	-	47
12	2	7	2	6	3	5	2	5	1	13	15	39	6	3	9	9	126
13	3	8	1	3	4	4	8	3	-	1	8	1	-	2	4	-	49
14	5	8	2	5	5	4	-	-	-	2	7	6	7	-	2	1	50
15	9	6	3	1	4	9	-	4	3	3	8	9	5	5	-	1	69
16	3	4	-	1	2	2	5	5	1	1	6	11	8	-	1	2	51
Total	80	83	74	173	138	199	59	66	62	120	138	128	69	39	48	30	1507

Changes to PM Peak Car In Work Matrix due to recalibration for Western Link

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	29	-5	-	-	-	-	-	-	-	-	-	-	-	24
3	-	-	-	-	2	-	-	-	-1	-	-	-	-	-	-	-	1
4	2	-	-	132	3	-	-	-	2	-	-	-	-	-	-	-	139
5	-	-1	-1	-	-5	-1	-	-	-1	4	-	-	-	-	-	-	-6
6	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
9	-	-	-	1	1	-1	-	-	-	-7	-	-	-	-	-	-	-7
10	-	-	-	-	-	-	-	-1	-	-	-	-	-	-	-	-	-1
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	2	-1	-1	162	-2	-2	-	-1	-1	-2	-	-	-	-	-	-	154

MFTM PM Peak Car Other Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	94	106	79	88	123	159	35	22	24	60	77	39	45	7	16	13	987
2	69	51	57	83	58	41	10	6	13	6	57	23	5	2	2	2	483
3	76	101	88	161	100	90	10	30	29	24	95	55	5	5	23	2	894
4	104	107	90	145	145	287	35	3	26	21	70	41	14	20	2	4	1114
5	162	107	118	168	273	120	15	1	15	73	41	36	6	2	7	2	1146
6	108	48	75	193	104	250	61	10	15	26	42	27	10	5	17	3	993
7	11	7	6	10	6	20	165	19	1	4	5	5	15	-	1	6	283
8	2	1	8	7	9	61	4	325	4	11	2	6	7	1	11	46	505
9	19	21	13	21	36	63	2	2	6	40	13	1	1	-	2	-	241
10	34	6	6	15	40	16	3	11	25	104	50	35	3	3	3	2	356
11	46	9	26	36	52	40	5	5	6	71	89	219	9	9	21	3	644
12	37	12	24	21	40	23	1	5	3	28	76	669	7	13	15	48	1022
13	18	5	10	16	9	19	24	9	-	6	17	16	-	8	8	-	163
14	22	6	11	15	11	15	7	2	6	-	33	15	15	-	36	-	194
15	13	1	6	8	9	19	11	14	4	8	8	13	13	12	-	4	142
16	7	2	4	6	5	10	16	6	-	2	6	18	12	1	2	-	96
Total	823	589	619	993	1021	1231	405	470	178	482	681	1217	165	87	165	137	9264

Changes to PM Peak Car Other Matrix due to recalibration for Western Link

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	-	-	-	84	33	-	-	-	4	-	-	-	-	-	-	-	121
2	-	-	-	-10	18	-	-	-	-2	-	-	-	-	-	-	-	7
3	-	-	-	-24	22	-	-	-	-5	-	-	-	-	-	-	-	-6
4	9	28	22	241	44	3	-	-	42	-	-	-	-	-	-	-	389
5	-9	-19	-3	39	49	-11	-	-	4	-	-	-	-	-	-	-	51
6	-	-	-	-4	11	-	-	-	-	-	-	-	-	-	-	-	6
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
9	-3	-4	-2	-4	2	-17	-	-	-	-21	-	-	-	-	-	-	-49
10	-	-	-	-	-	-	-	-1	-7	-	-	-	-	-	-	-	-7
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-3	5	17	322	180	-25	-	-	37	-20	-	-	-	-	-	-	513

Appendix D: Trip Length Distributions

Appendix D: Trip Length Distributions

Figure D1: AM In Work Trip Length Distribution

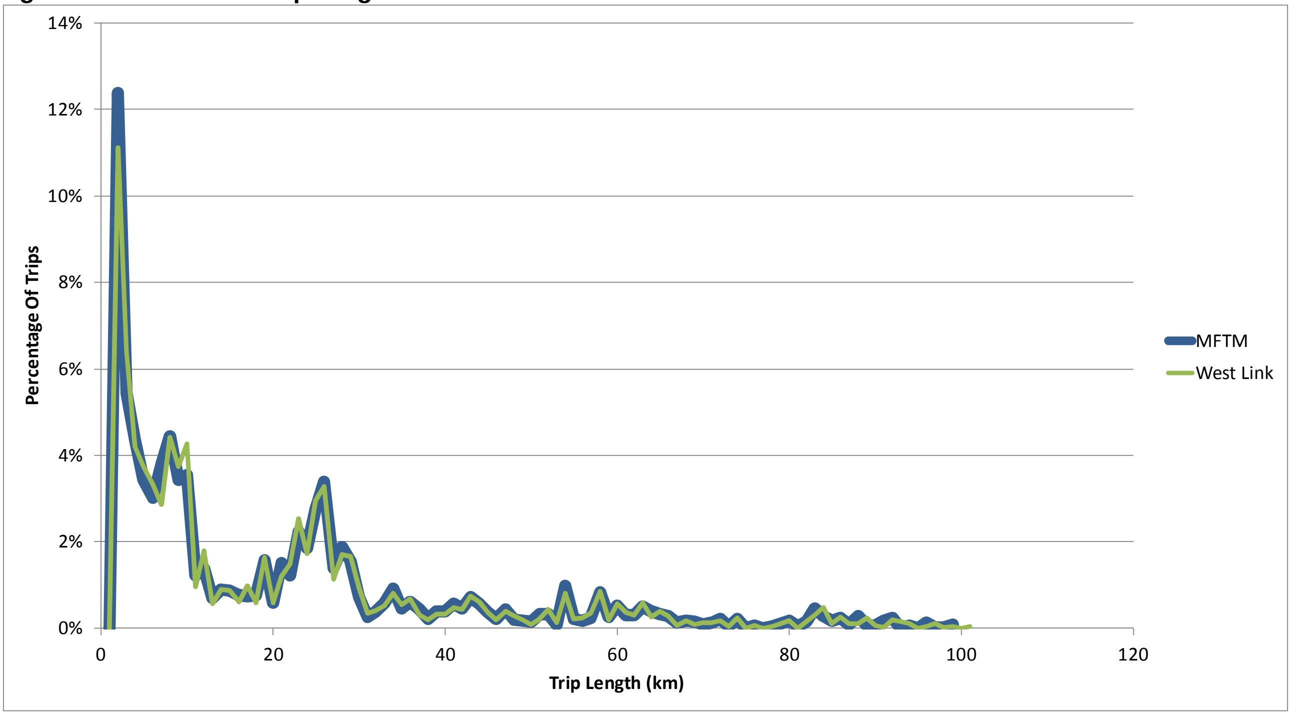


Figure D2: AM Other Trip Length Distribution

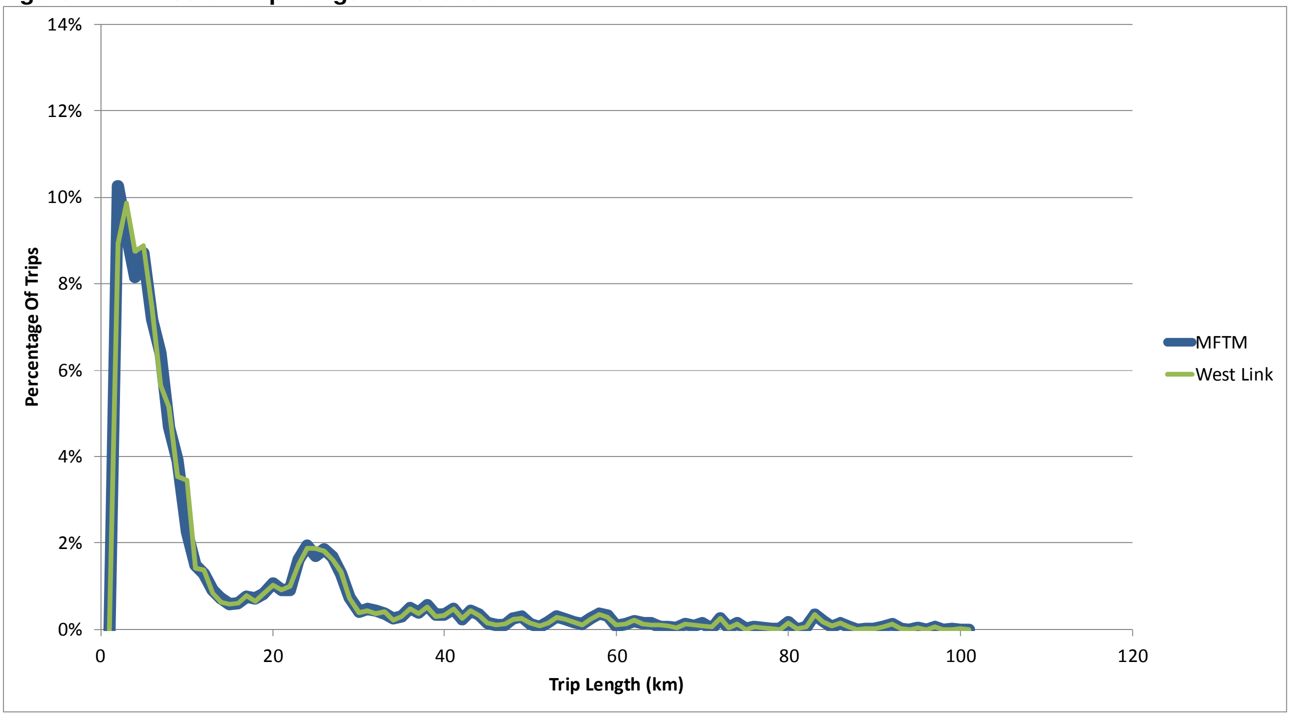


Figure D3: PM In Work Trip Length Distribution

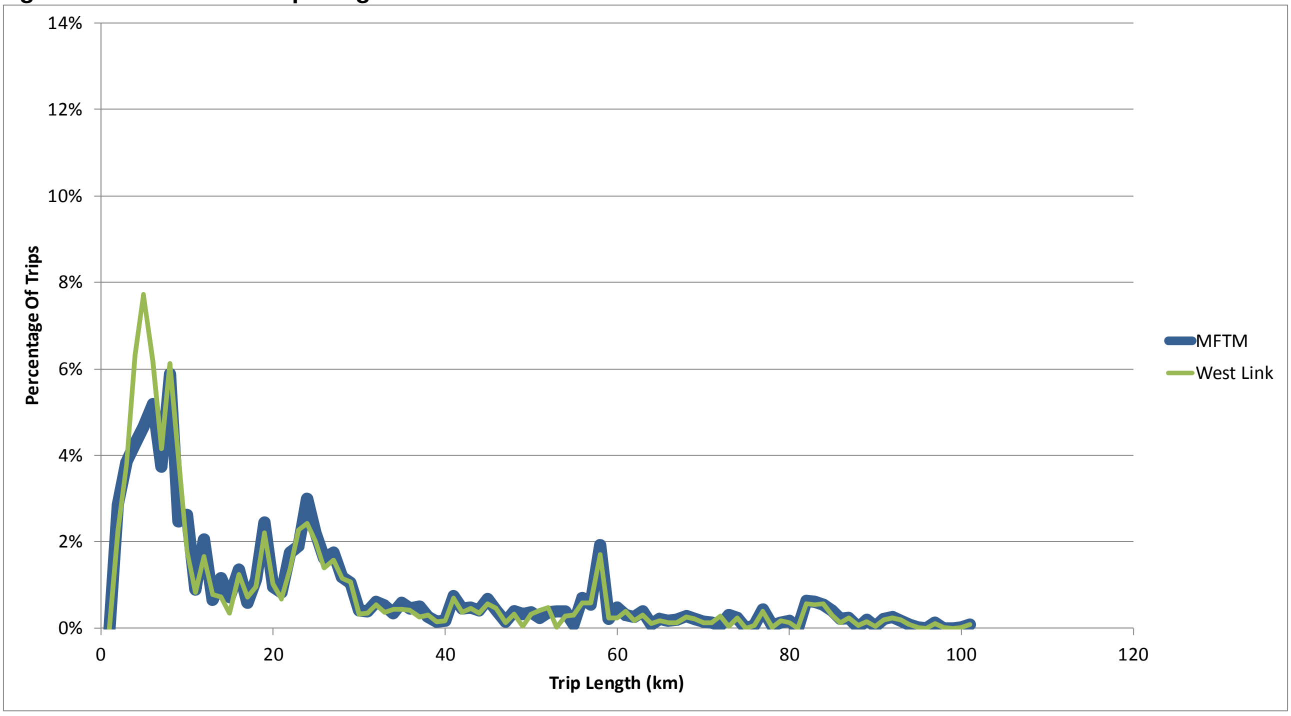
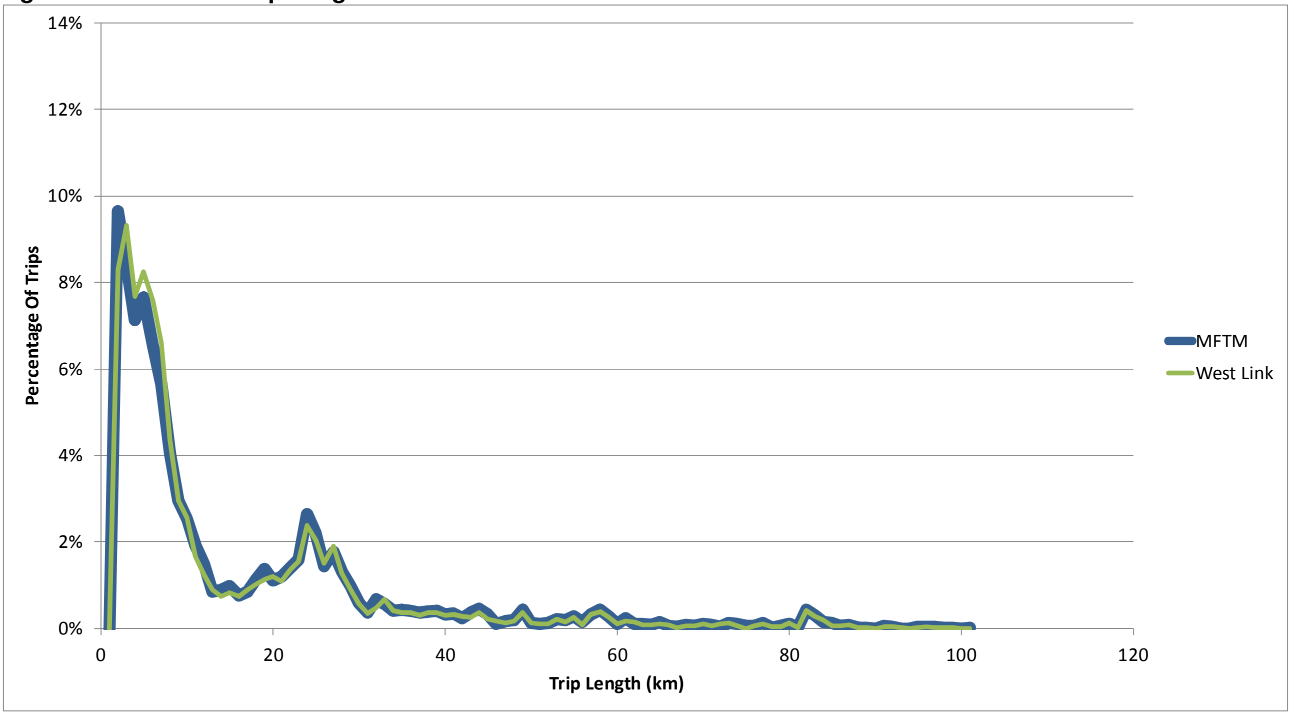


Figure D4: PM Other Trip Length Distribution



Appendix E: Screenline comparison after recalibration

Appendix E: Screenline comparison after recalibration

AM Base Model Calibration Link Results					
Location	Direction	AM Survey Total	AM Model Total	Difference	GEH
Industrial Exit to B8082	W	169	141	-28	2.2
Industrial Exit to B8082	E	314	244	-70	4.2
A82/ General Booth Rd	SW	286	335	49	2.8
A82/ General Booth Rd	E	206	158	-48	3.6
Sir Walter Scott Dr	NE	573	607	34	1.4
Sir Walter Scott Dr	SW	487	502	15	0.7
Sir Walter Scott Dr	S	451	470	19	0.9
Sir Walter Scott Dr	N	392	472	80	3.8
B862/ Dores Rd south	NE	103	189	86	7.1
B862/ Dores Rd south	SW	45	79	34	4.3
Holm Road	NW	92	59	-33	3.8
Holm Road	SE	153	136	-17	1.4
B862/ Dores Rd North	SW	122	141	19	1.7
B862/ Dores Rd North	NE	119	175	56	4.6
Sir Walter Scot Drive	NE	551	607	56	2.3
Sir Walter Scot Drive	SW	513	502	-11	0.5
B9006 Old Perth Road EB	SE	452	473	21	1.0
B8082 Sir Walter Scott Drive	N	411	472	61	2.9
Old Edinburgh Road	NW	348	241	-107	6.2
Old Edinburgh Road	SE	310	305	-5	0.3
B8082/ Old Edinburgh Rd roundabout	SW	431	378	-53	2.6
B8082/ Old Edinburgh Rd roundabout	NE	385	364	-21	1.1
A82 - Glenurquhart Road - West (ATC 01042)	SW	436	413	-23	1.1
A82 - Glenurquhart Road - East (ATC 01042)	NE	326	398	72	3.8
Gordon Terrace	SW	58	67	9	1.1
Culduthel Road/B861 north	S	636	582	-54	2.2
Culduthel Road/B861 north	N	704	675	-29	1.1
Culduthel Road/B861 south	S	243	188	-55	3.7
Culduthel Road/B861 south	N	690	610	-80	3.1

PM Base Model Calibration Link Results					
Location	Direction	PM Survey Total	PM Model Total	Difference	GEH
Industrial Exit to B8082	W	307	275	-32	1.9
Industrial Exit to B8082	E	351	330	-21	1.1
A82/ General Booth Rd	SW	211	197	-14	1.0
A82/ General Booth Rd	E	288	236	-52	3.2
Sir Walter Scott Dr	NE	650	655	5	0.2
Sir Walter Scott Dr	SW	732	737	5	0.2
Sir Walter Scott Dr	S	622	717	95	3.7
Sir Walter Scott Dr	N	496	580	84	3.6
B862/ Dores Rd south	NE	54	83	29	3.5
B862/ Dores Rd south	SW	87	157	70	6.3
Holm Road/	NW	134	163	29	2.4
Holm Road/	SE	128	51	-77	8.1
B862/ Dores Rd North	SW	149	97	-52	4.7
B862/ Dores Rd North	NE	123	134	11	1.0
Sir Walter Scot Drive	NE	783	655	-128	4.8
Sir Walter Scot Drive	SW	811	737	-74	2.7
B9006 Old Perth Road EB	SE	758	874	116	4.1
B8082 Sir Walter Scott Drive	N	528	580	52	2.2
Old Edinburgh Road/	NW	432	392	-40	2.0
Old Edinburgh Road/	SE	814	694	-120	4.4
B8082/ Old Edinburgh Rd roundabout	SW	596	541	-55	2.3
B8082/ Old Edinburgh Rd roundabout	NE	349	309	-40	2.2
A82 - Glenurquhart Road - East (ATC 01042)	NE	588	481	-107	4.6
A82 - Glenurquhart Road - West (ATC 01042)	SW	354	374	20	1.0
Gordon Terrace/	SW	61	136	75	7.6
Culduthel Road/B861 north	S	721	765	44	1.6
Culduthel Road/B861 north	N	558	610	52	2.2
Culduthel Road/B861 south	S	319	322	3	0.2
Culduthel Road/B861 south	N	541	486	-55	2.4

Appendix F: MFTM Journey Time Routes

Appendix E: Screenline comparison after recalibration

Figure F1: Inner Journey Time Route 1

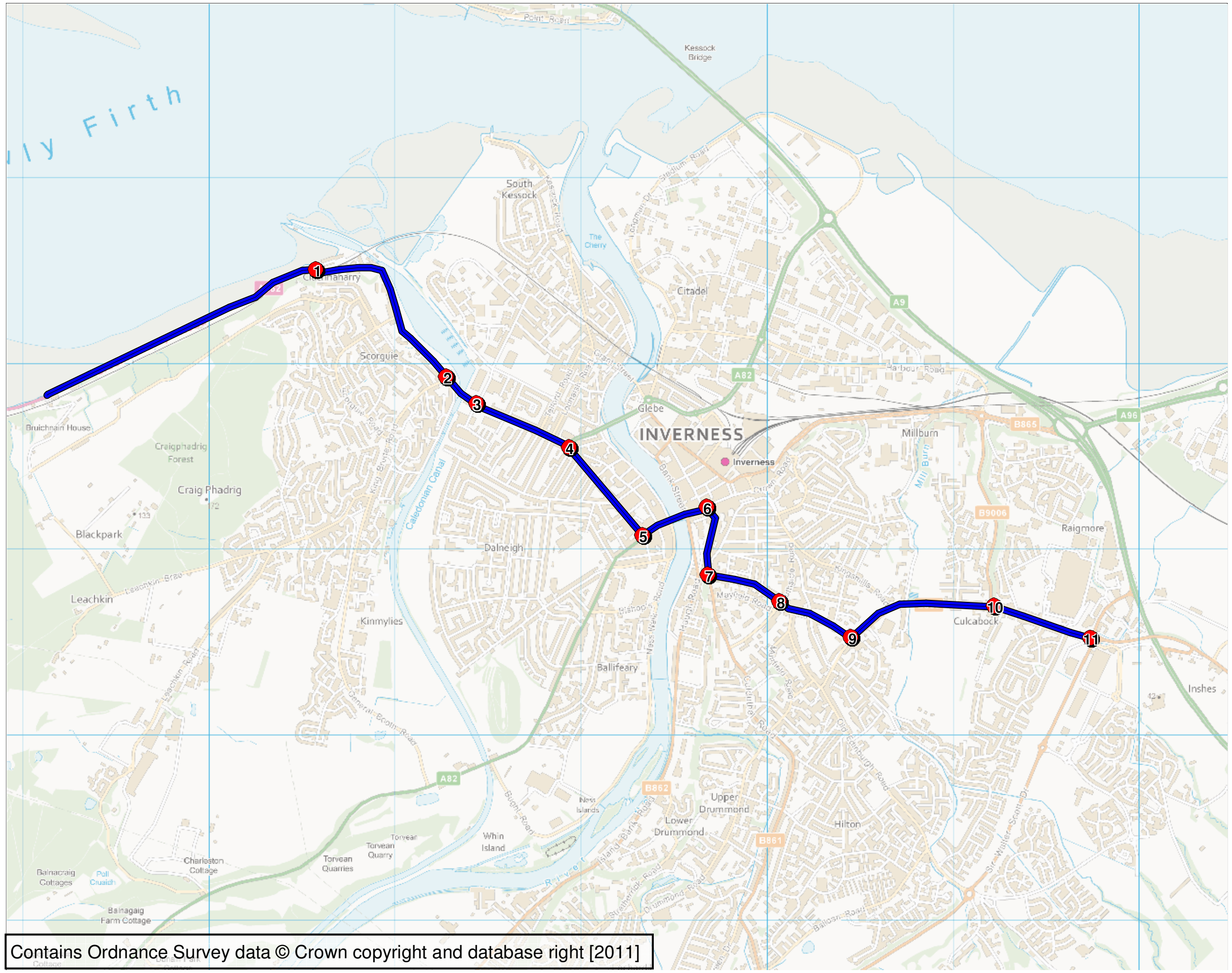


Figure F1: Inner Journey Time Route 2

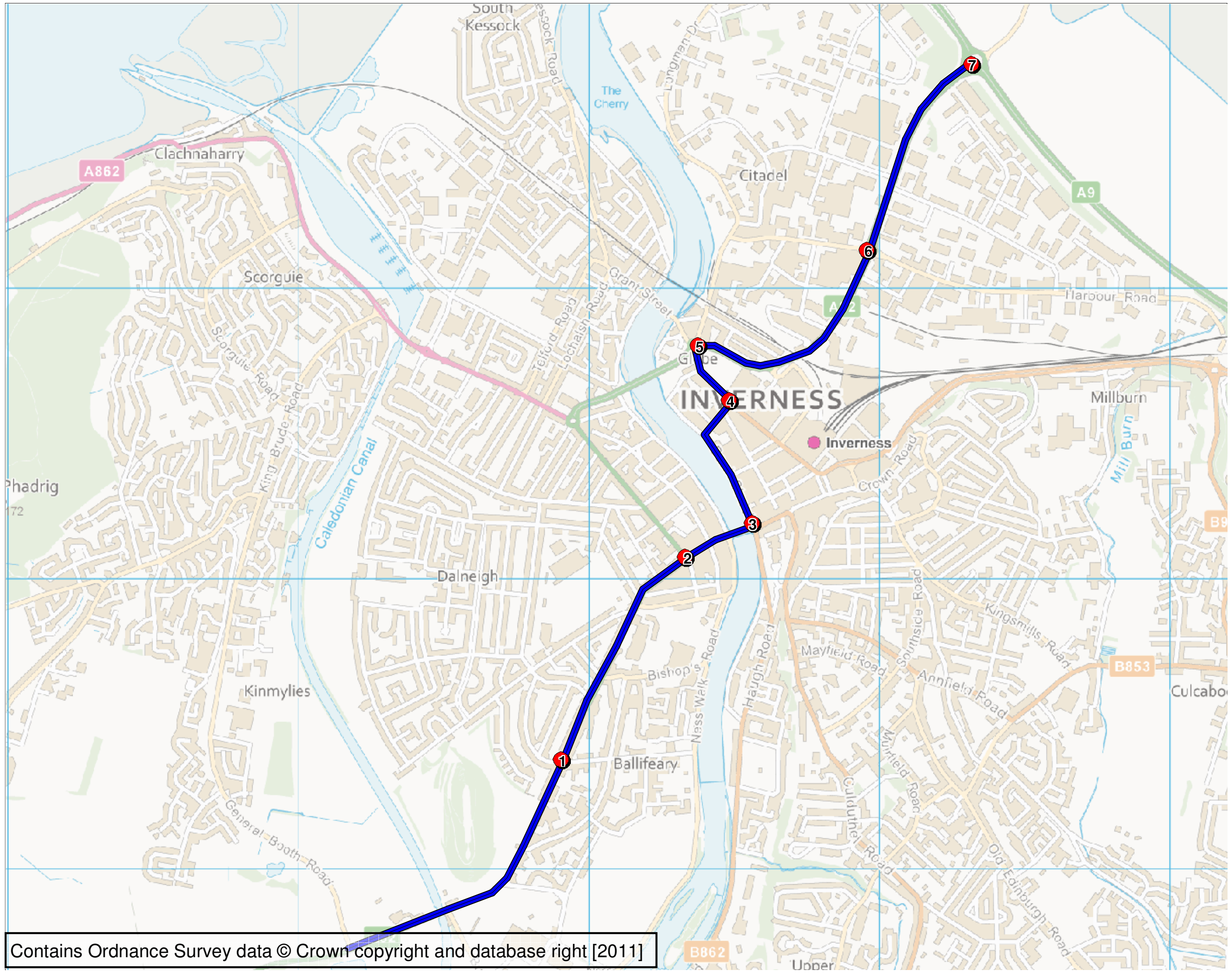


Figure F3: Inner Journey Time Route 3

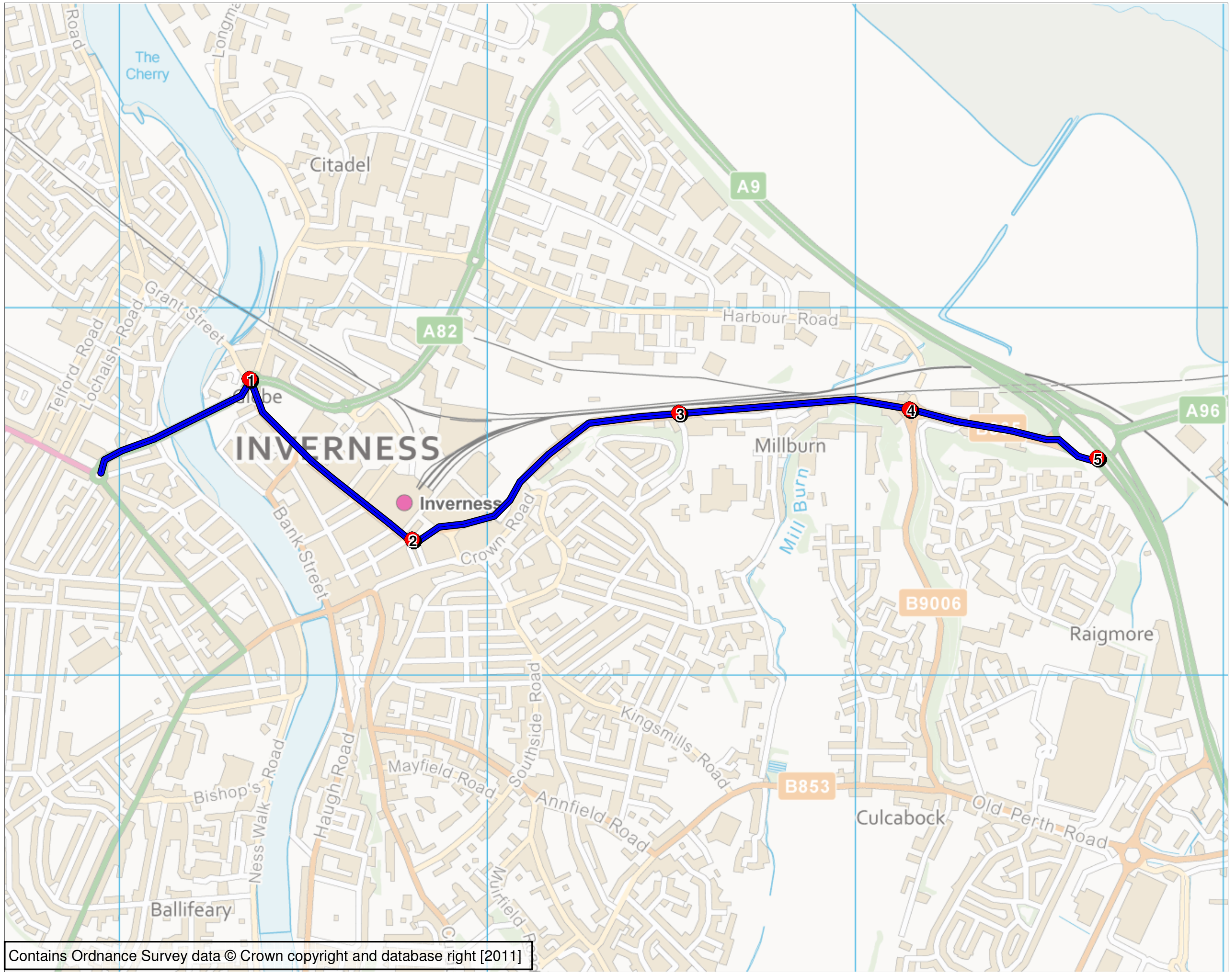
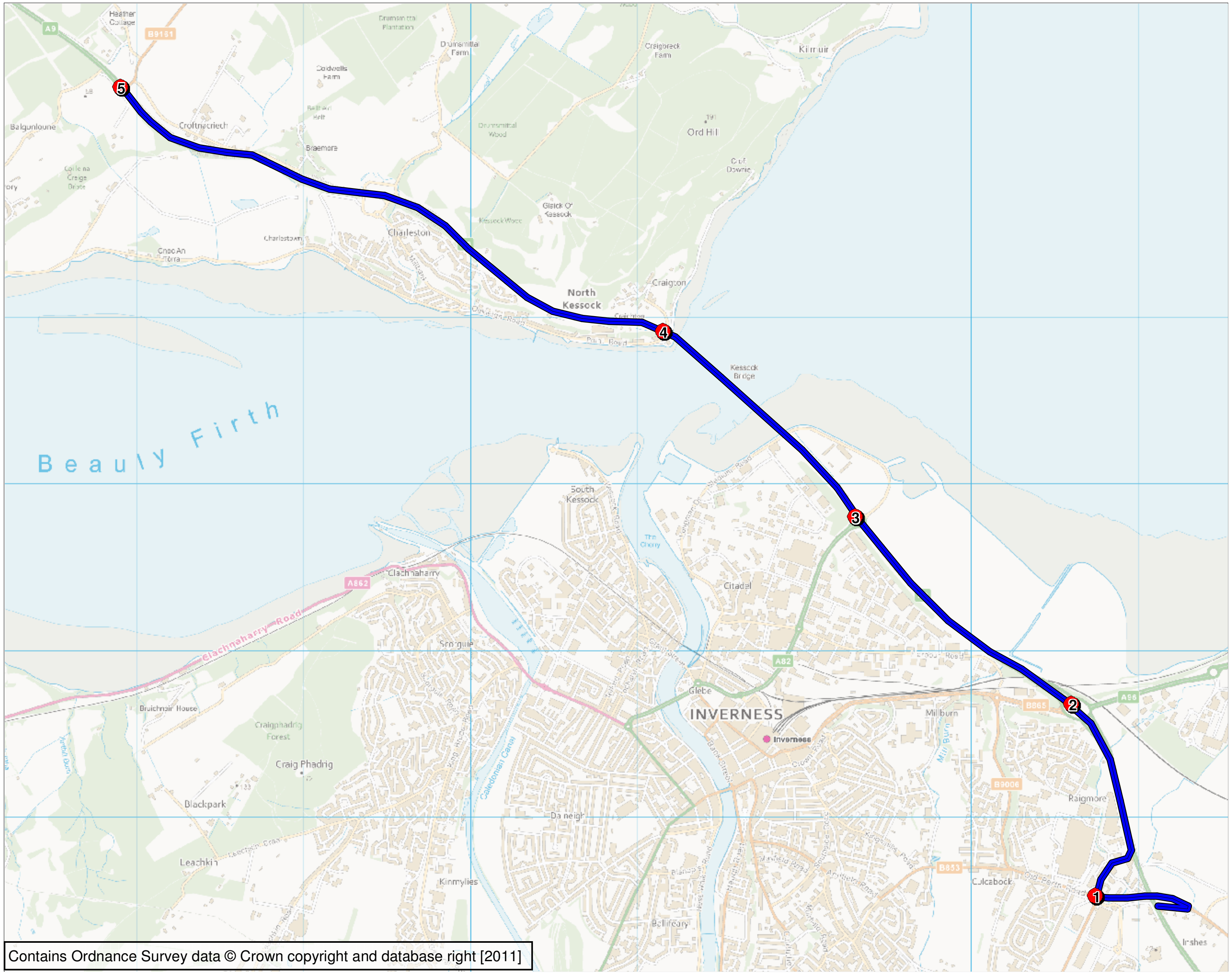
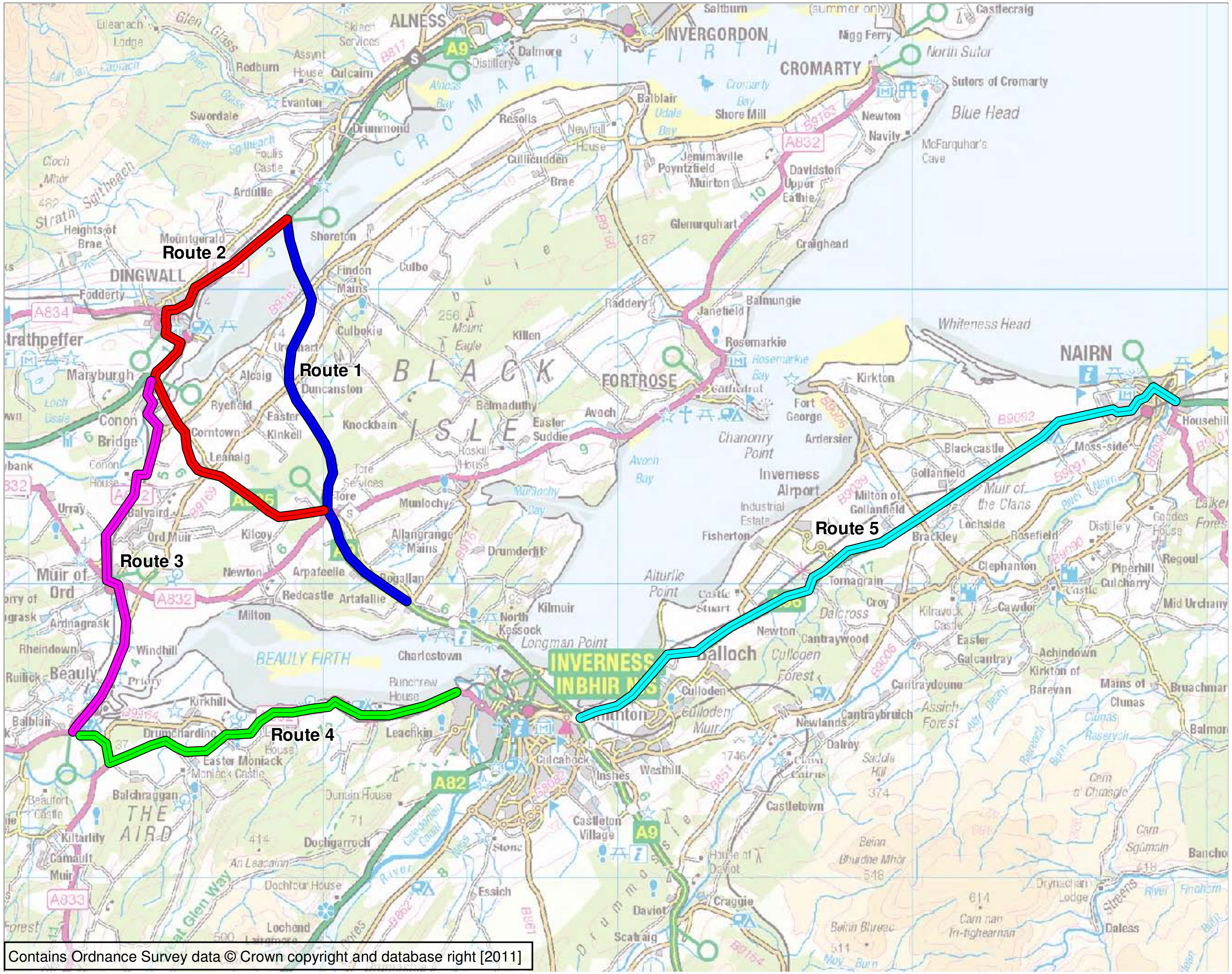


Figure F4: Inner Journey Time Route 4

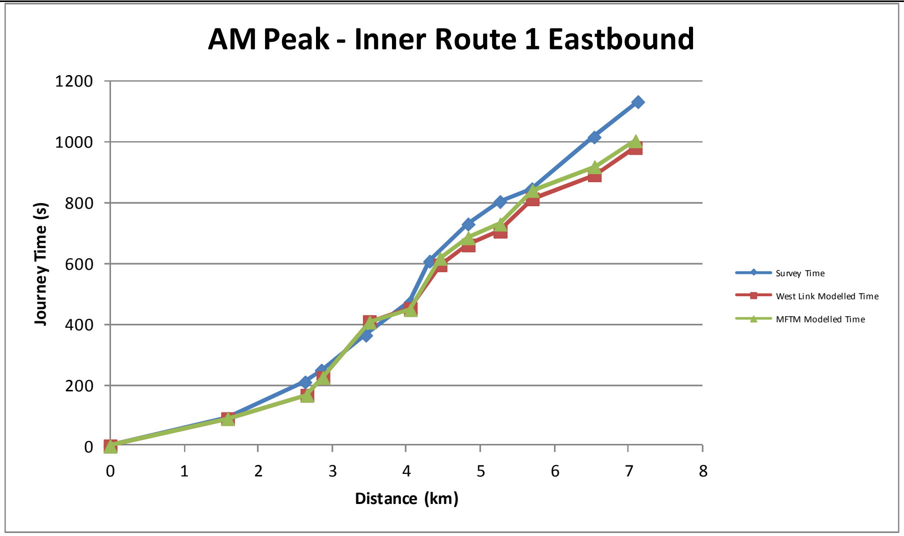


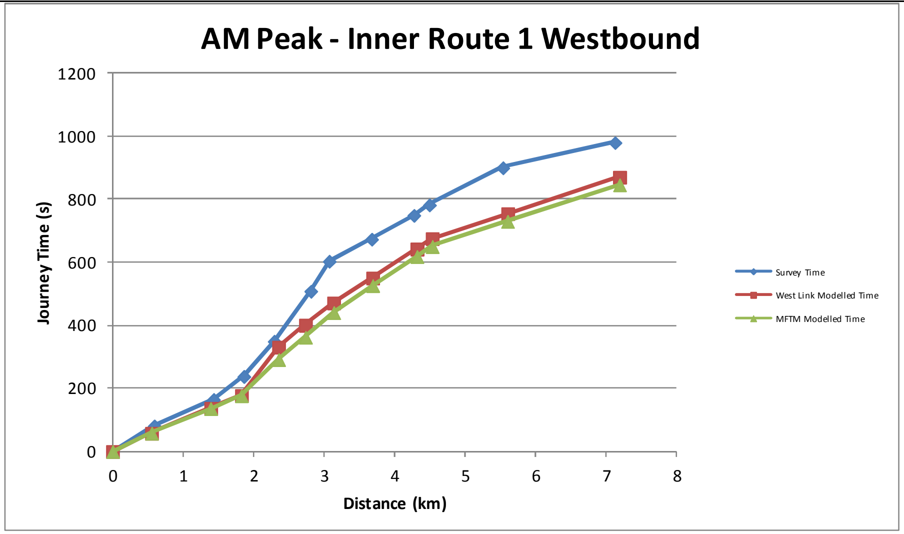
Capabilities on project:
Transportation

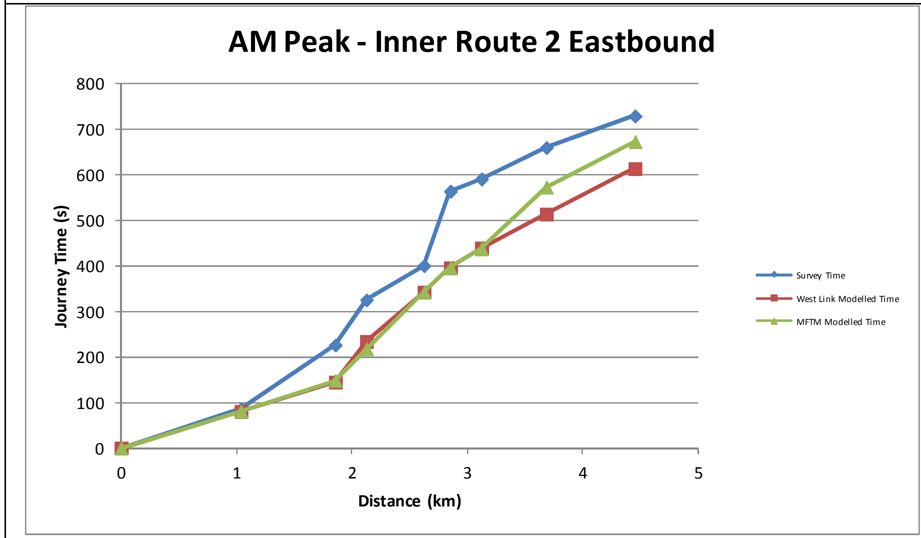
Figure F5: Outer Journey Time Routes

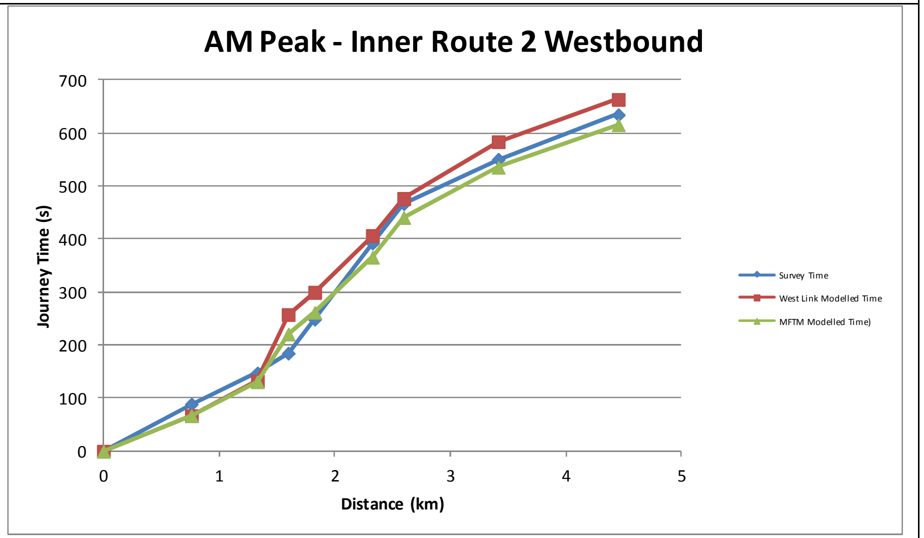


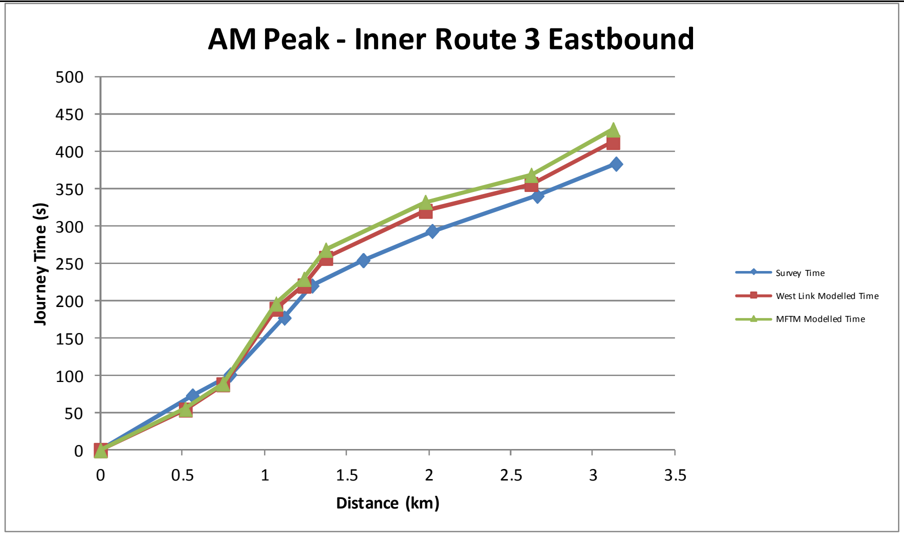
Appendix G: Journey Time Results

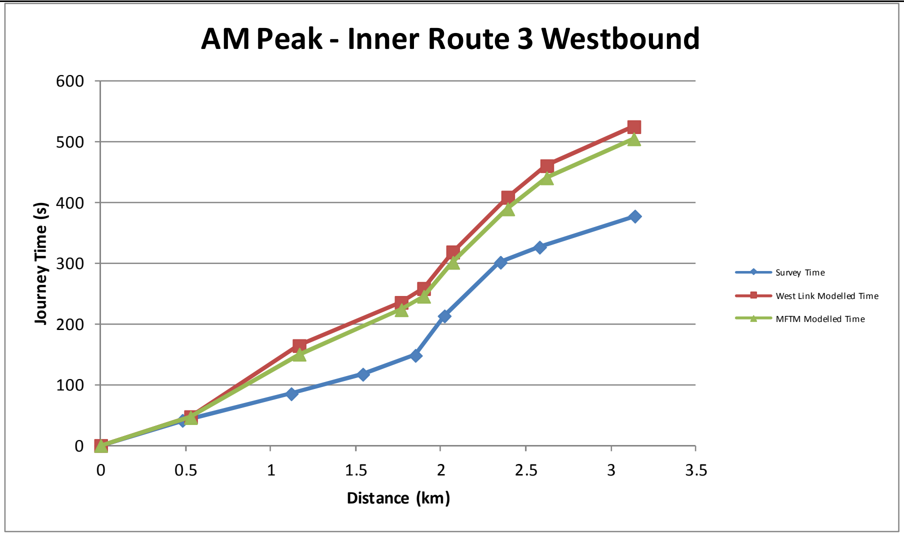

AM Peak - Inner Route 1 Eastbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

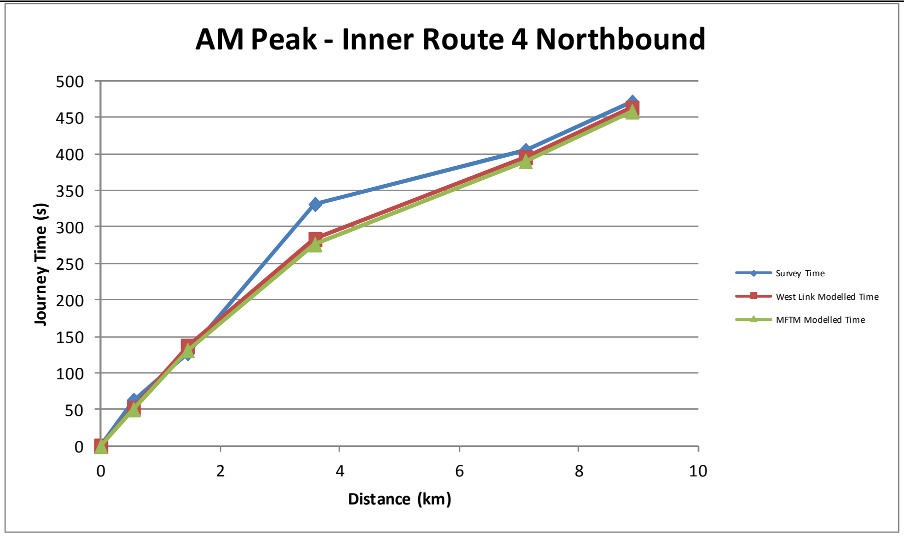

AM Peak - Inner Route 1 Westbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

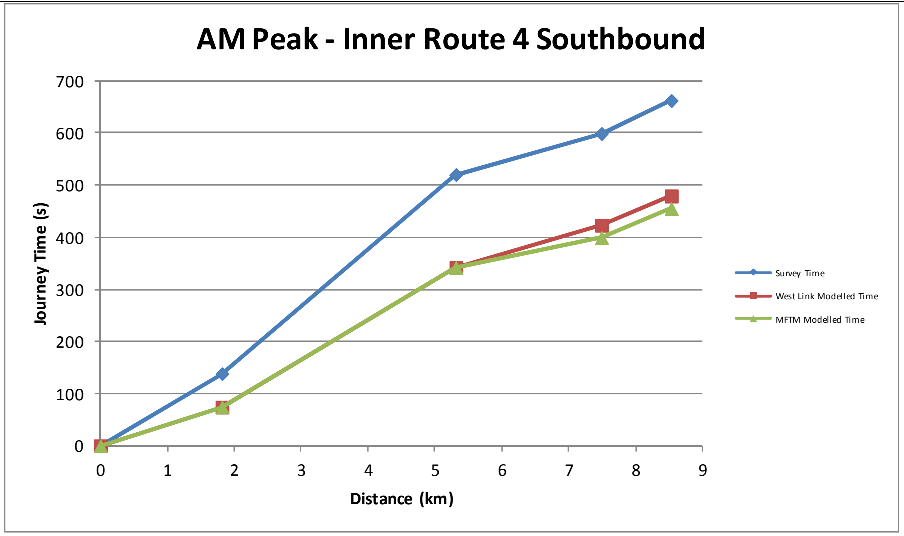

AM Peak - Inner Route 2 Eastbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


AM Peak - Inner Route 2 Westbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time)


AM Peak - Inner Route 3 Eastbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


AM Peak - Inner Route 3 Westbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


AM Peak - Inner Route 4 Northbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time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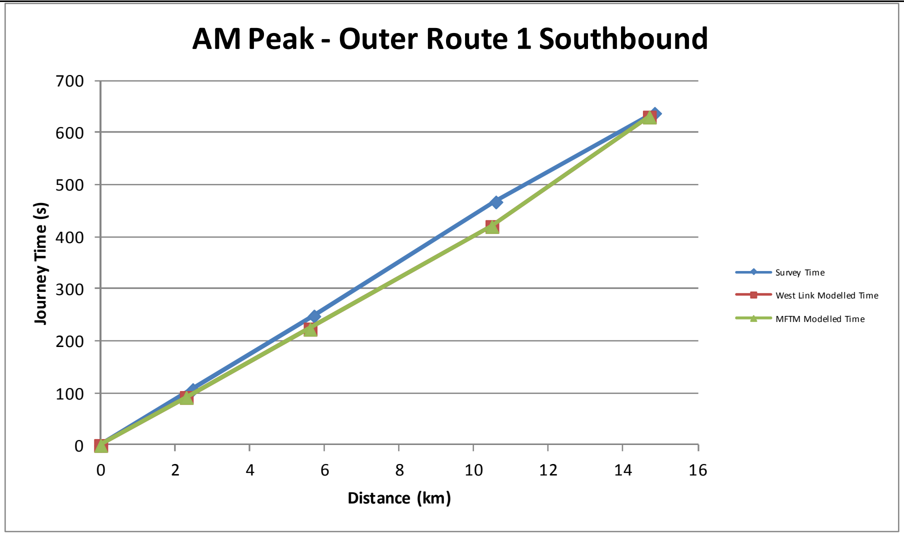
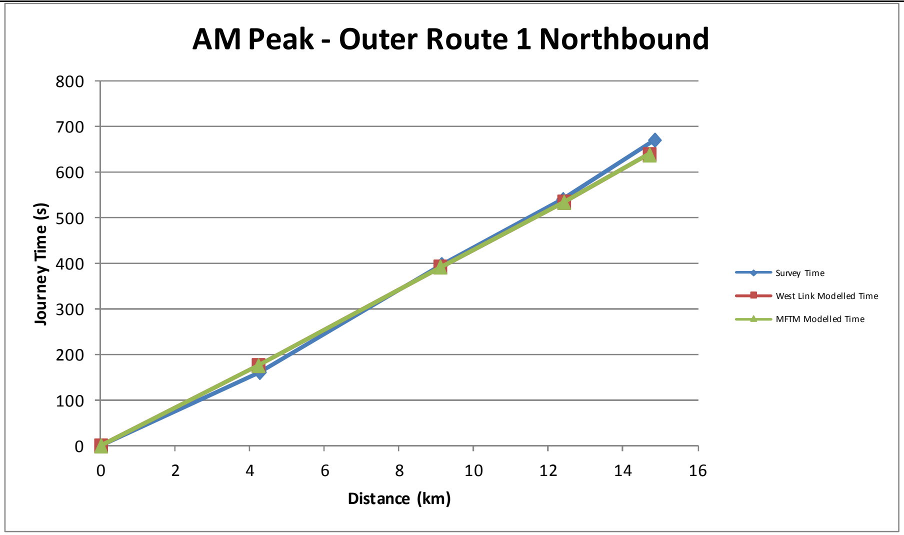
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


AM Peak - Outer Route 1 Southbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time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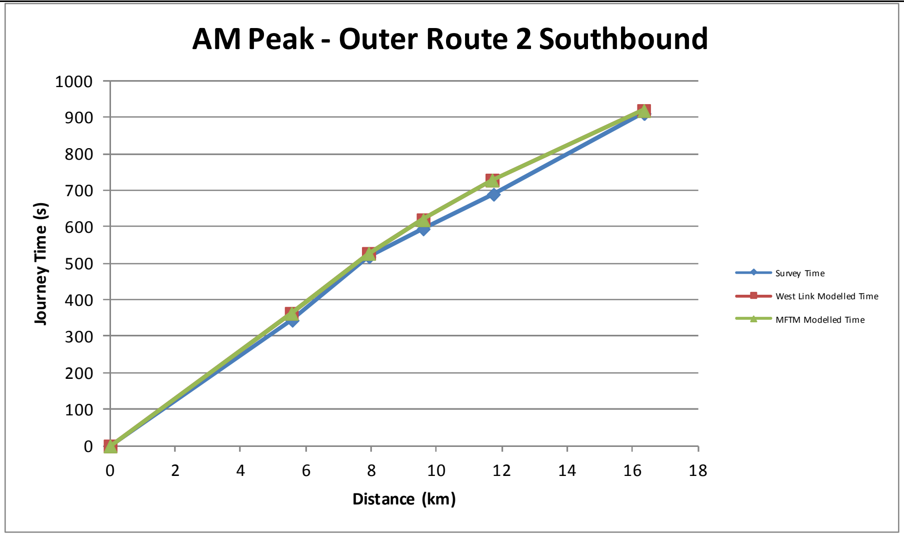
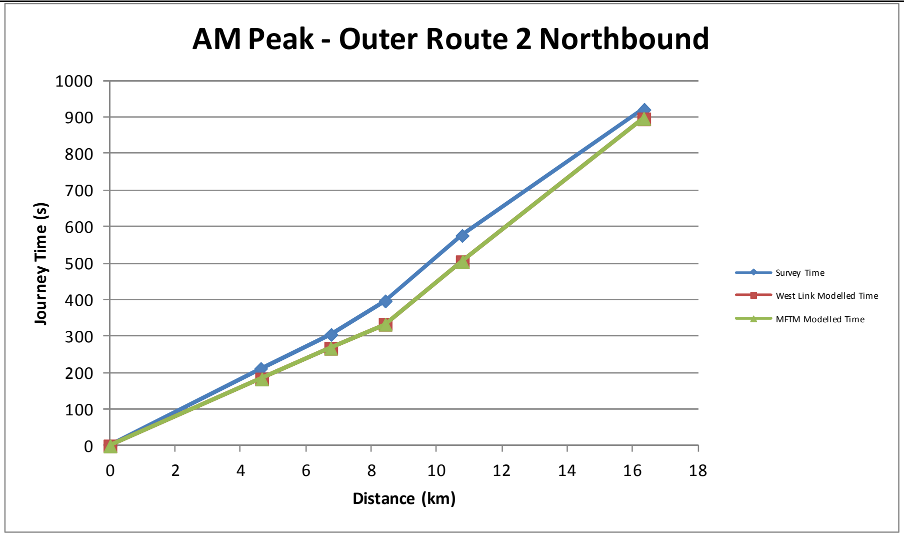
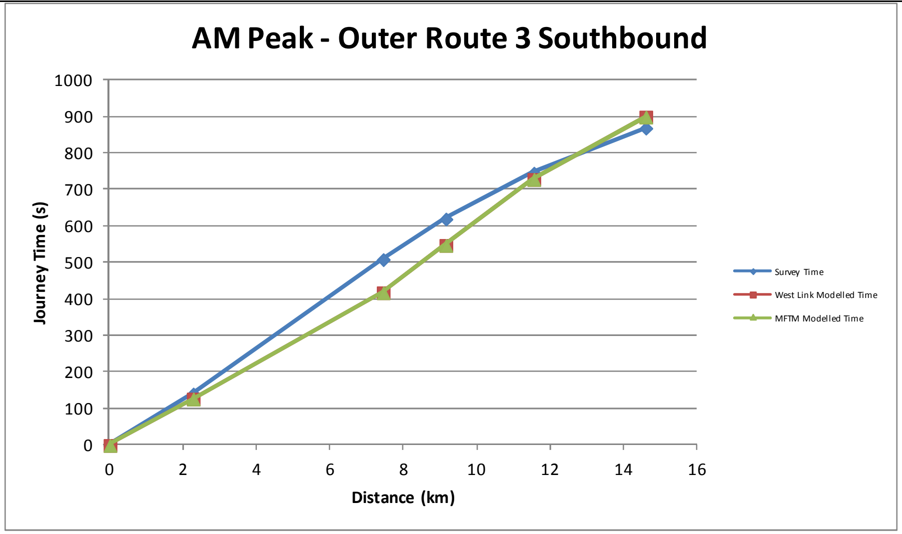
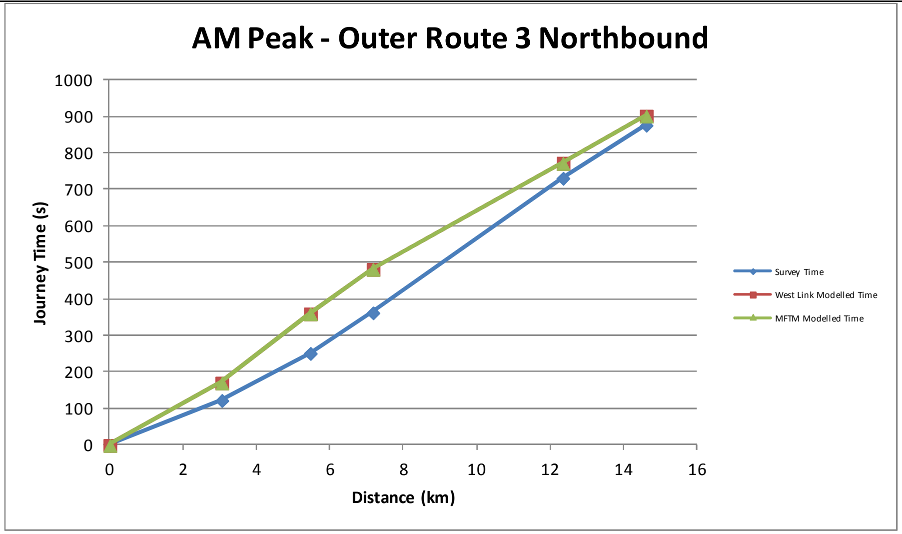
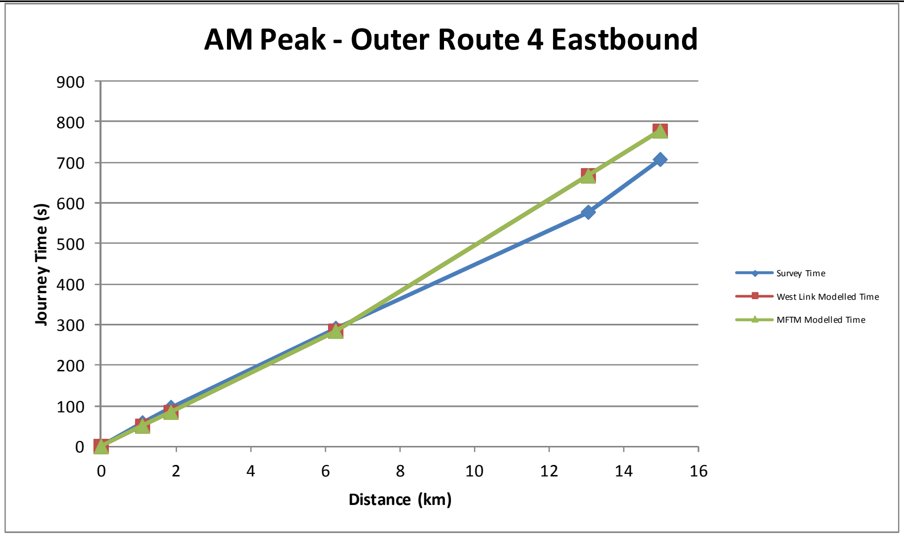
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

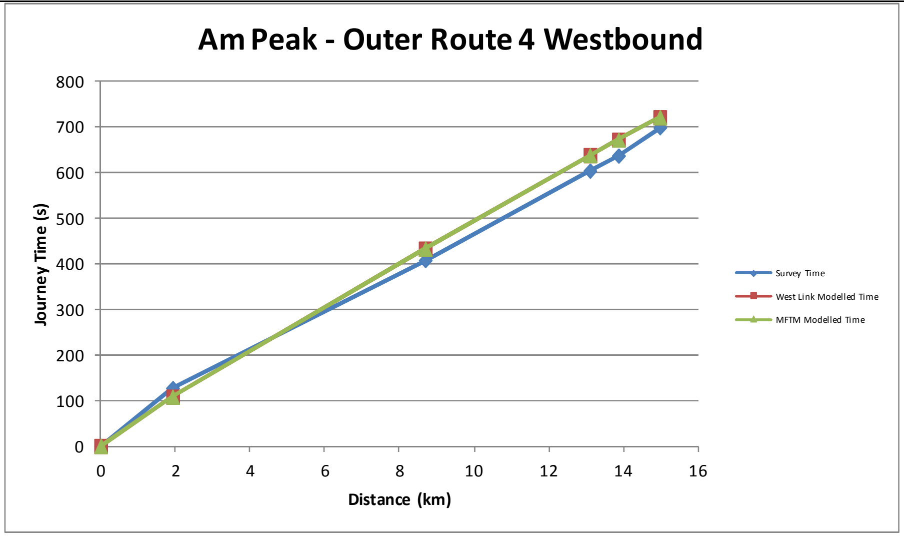

AM Peak - Outer Route 2 Southbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

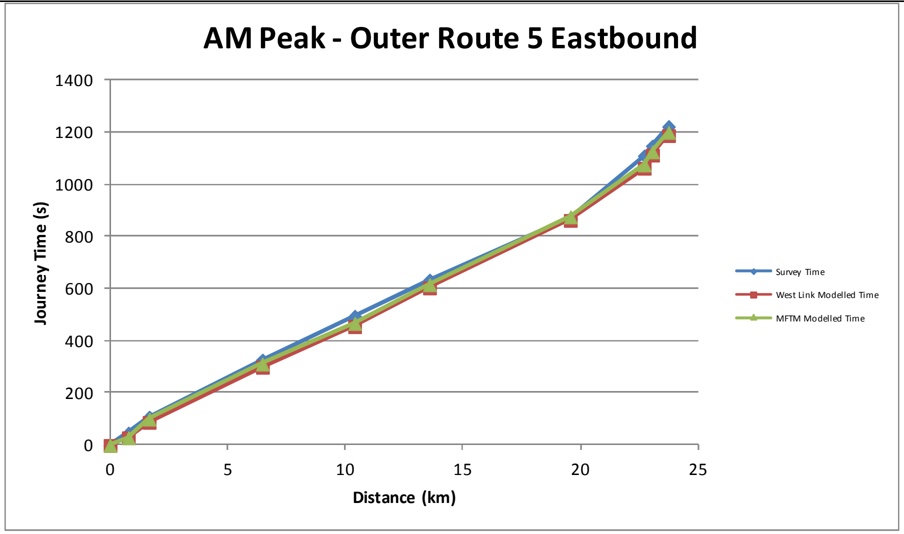

AM Peak - Outer Route 2 Northbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

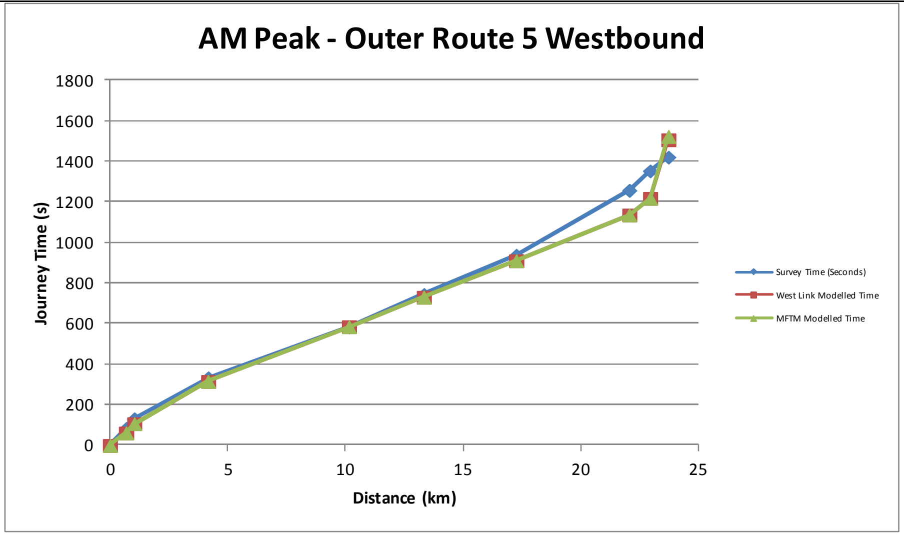

AM Peak - Outer Route 3 Southbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

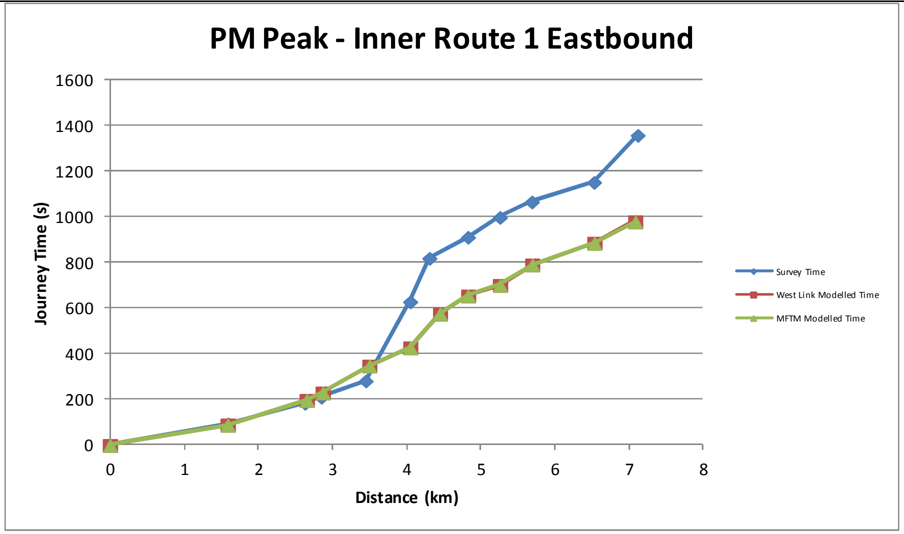

AM Peak - Outer Route 3 Northbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

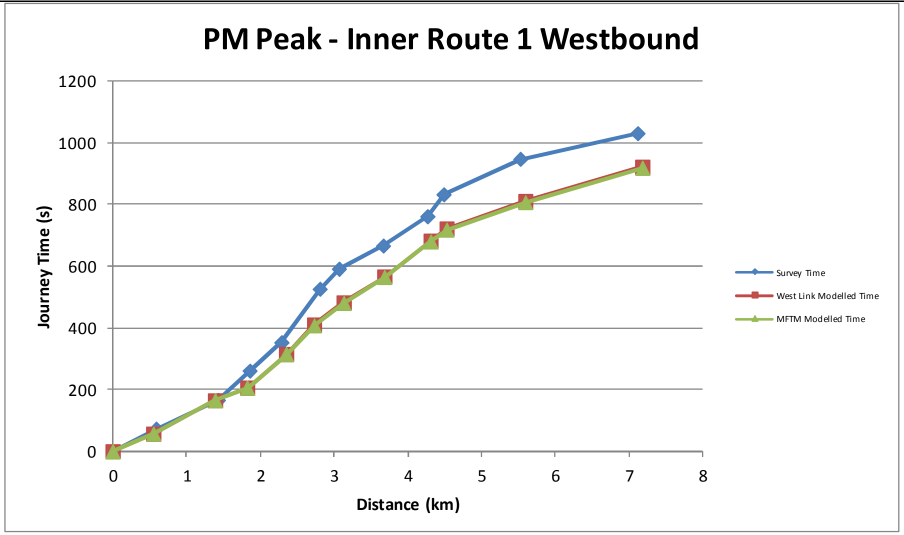

AM Peak - Outer Route 4 Eastbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

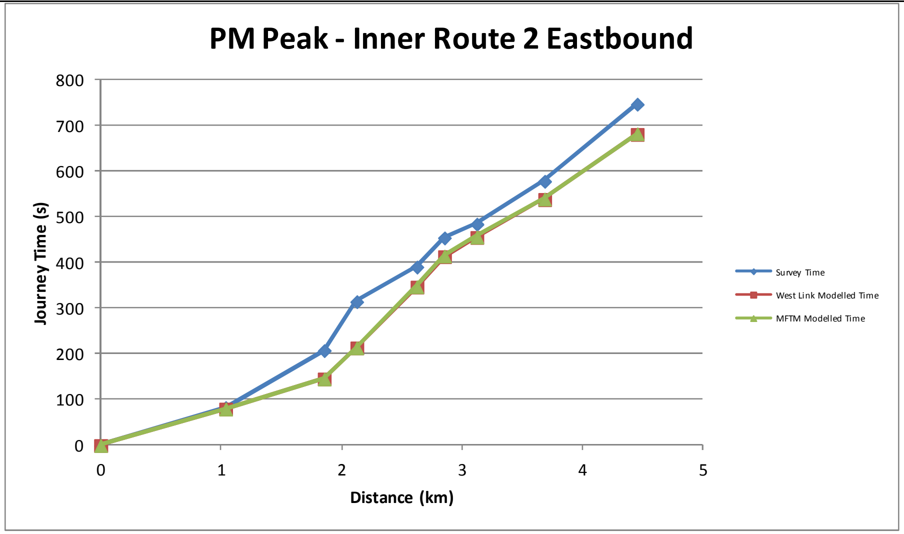

Am Peak - Outer Route 4 Westbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


AM Peak - Outer Route 5 Eastbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


AM Peak - Outer Route 5 Westbound
Journey Time (s)
Distance (km)
Survey Time (Seconds)
West Link Modelled Time
MFTM Modelled Time


PM Peak - Inner Route 1 Eastbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


PM Peak - Inner Route 1 Westbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time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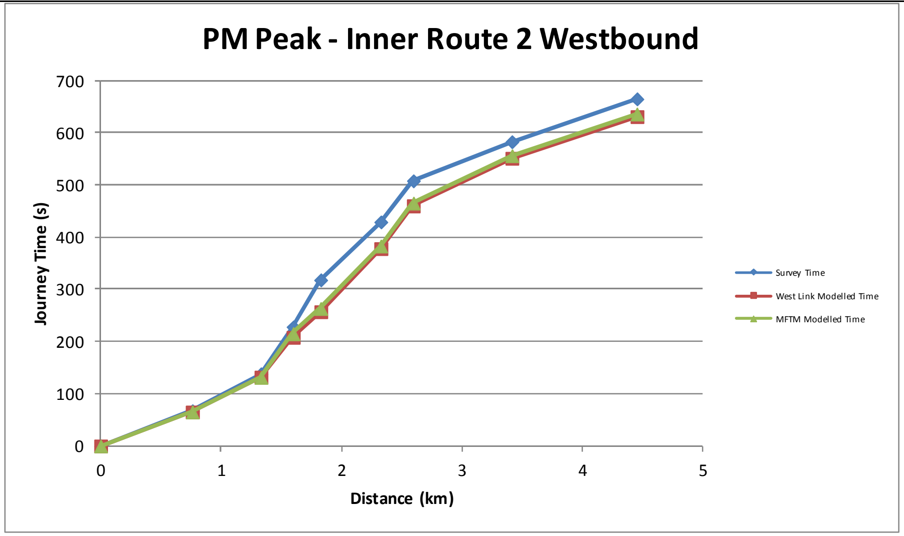
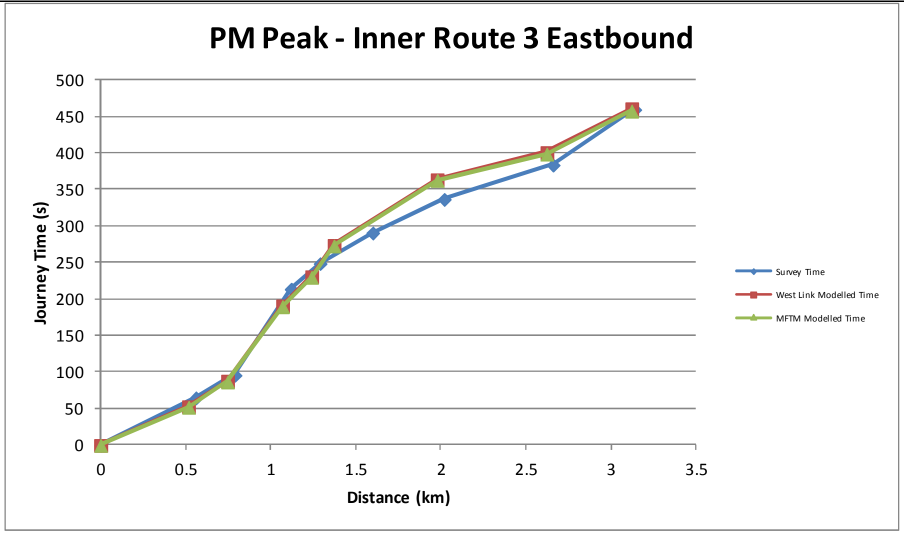
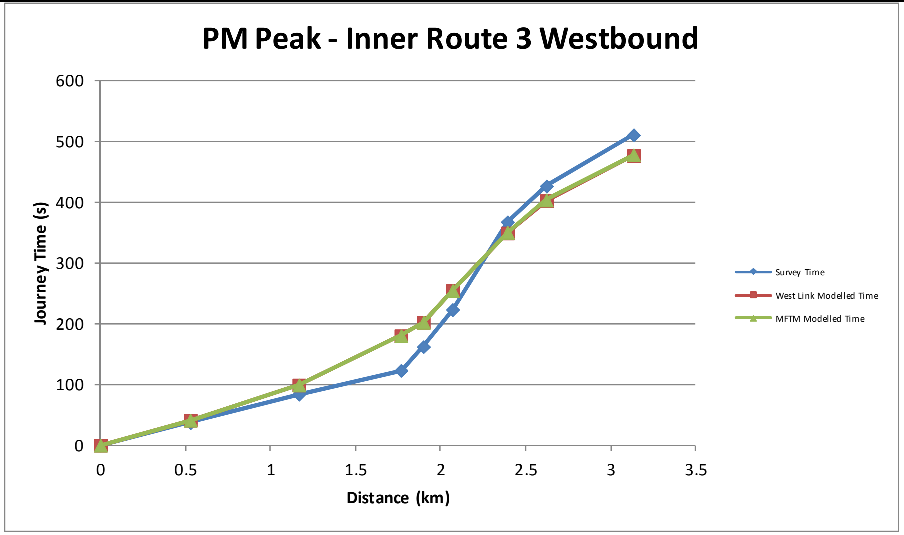
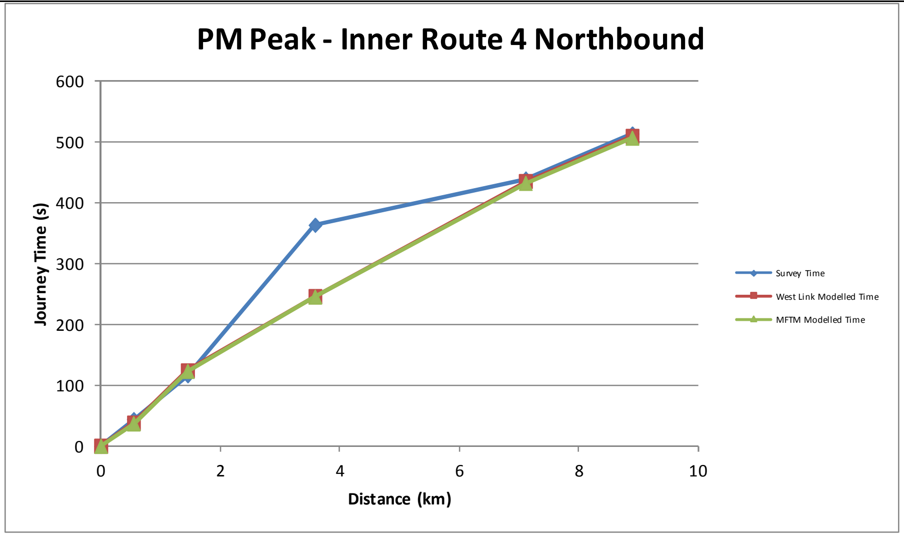
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

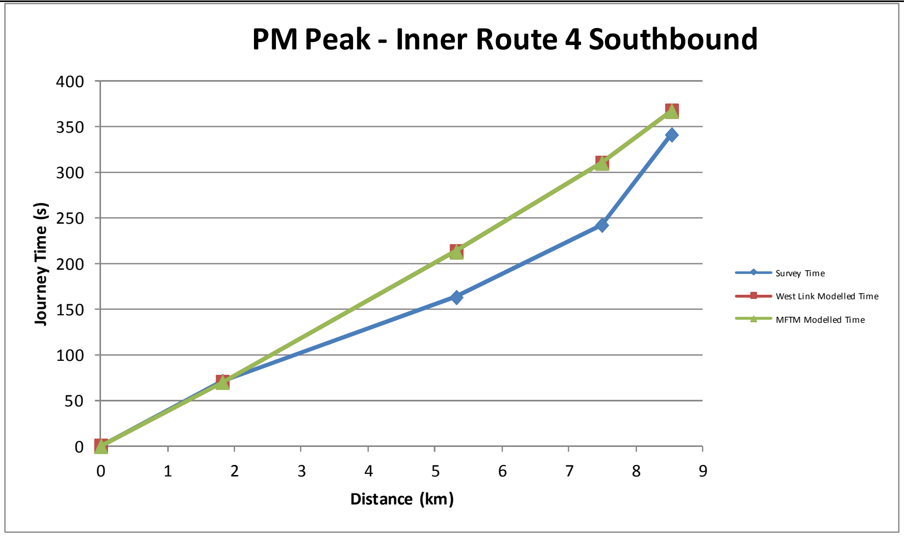

PM Peak - Inner Route 2 Westbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

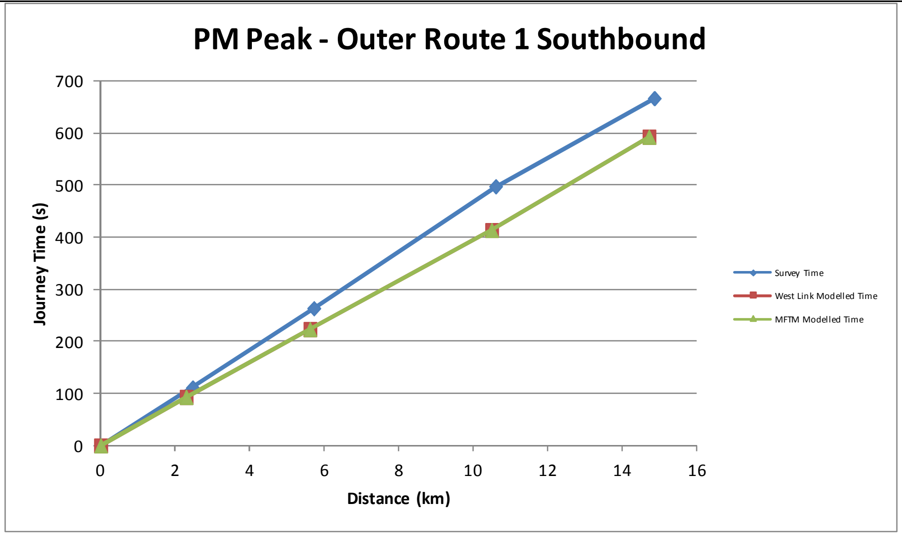
Capabilities on project:
Transportation

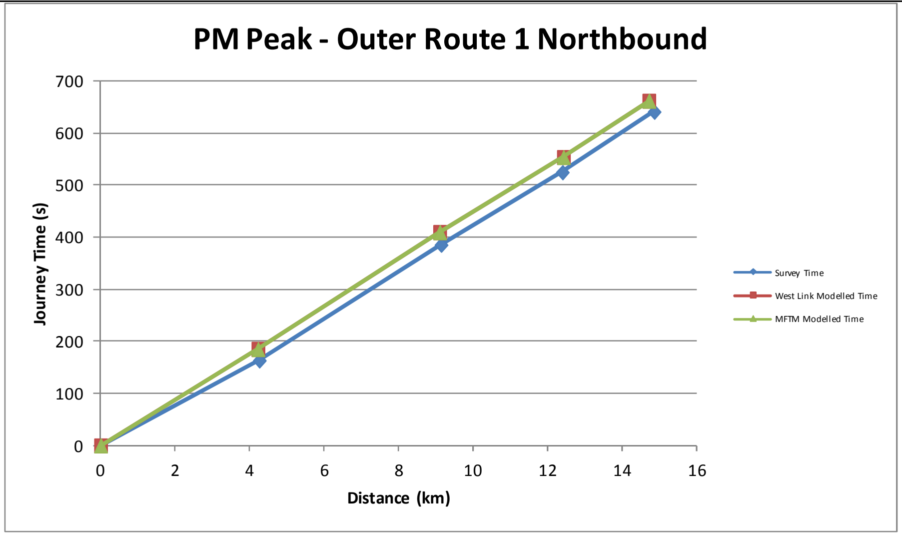


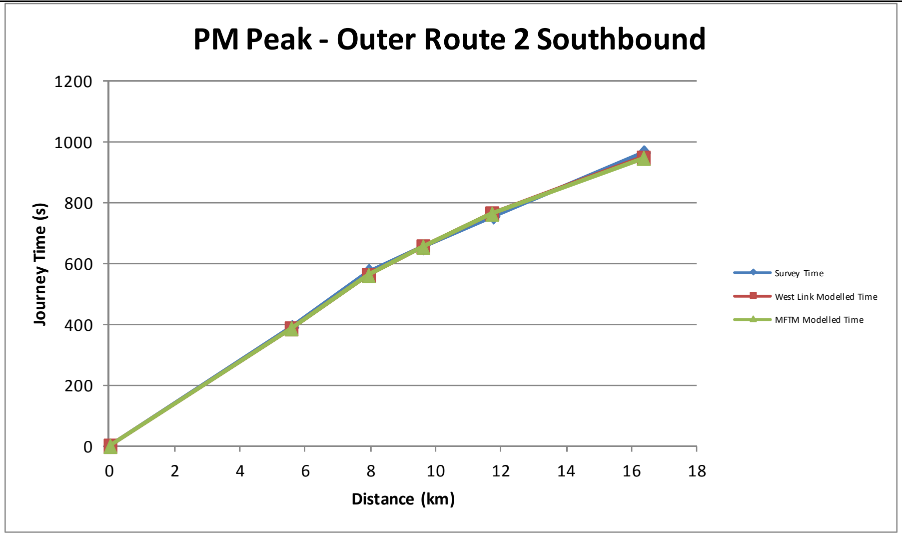


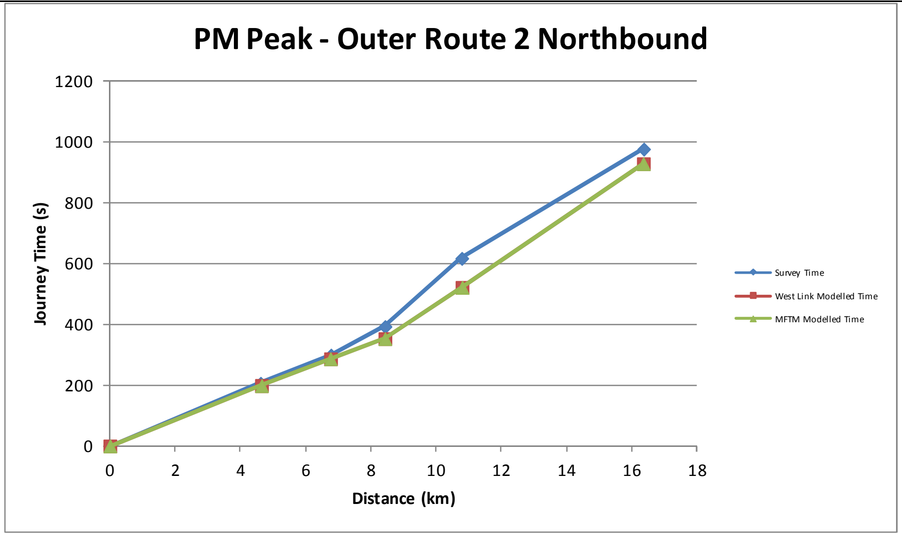


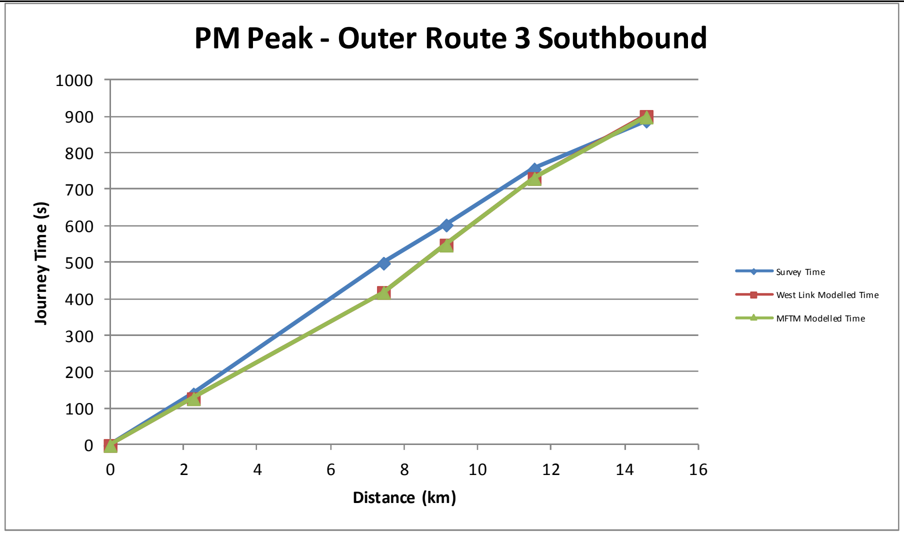


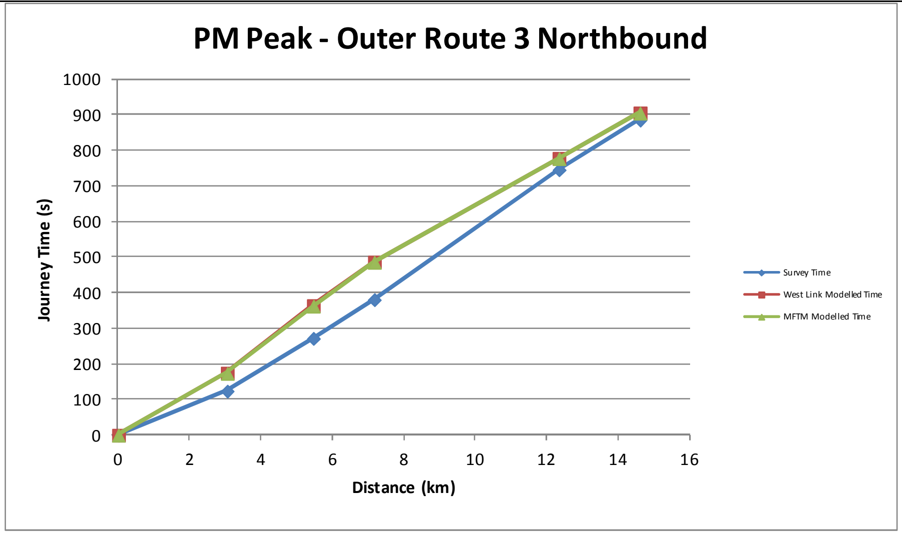

PM Peak - Outer Route 1 Southbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

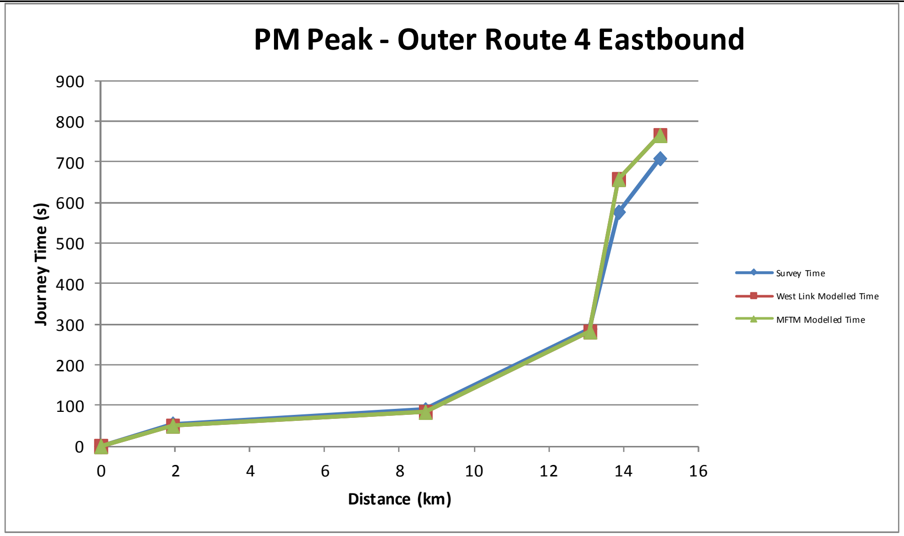

PM Peak - Outer Route 1 Northbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time

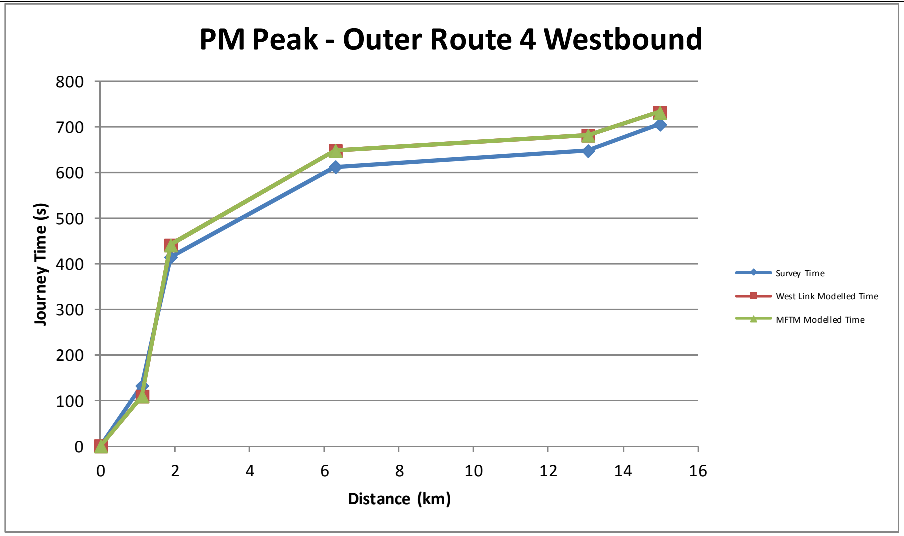

PM Peak - Outer Route 2 Southbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


PM Peak - Outer Route 2 Northbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


PM Peak - Outer Route 3 Southbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


PM Peak - Outer Route 3 Northbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


PM Peak - Outer Route 4 Eastbound
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time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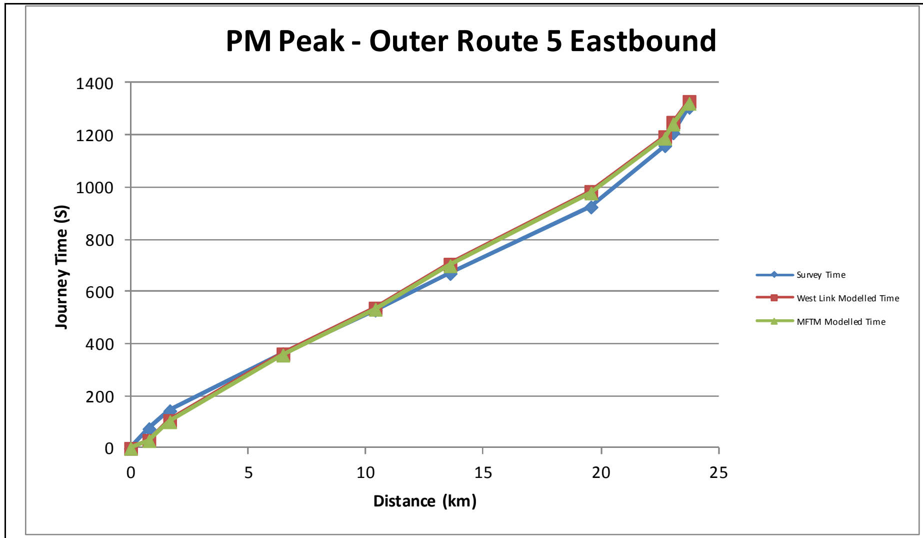
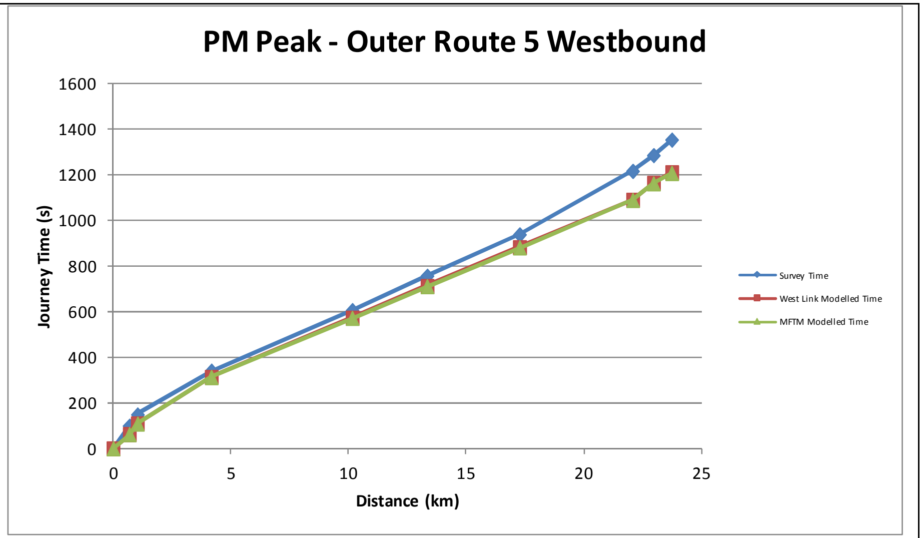
Journey Time (s)
Distance (km)
Survey Time
West Link Modelled Time
MFTM Modelled Time


PM Peak - Outer Route 5 Eastbound
Journey Time (S)
Distance (km)
0
200
400
600
800
1000
1200
1400
0
5
10
15
20
25
Survey Time
West Link Modelled Time
MFTM Modelled Time


PM Peak - Outer Route 5 Westbound
Journey Time (s)
Distance (km)
0
200
400
600
800
1000
1200
1400
1600
0
5
10
15
20
25
Survey Time
West Link Modelled Time
MFTM Modelled Time

Appendix H: Input Scheme Costs

-

Capabilities on project:
Transportation

Summary of Cost Estimates for Options 1 to 8

Item Description	Rate	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8
Preliminaries	15%	£1,667,000	£1,838,000	£1,682,000	£1,825,000	£1,786,000	£1,972,000	£4,874,000	£4,793,000
Roadworks Total		£5,153,000	£6,295,000	£4,812,000	£5,768,000	£5,527,000	£7,191,000	£14,766,000	£5,068,000
Structures Total		£5,955,000	£5,955,000	£6,395,000	£6,395,000	£6,375,000	£5,955,000	£17,725,000	£26,880,000
Construction Works sub-total		**£12,775,000**	**£14,088,000**	**£12,889,000**	**£13,988,000**	**£13,688,000**	**£15,118,000**	**£37,365,000**	**£36,741,000**
Risk Allowance	20%	£2,555,000	£2,818,000	£2,578,000	£2,798,000	£2,738,000	£3,024,000	£7,473,000	£7,349,000
Optimism Bias	25%	£3,194,000	£3,522,000	£3,223,000	£3,497,000	£3,422,000	£3,780,000	£9,342,000	£9,186,000
Optimism Bias addition relevant to Structures Costs	20%	£1,191,000	£1,191,000	£1,279,000	£1,279,000	£1,275,000	£1,191,000	£3,545,000	£5,376,000
Land & Property		£864,000	£2,313,000	£5,652,000	£6,357,000	£5,680,000	£768,000	£1,708,000	£7,559,000
Scheme Preparation & Administration Costs	9%	£1,853,000	£2,154,000	£2,306,000	£2,513,000	£2,413,000	£2,150,000	£5,349,000	£5,959,000
Site Supervision & Testing	5%	£1,029,000	£1,197,000	£1,282,000	£1,396,000	£1,341,000	£1,195,000	£2,972,000	£3,311,000
Total Scheme Cost		**£23,461,000**	**£27,283,000**	**£29,209,000**	**£31,828,000**	**£30,557,000**	**£27,226,000**	**£67,754,000**	**£75,481,000**
Annual Maintenance Costs		**£83,000**	**£85,000**	**£84,000**	**£86,000**	**£88,000**	**£91,000**	**£197,000**	**£225,000**
Roads and Bridges									
Annual Operating Costs - Canal Crossing		**£10,000**	**£10,000**	**£10,000**	**£10,000**	**£10,000**	**£10,000**	**£10,000**	**£74,000**
Year 6 Additional Costs		**£557,000**	**£549,000**	**£500,000**	**£500,000**	**£500,000**	**£598,000**	**£500,000**	**£500,000**
Access Tracks (Post Completion), Riverside Improvements for Cyclists, Park & Ride Facilities									

Appendix I: Network Flow Effects

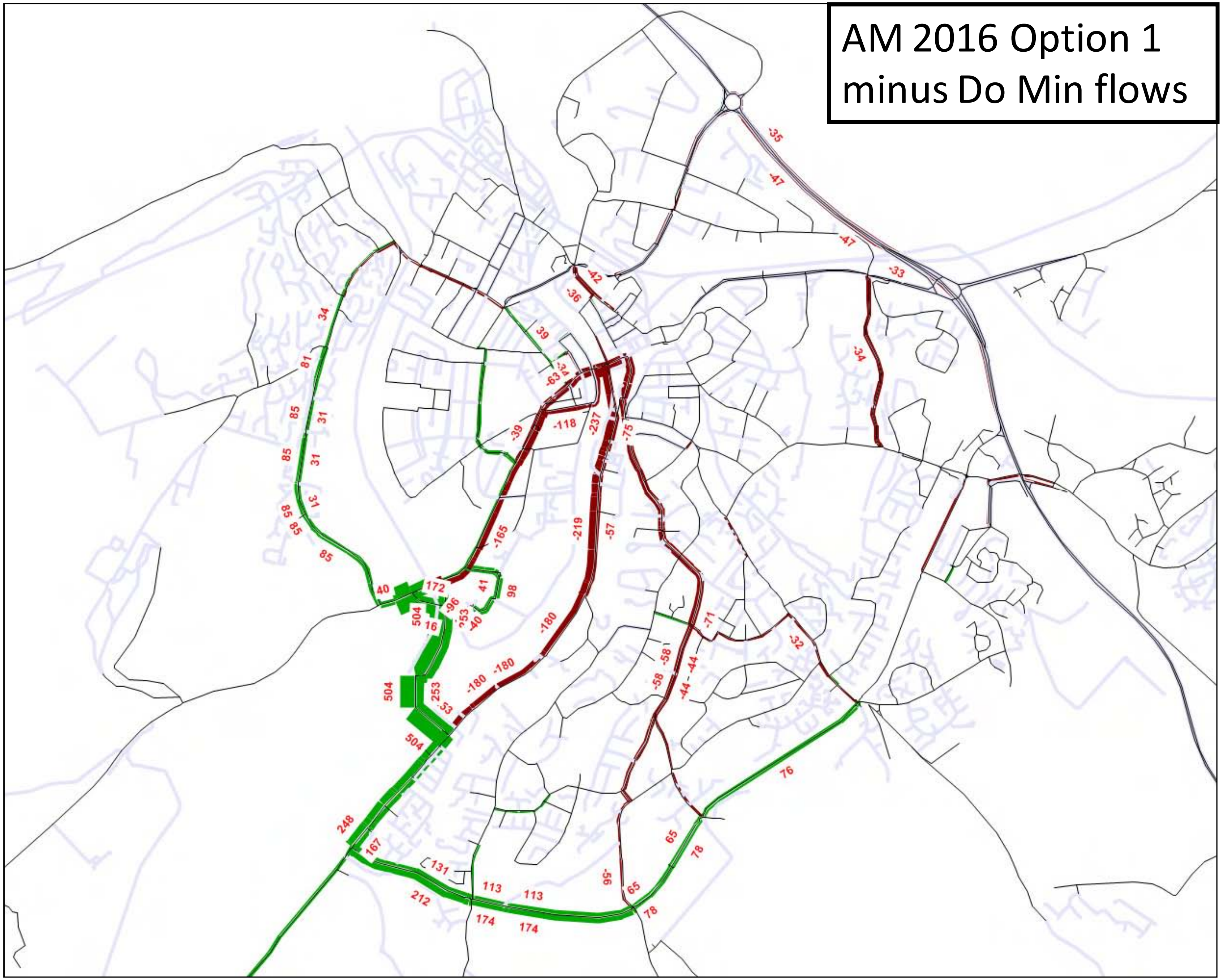

Do Min
2016
AM Peak

Capabilities on project:
Transportation

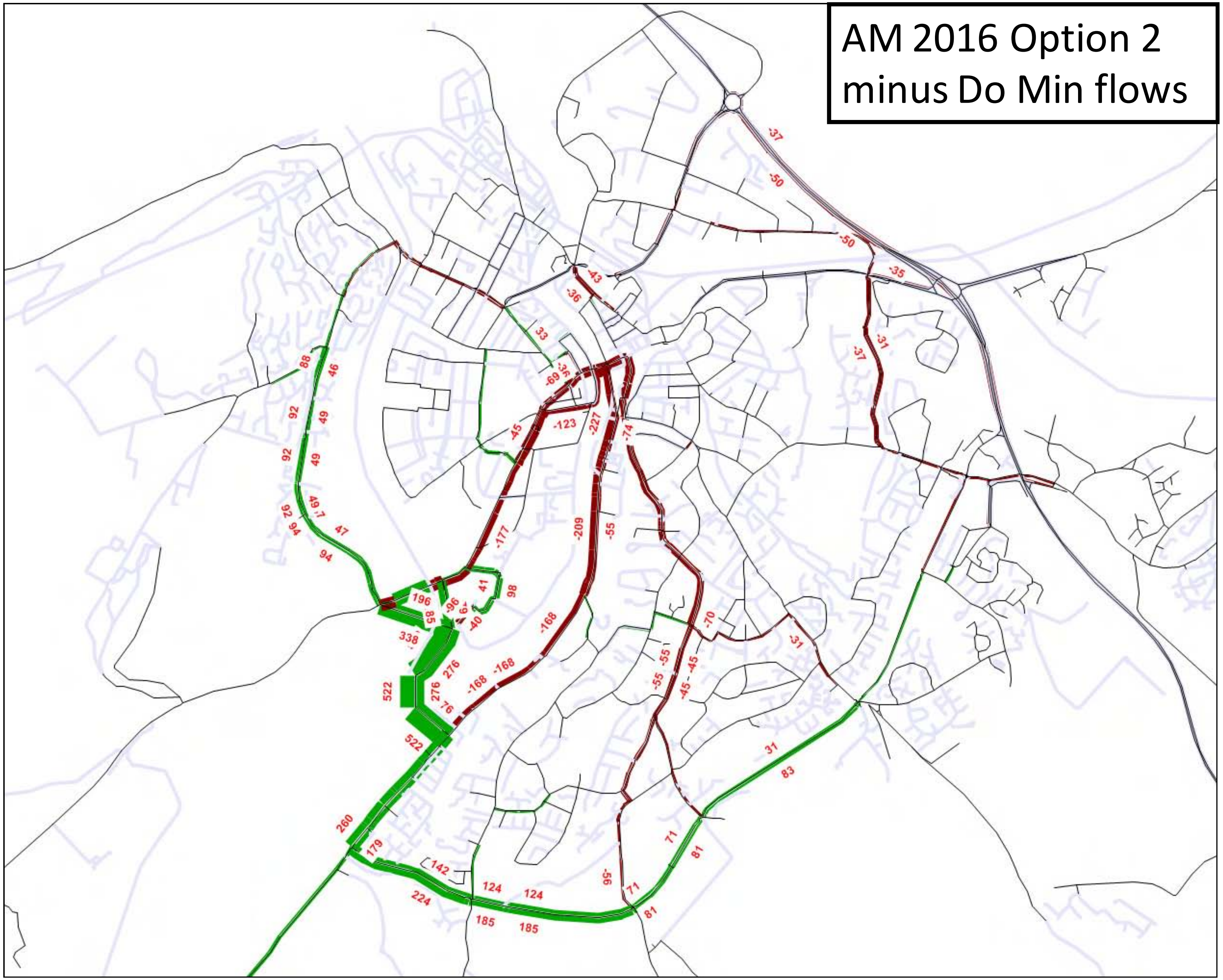
Capabilities on project:
Transportation

Capabilities on project:
Transportation

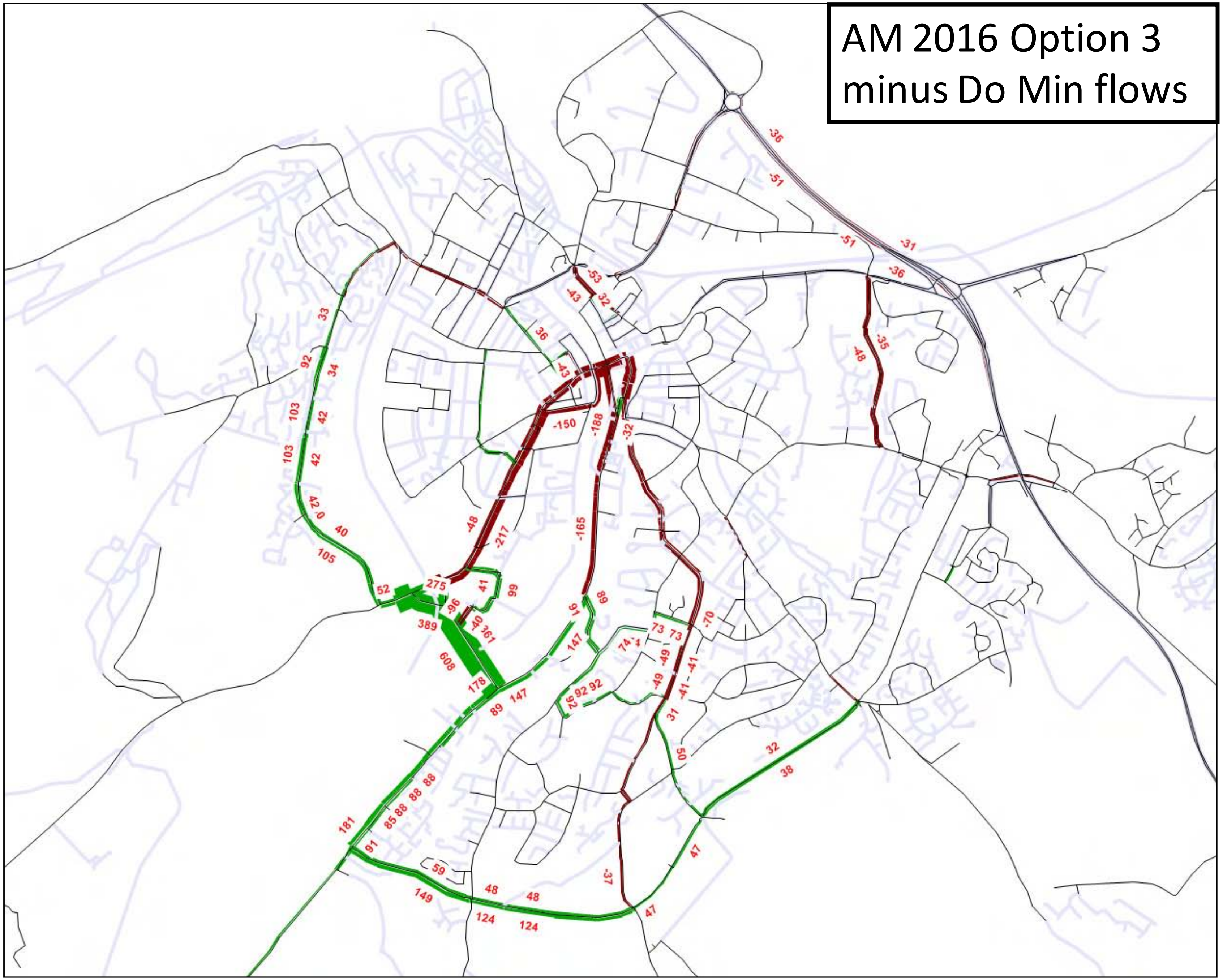
Capabilities on project:
Transportation



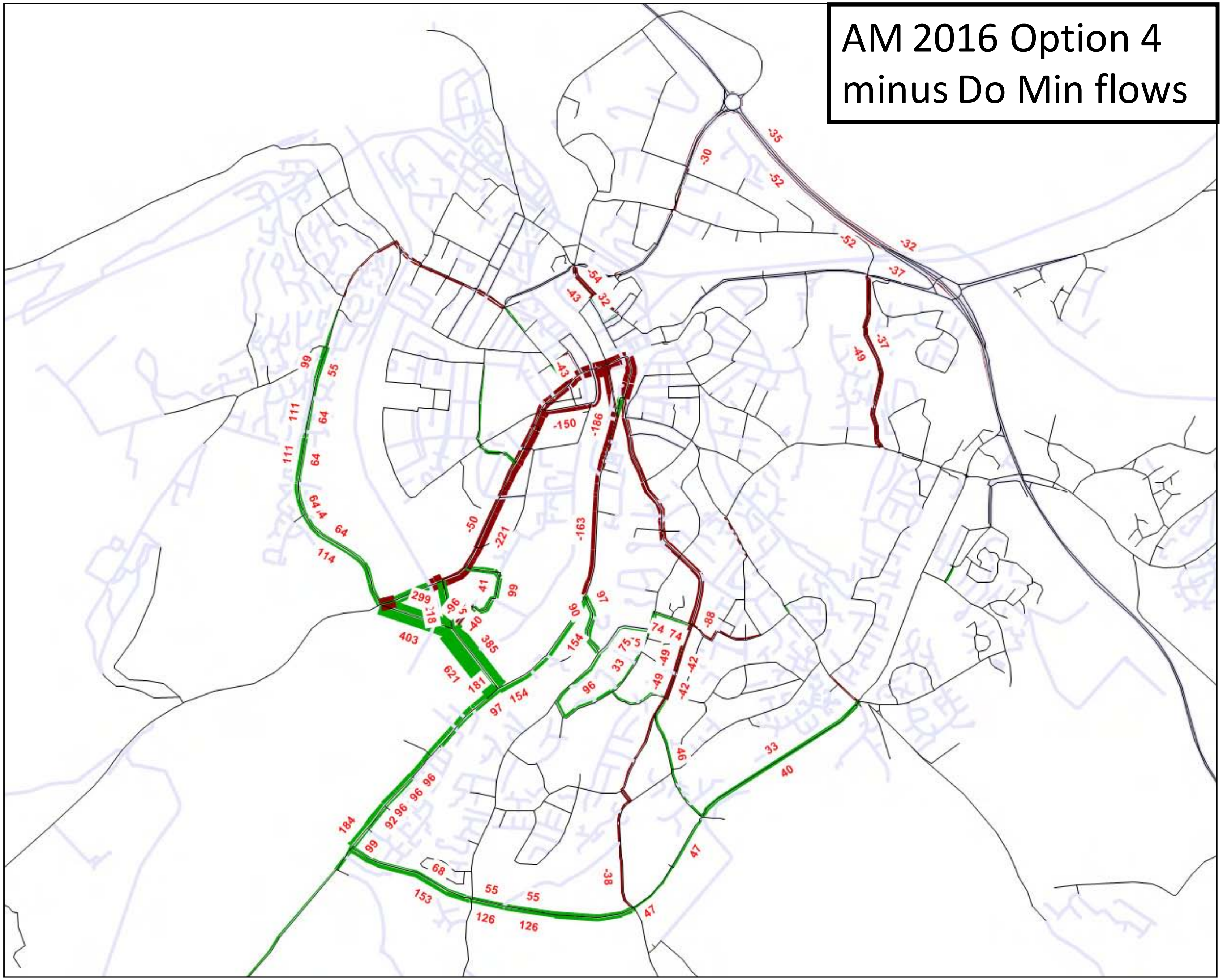
Capabilities on project:
Transportation



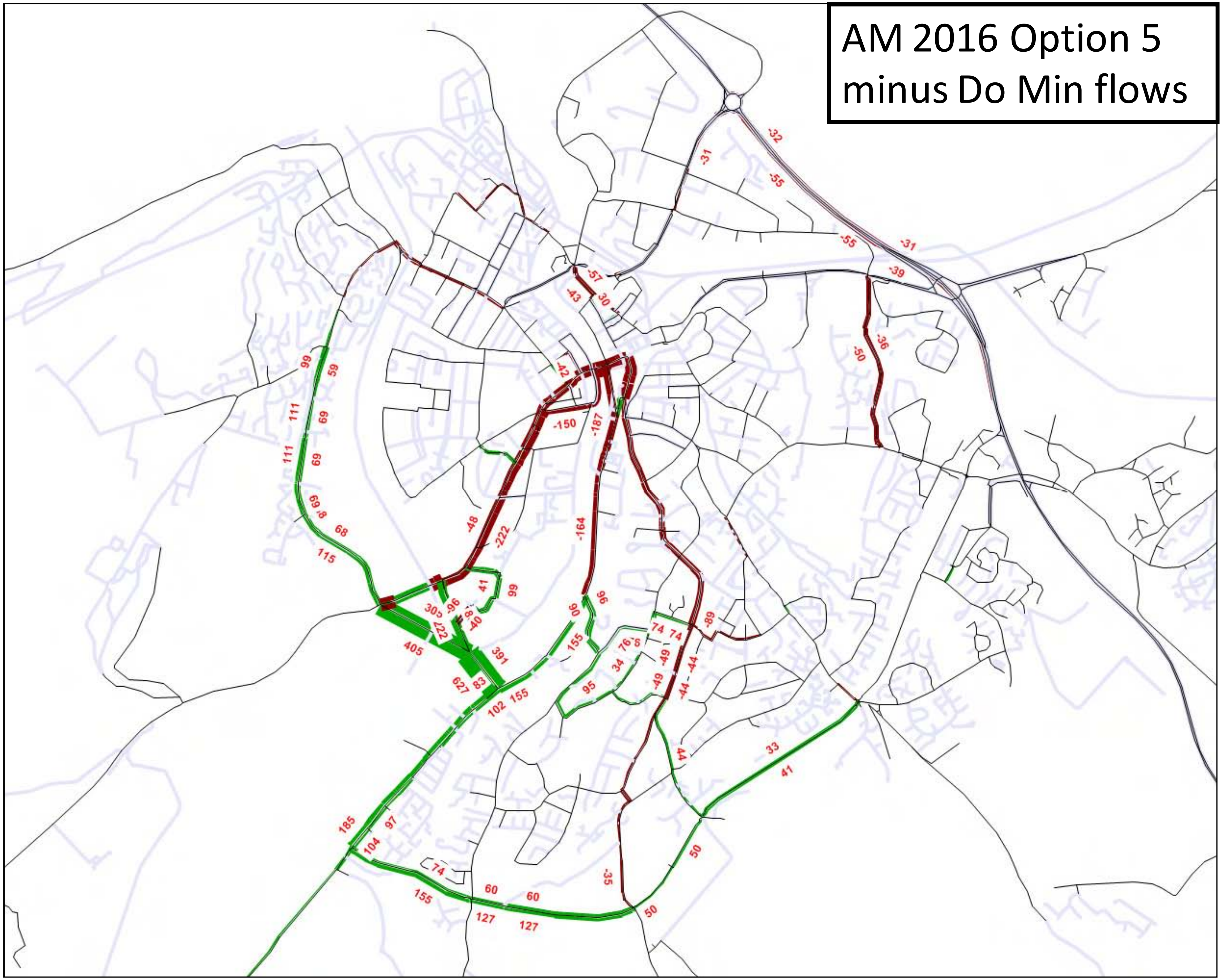
Capabilities on project:
Transportation



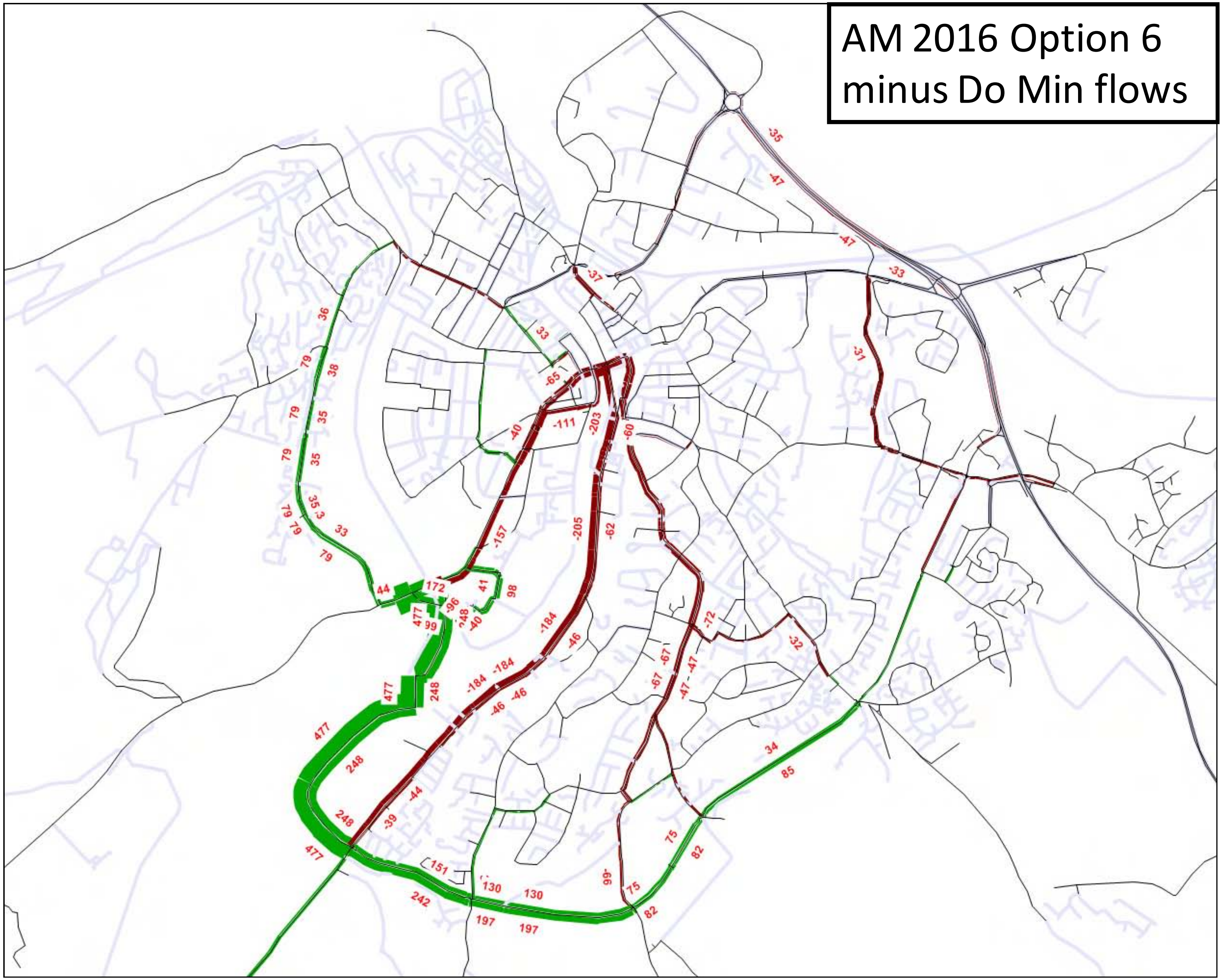
Capabilities on project:
Transportation



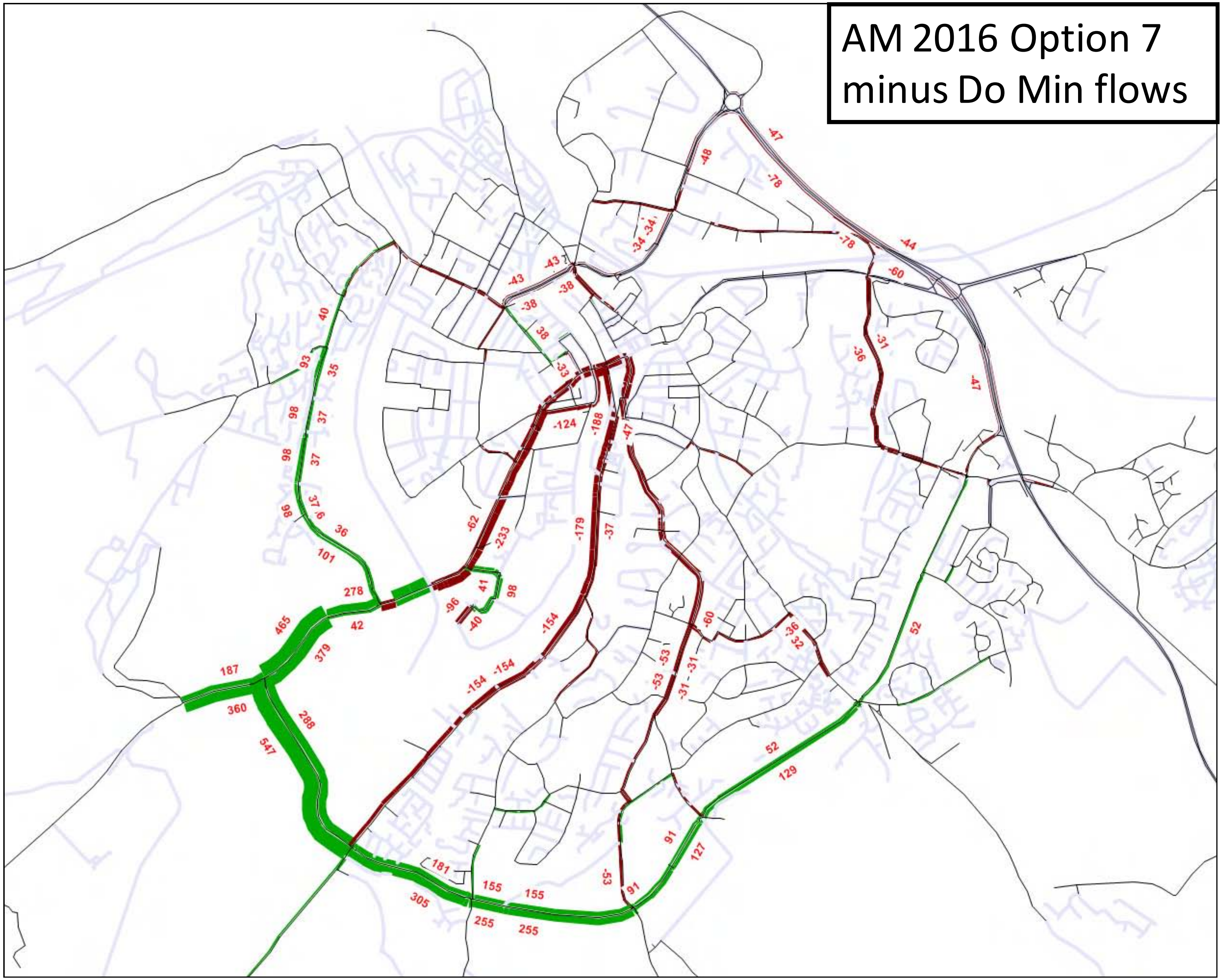
Capabilities on project:
Transportation



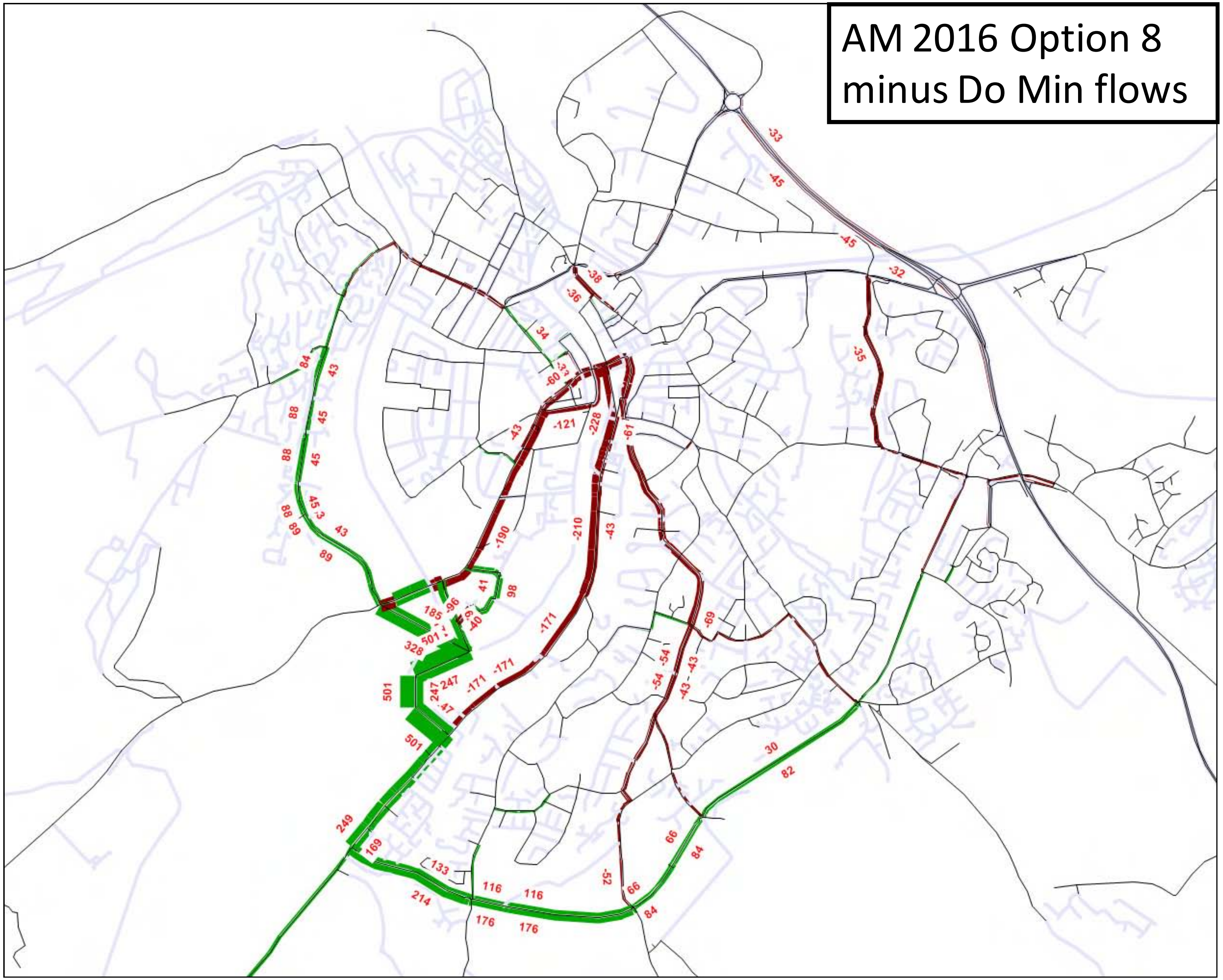
Capabilities on project:
Transportation



Capabilities on project:
Transportation



Capabilities on project:
Transportation



Capabilities on project:
Transportation


Do Min
2016
PM Peak

Capabilities on project:
Transportation

Capabilities on project:
Transportation

Capabilities on project:
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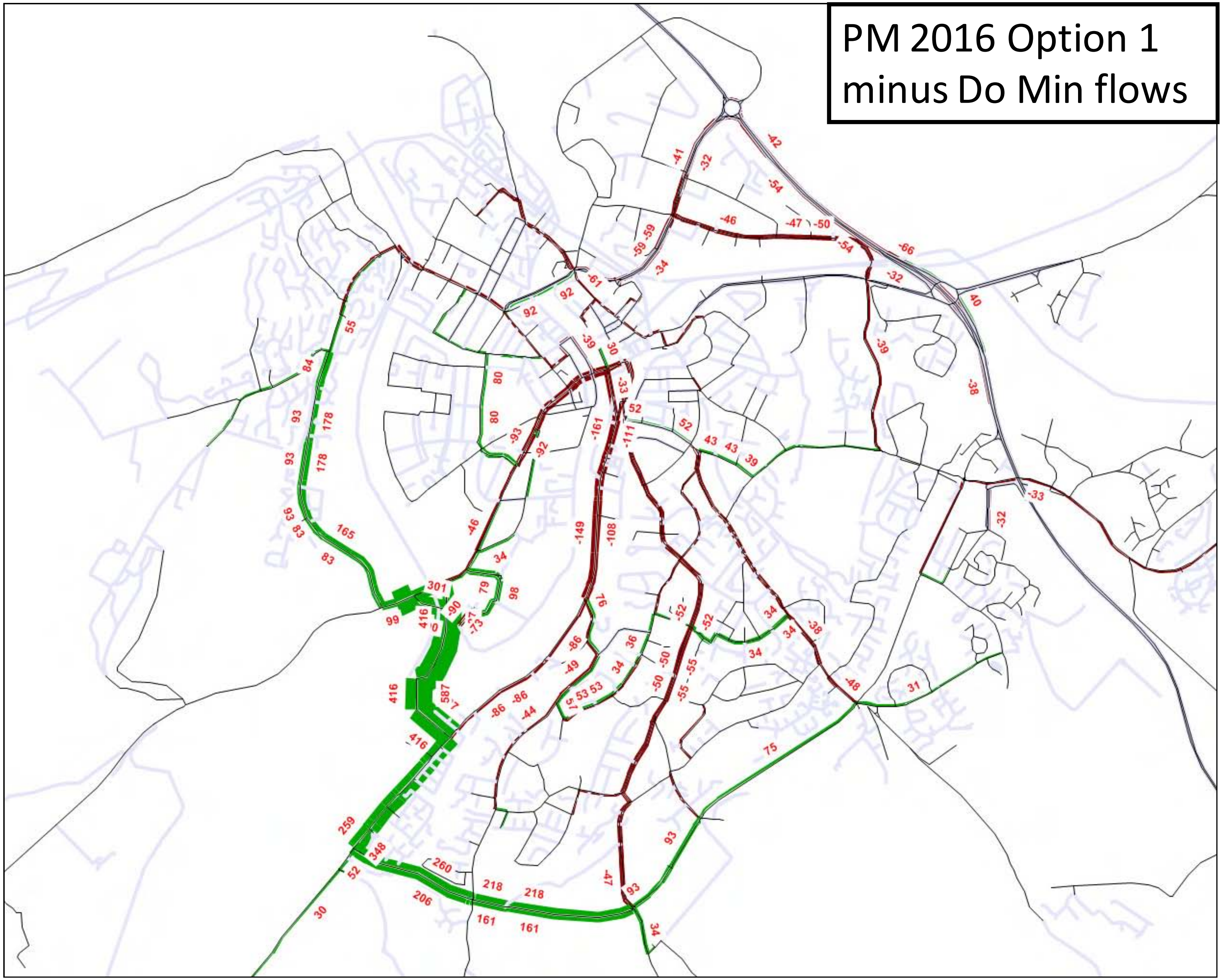

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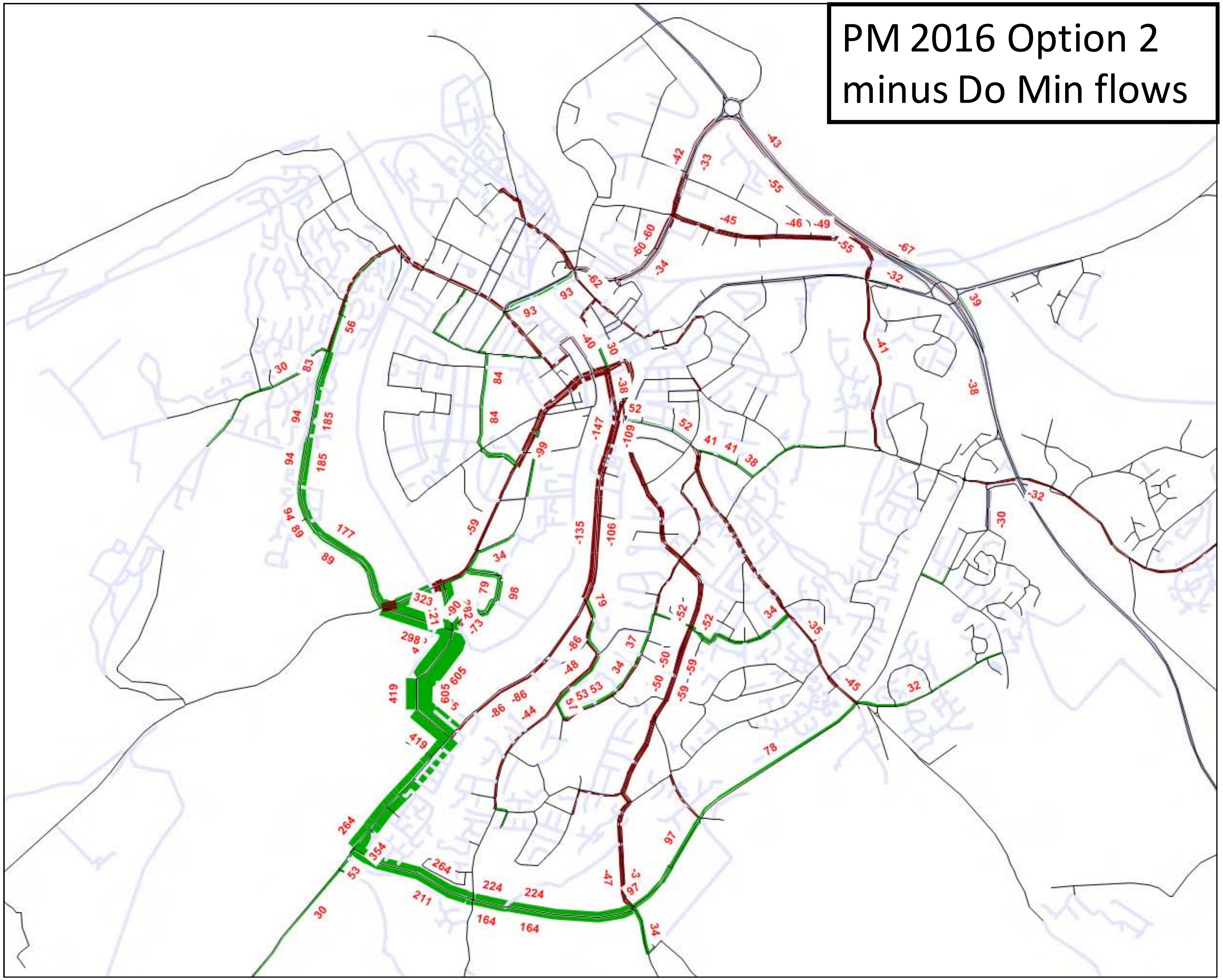

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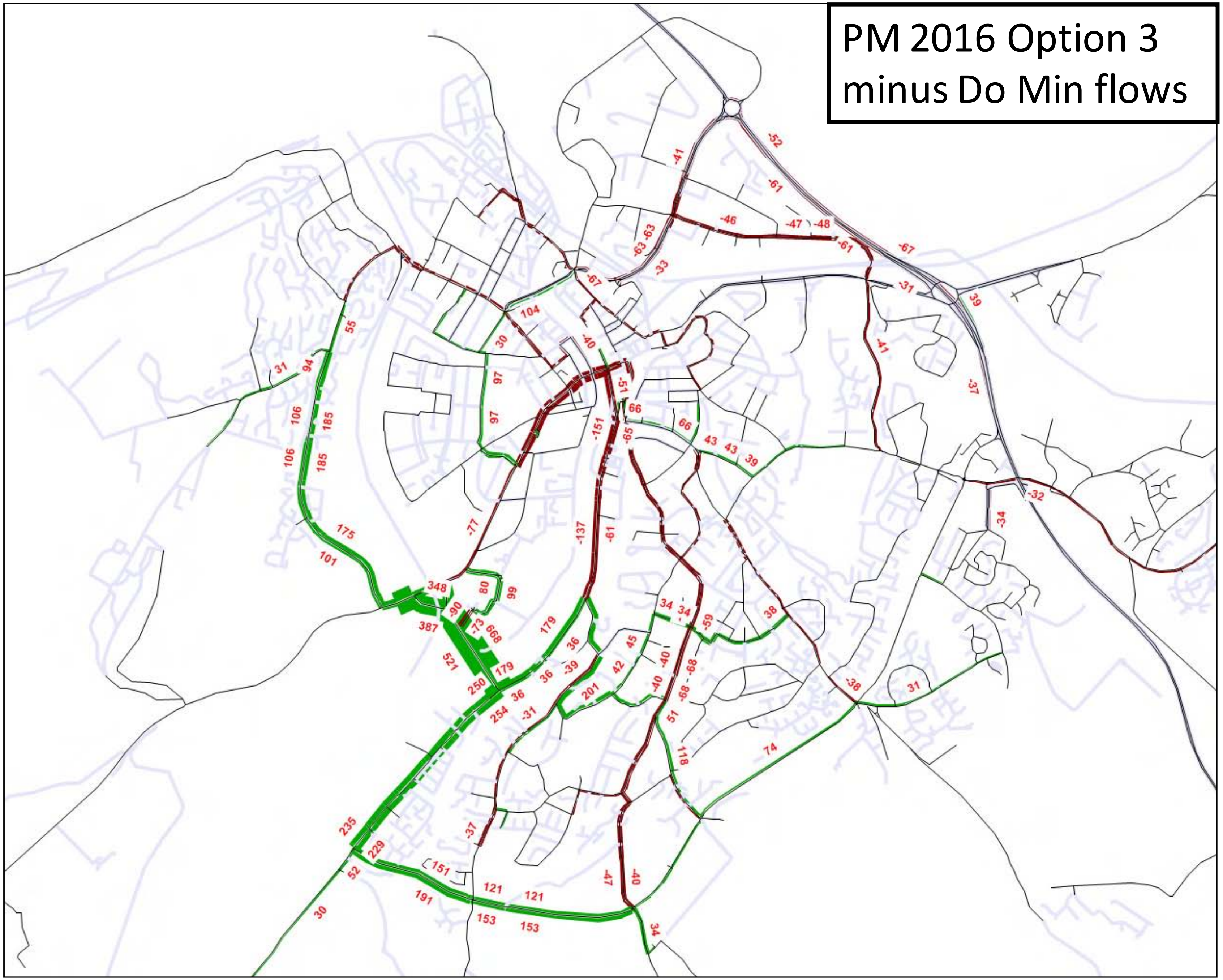

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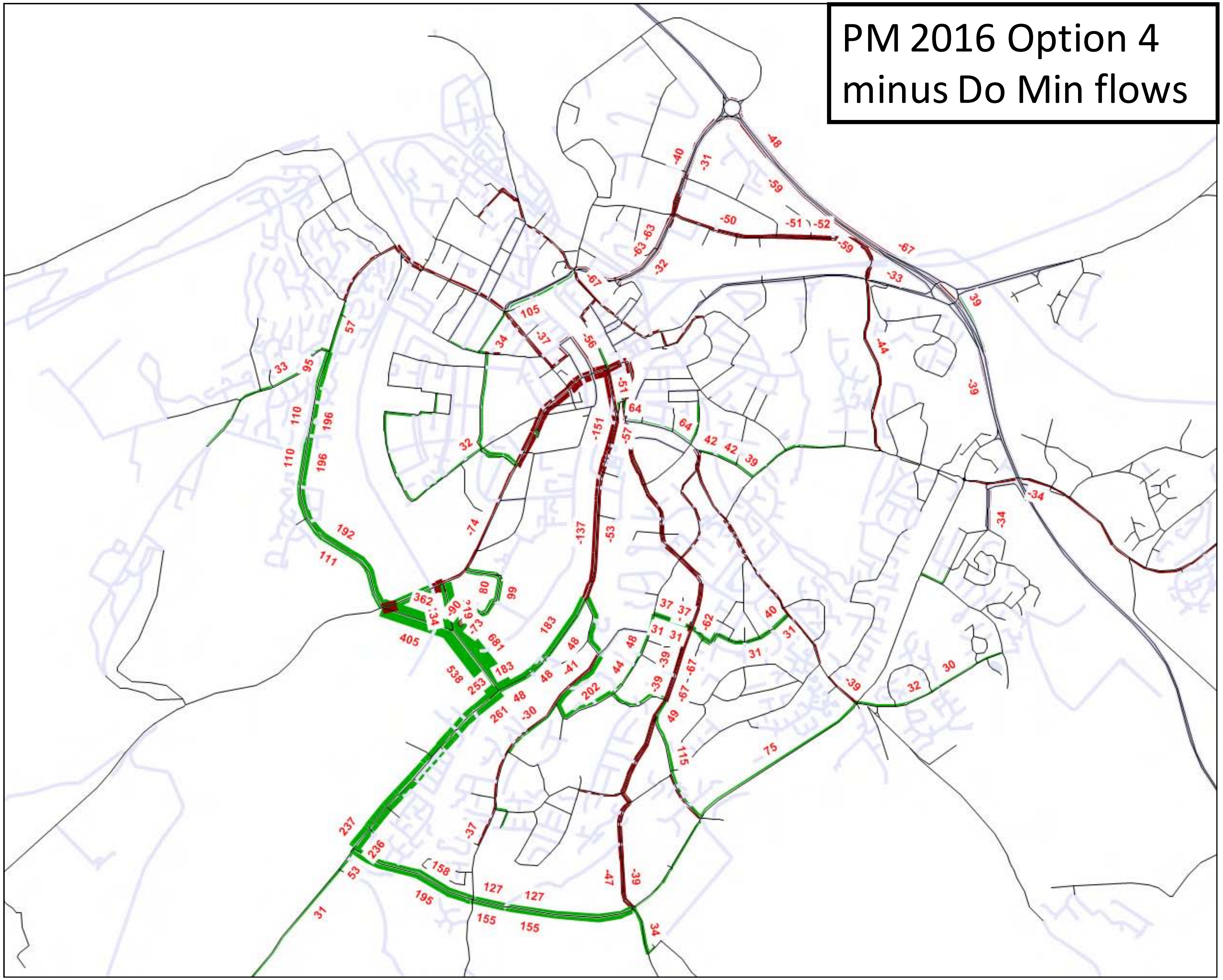

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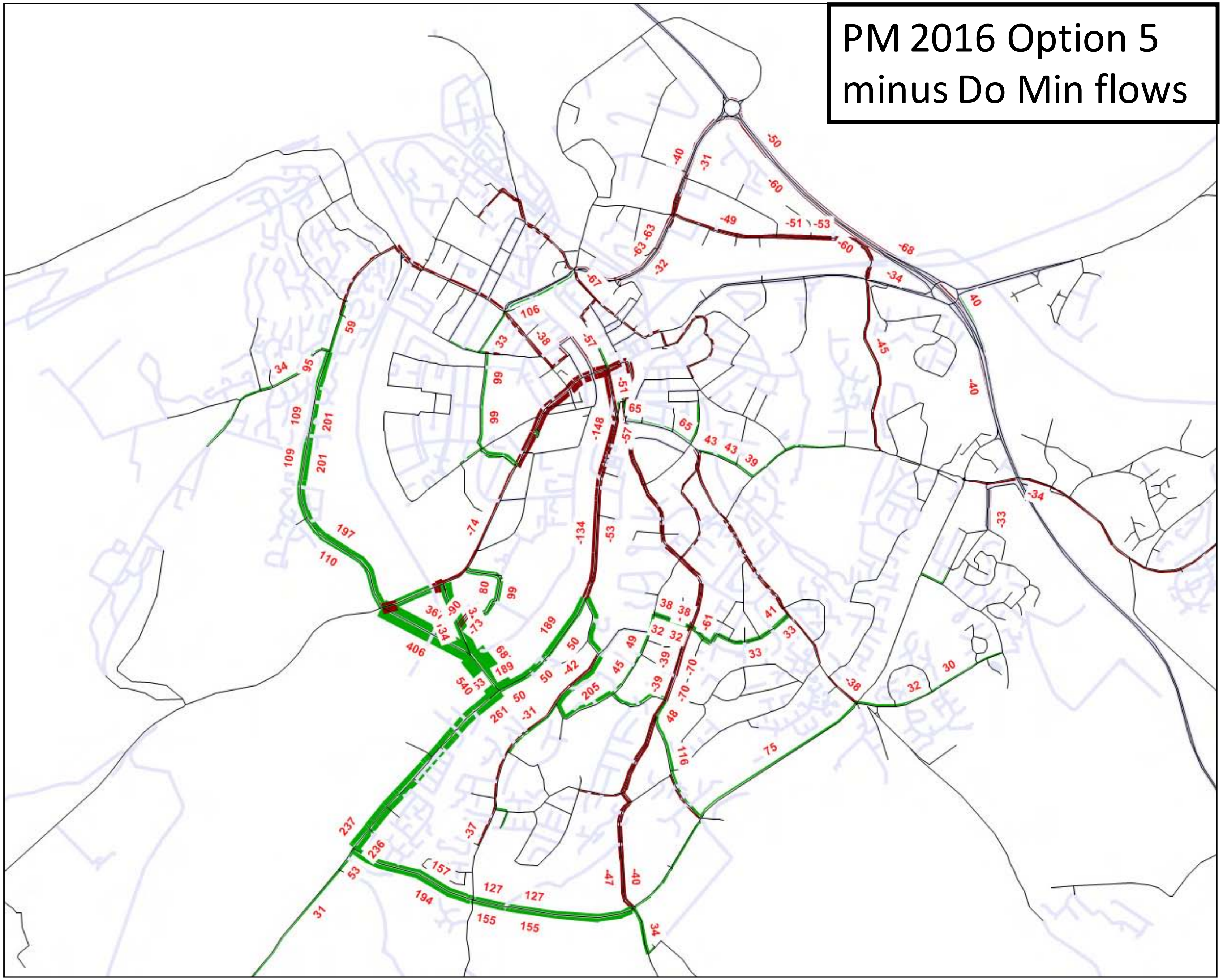

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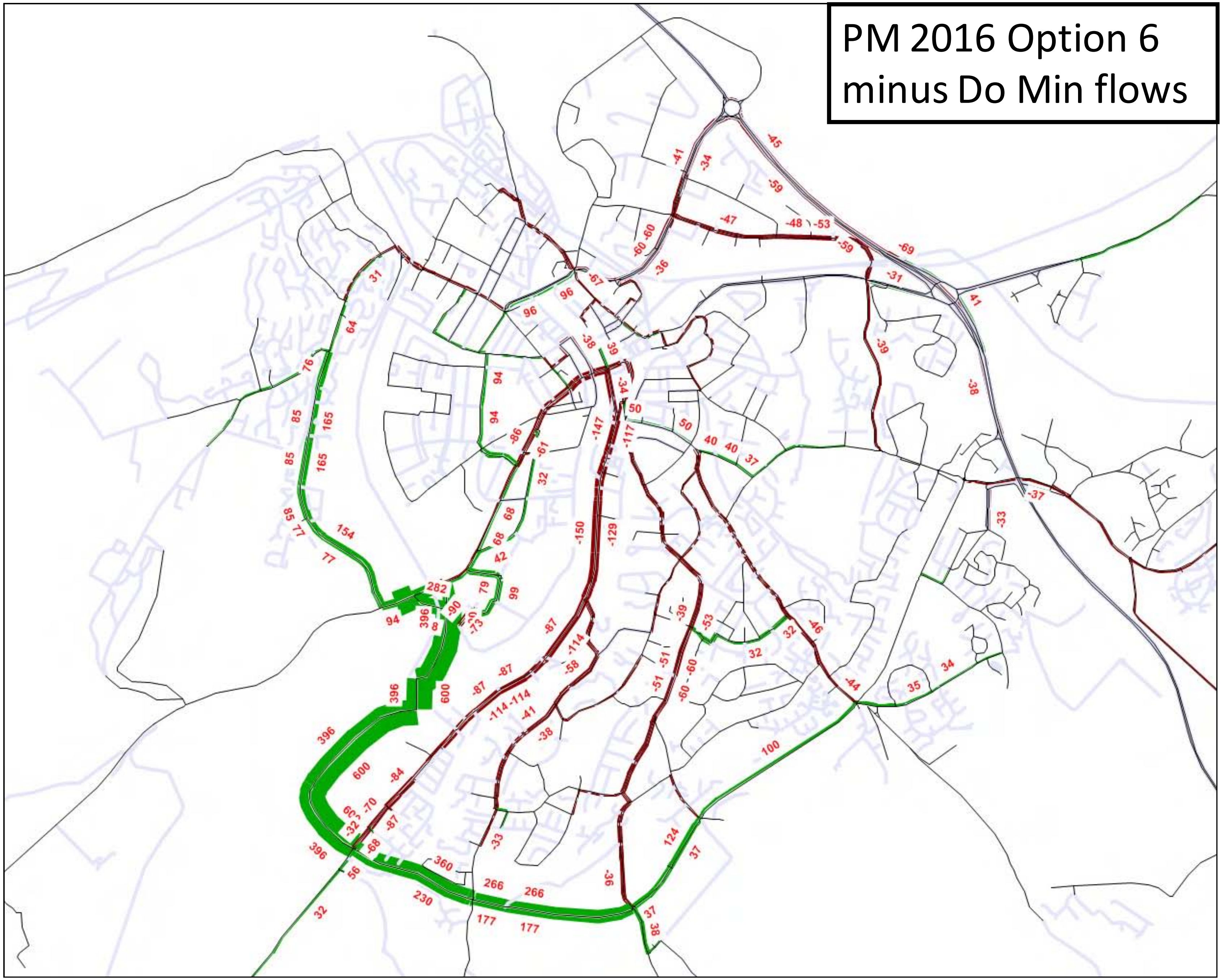

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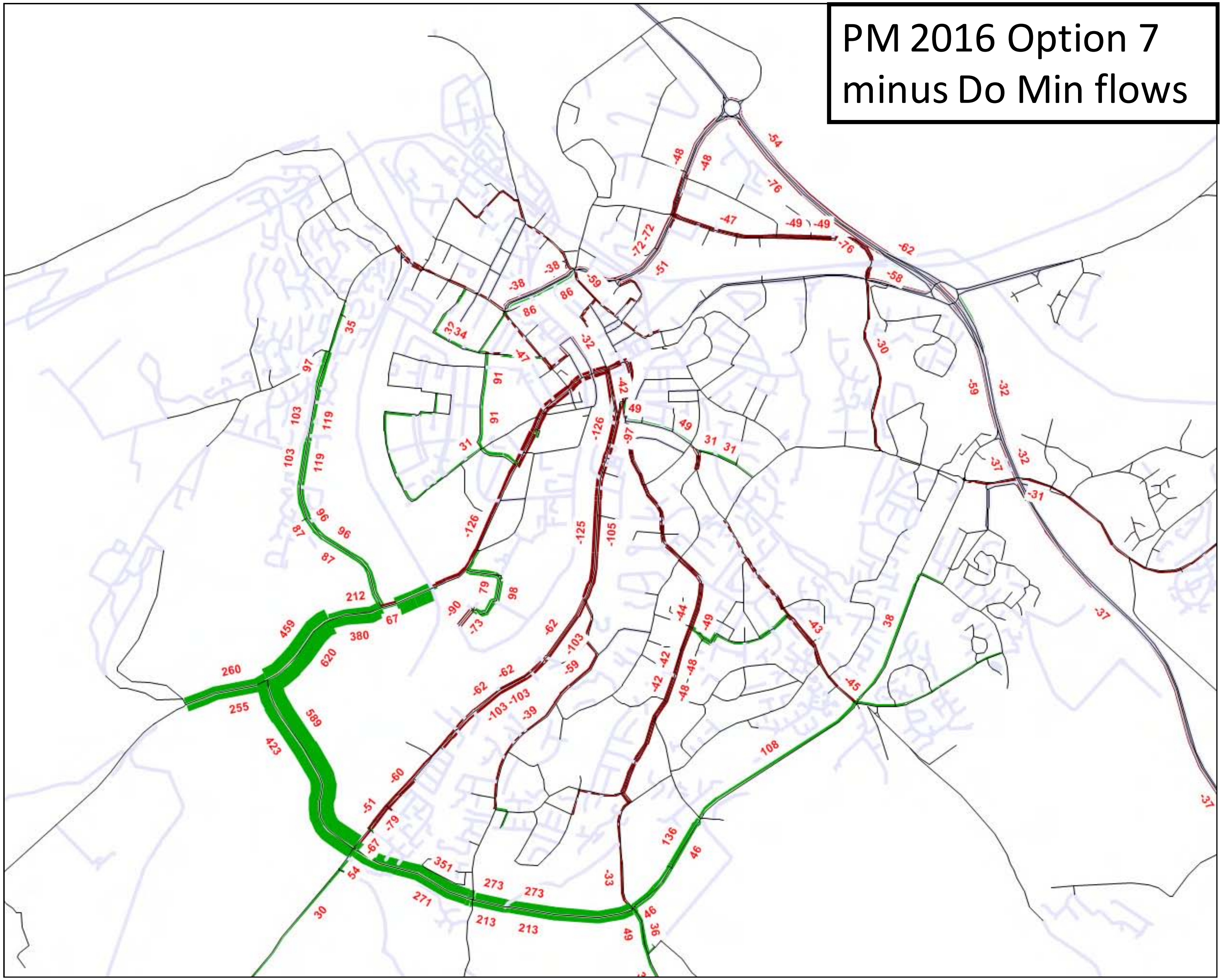

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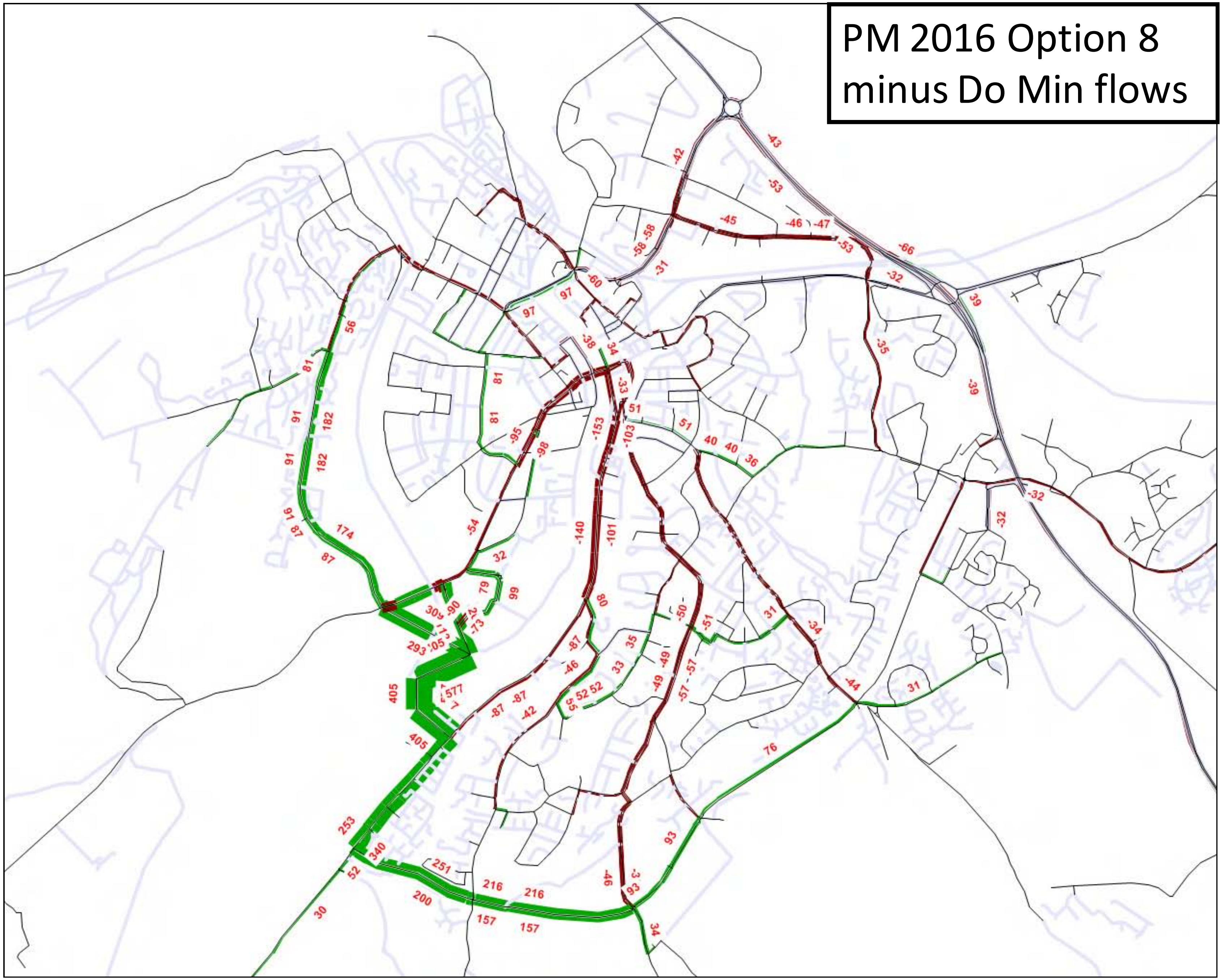

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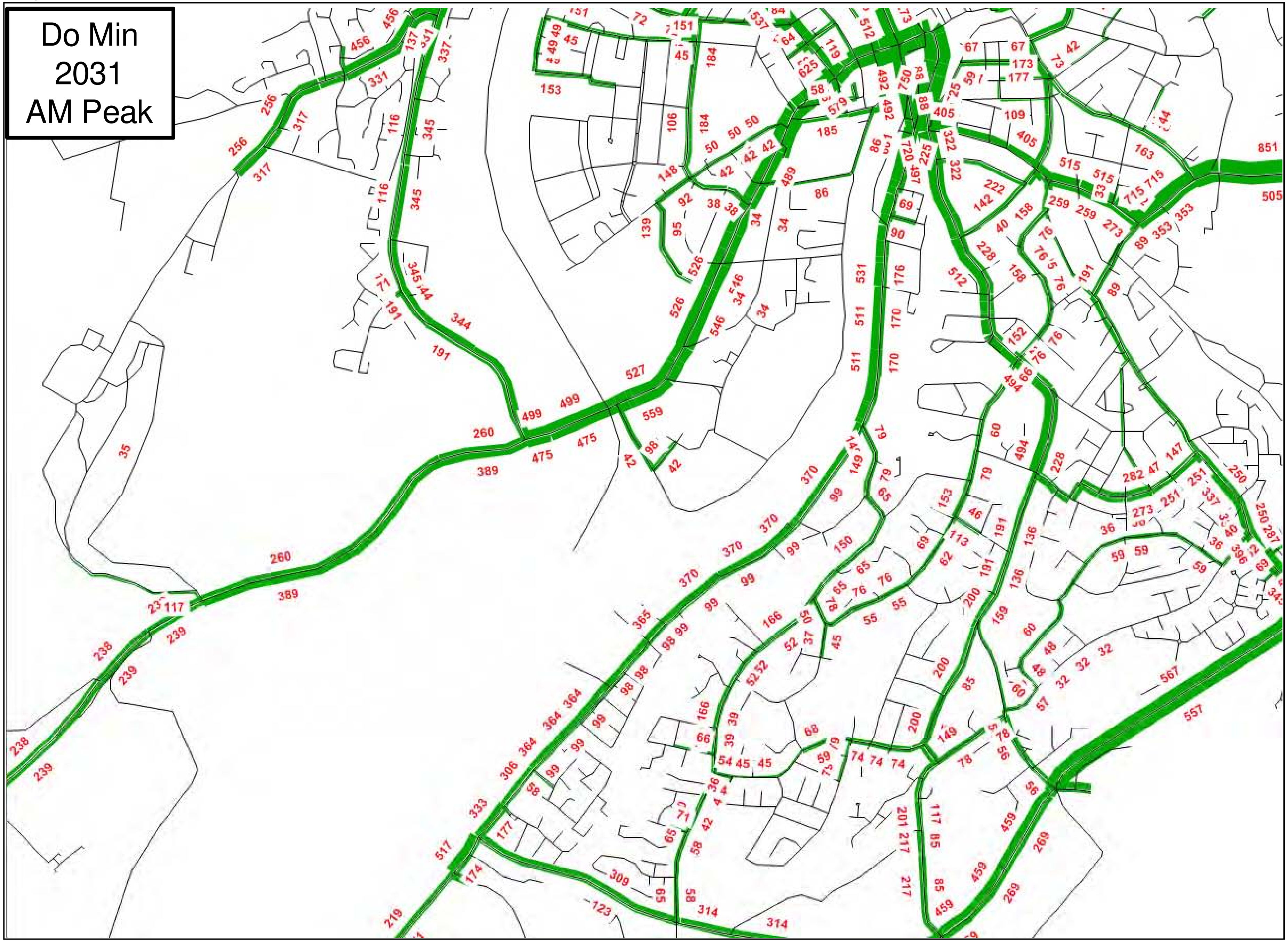


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Capabilities on project:
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Capabilities on project:
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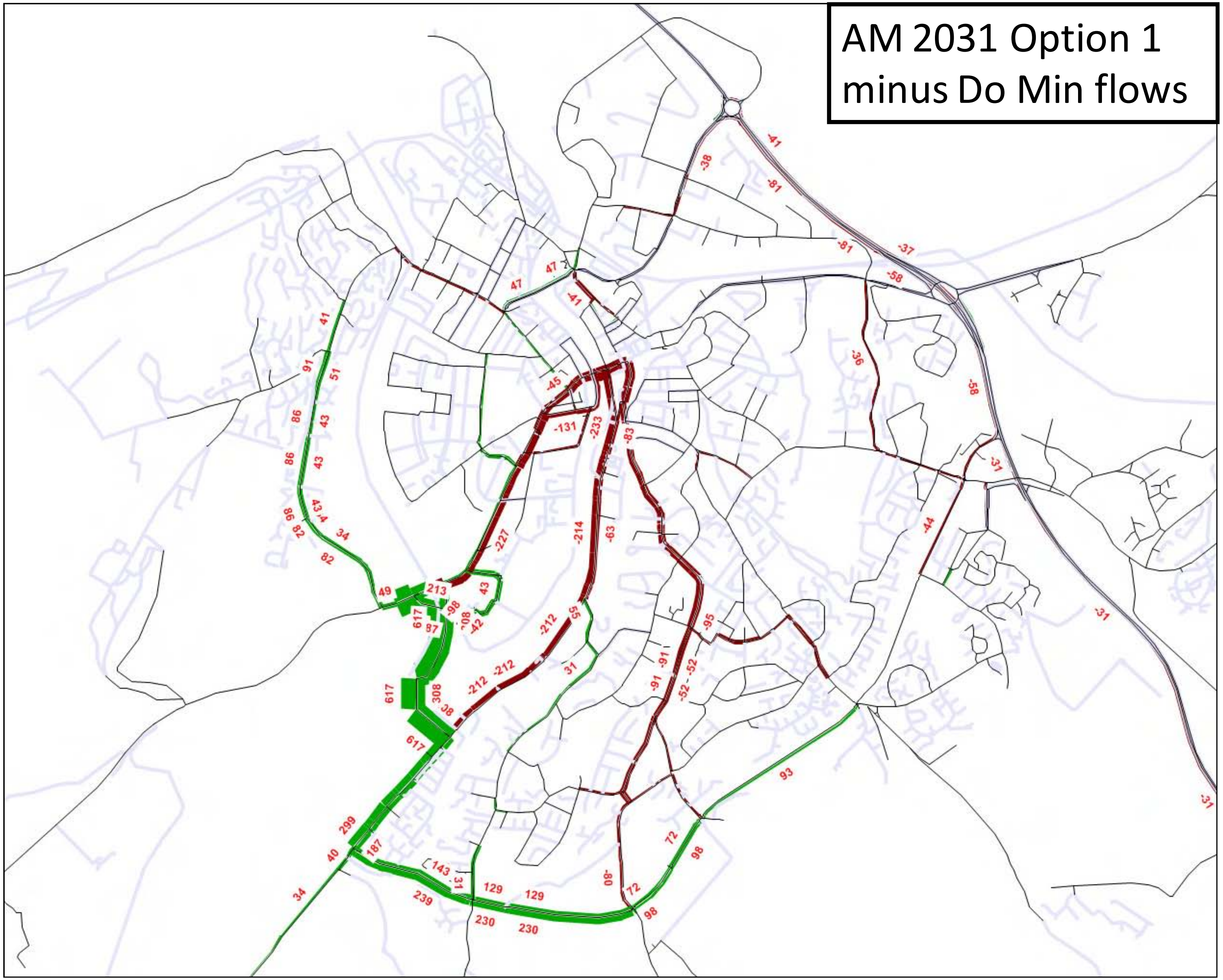

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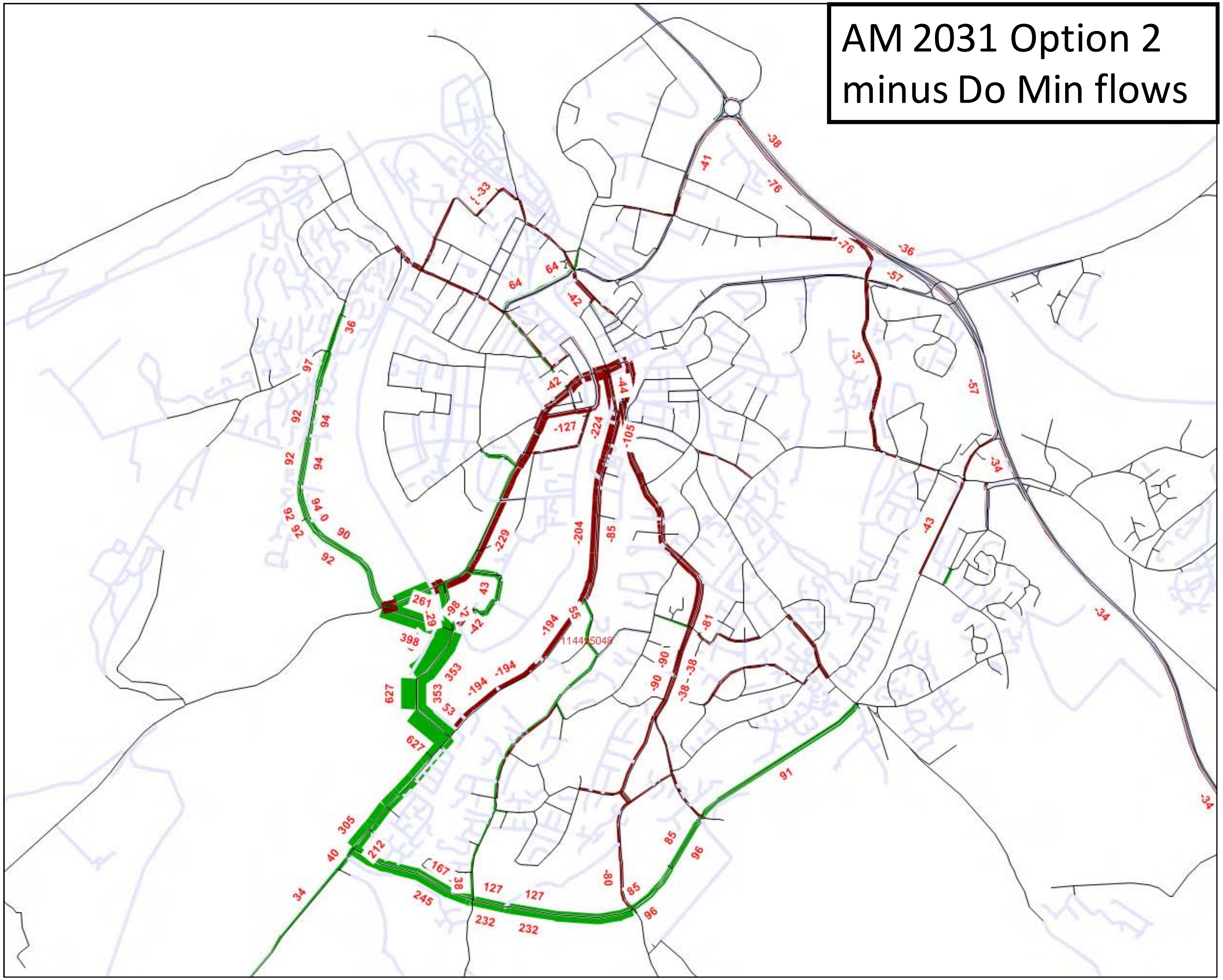

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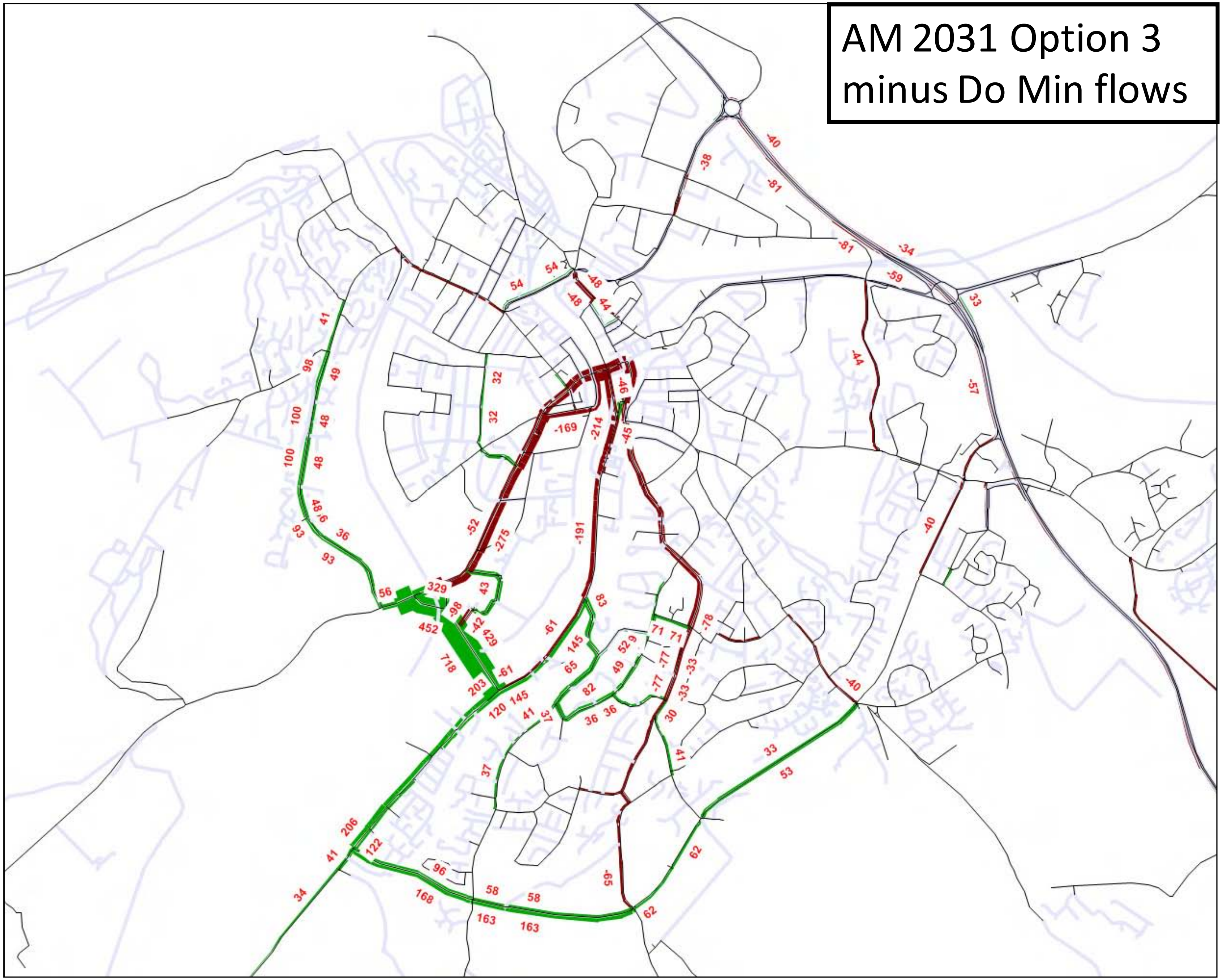

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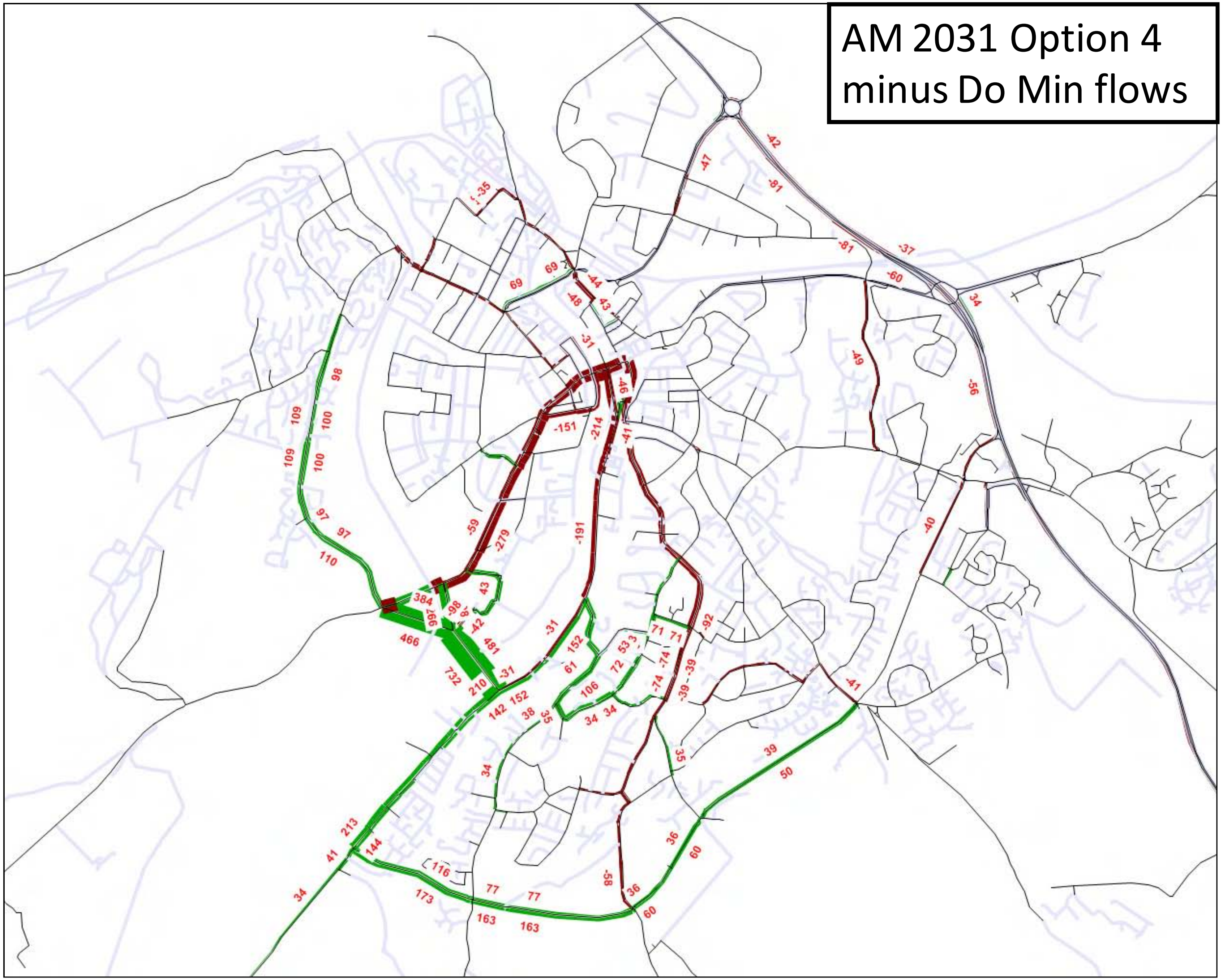

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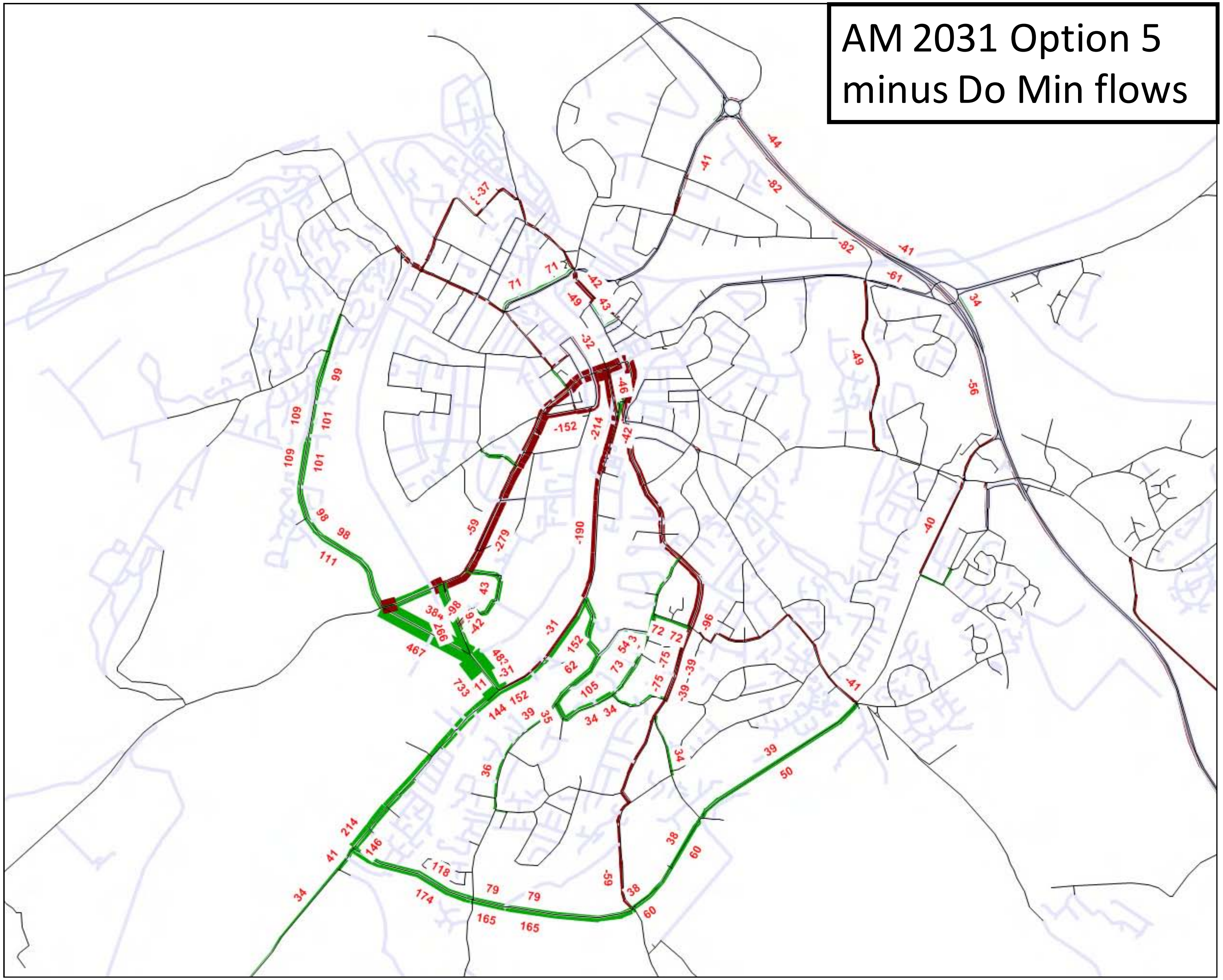

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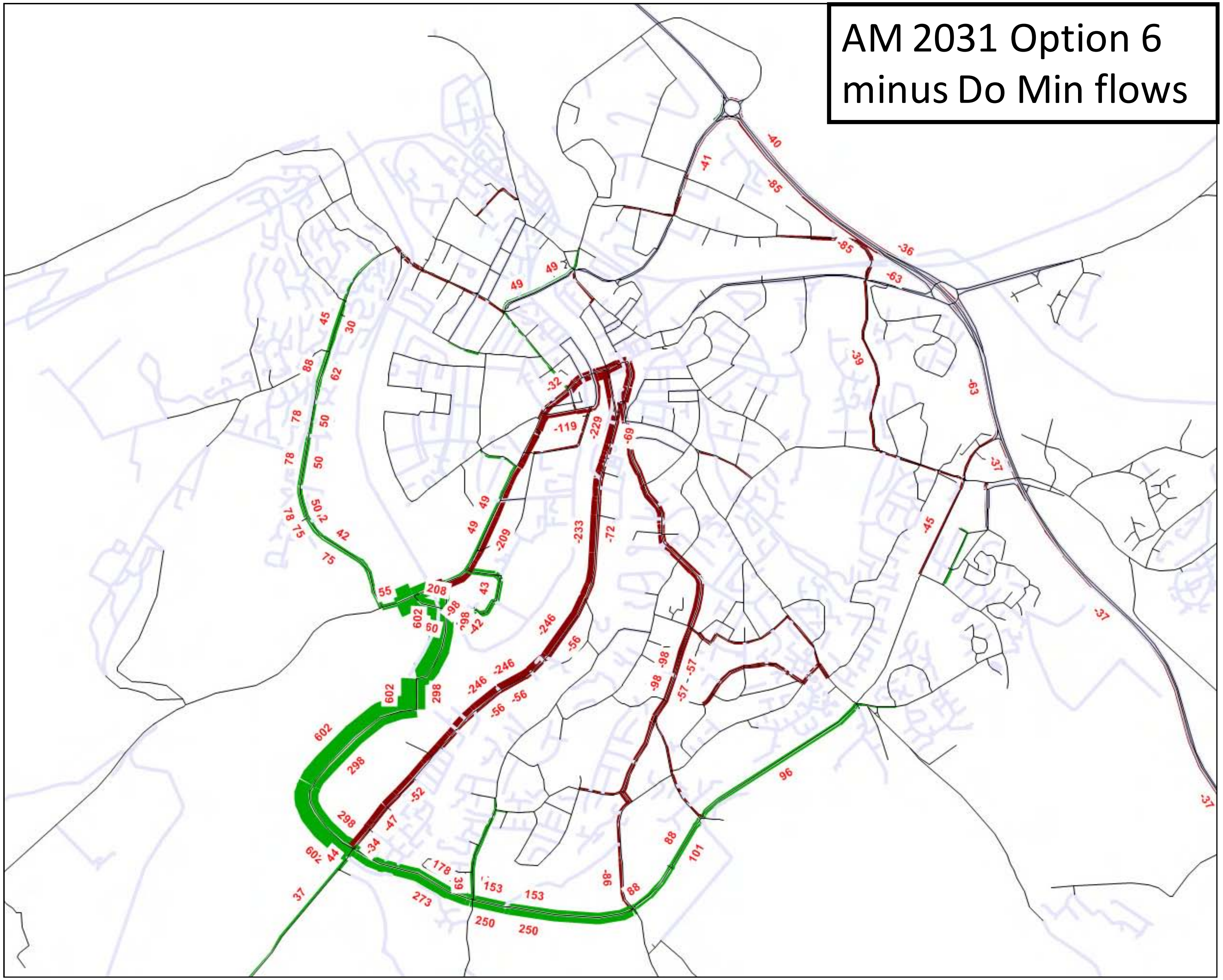

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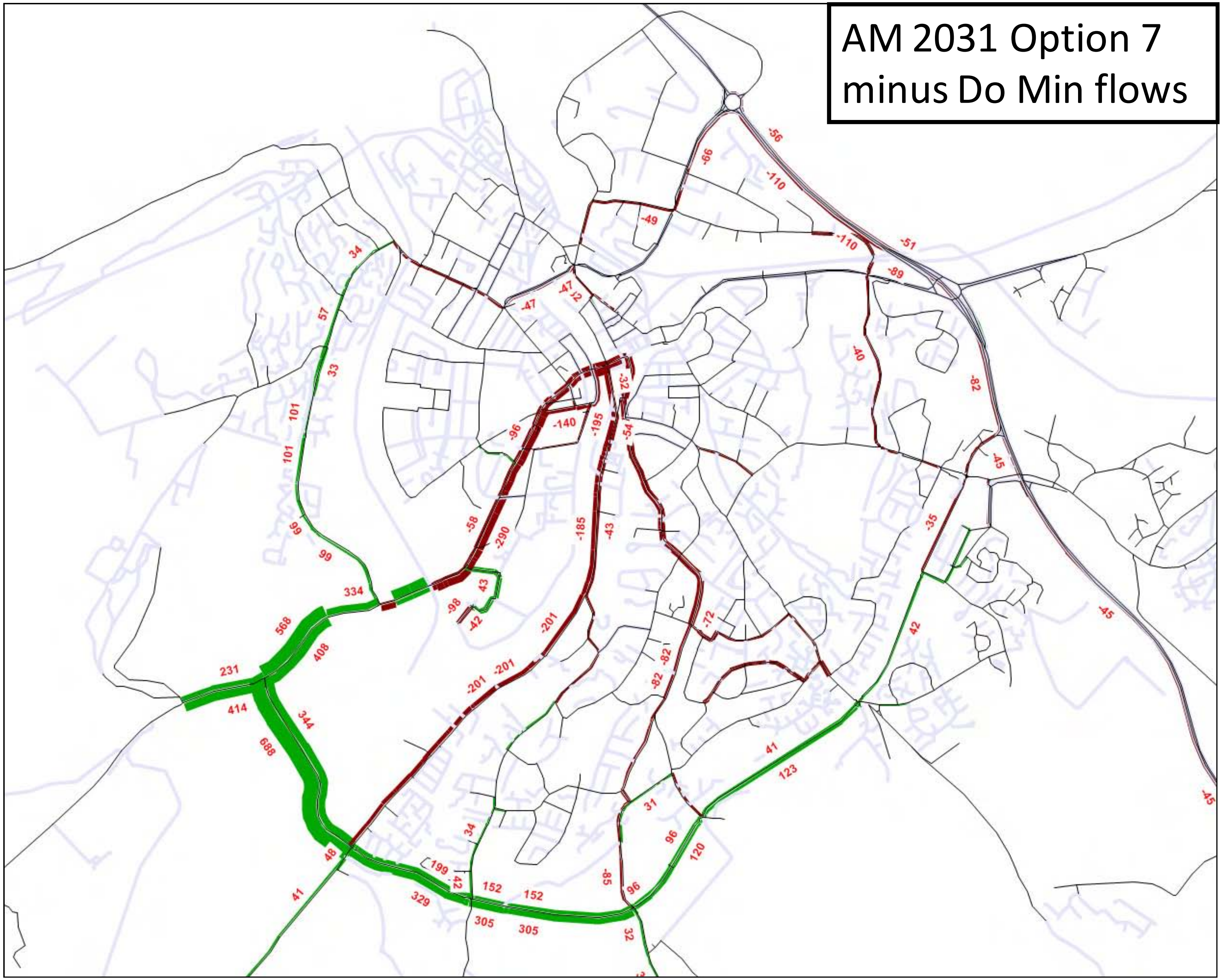

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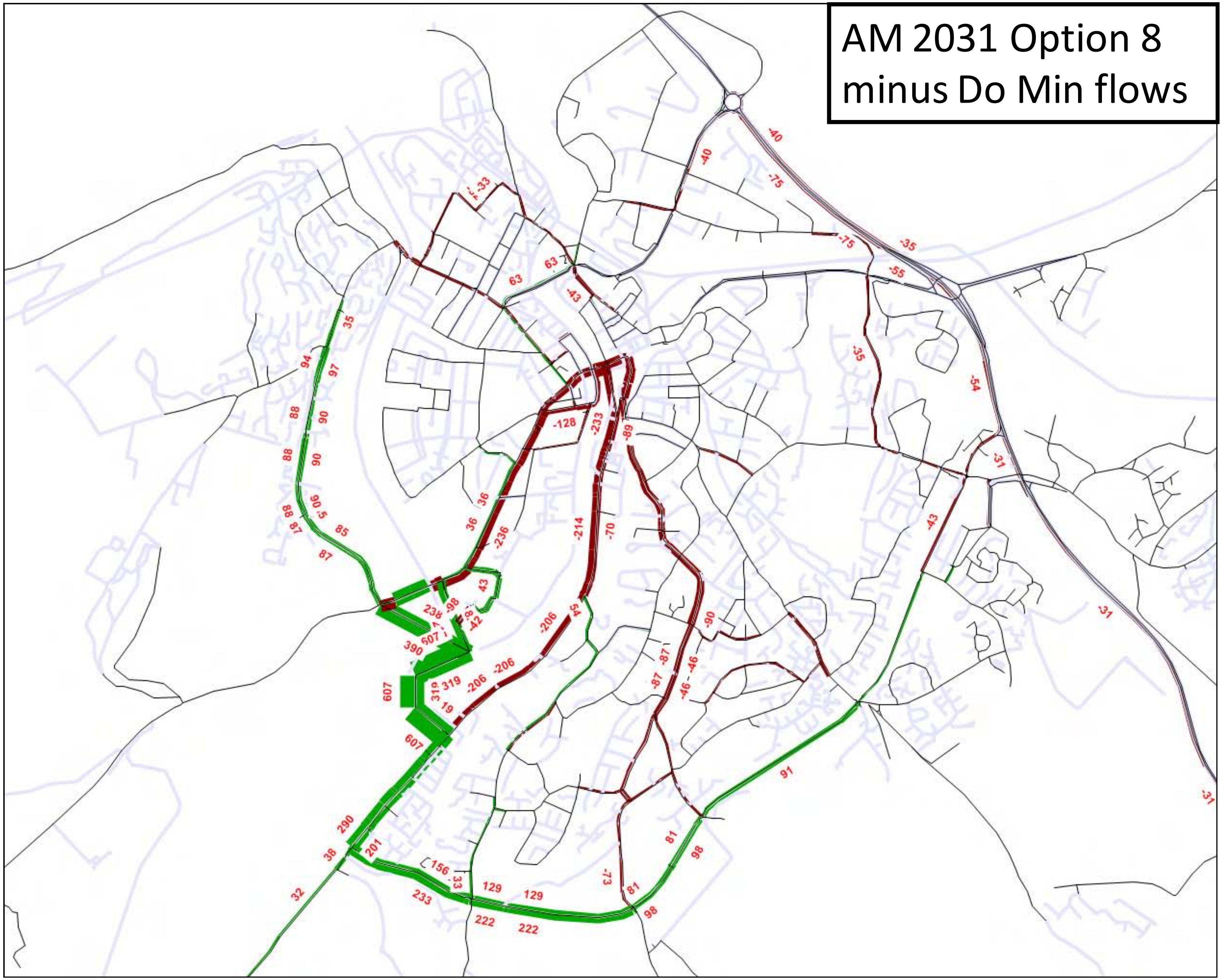

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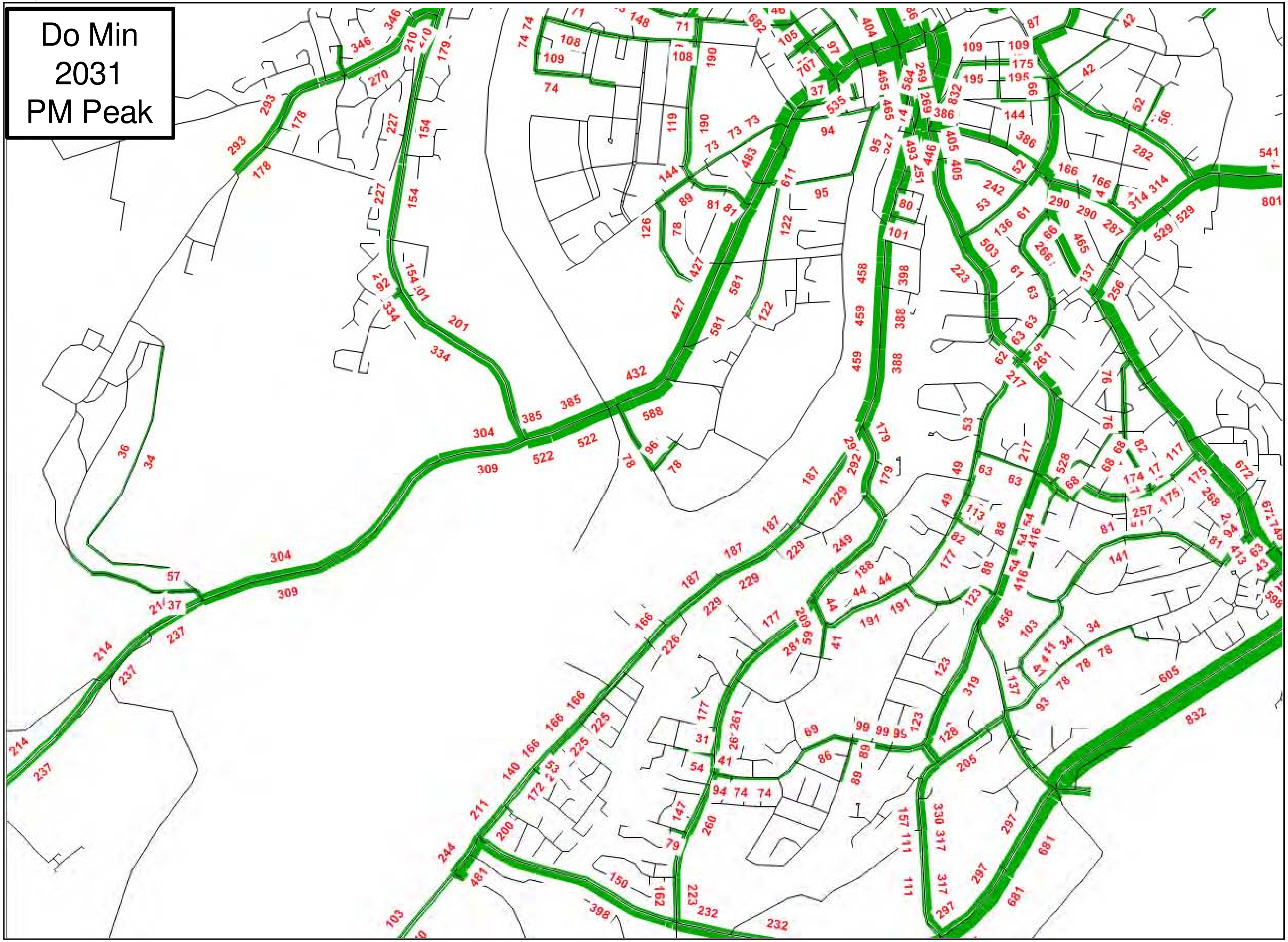

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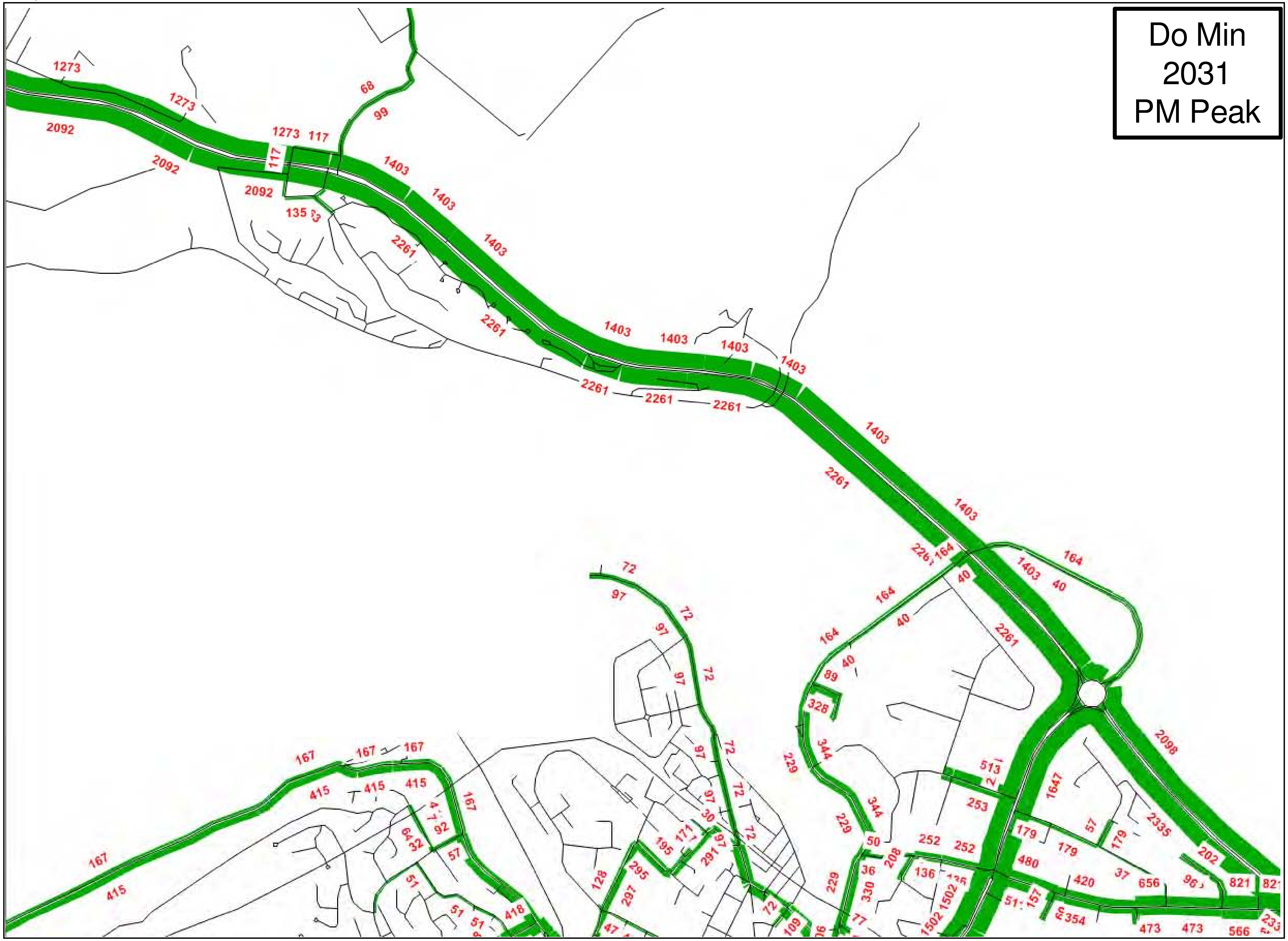

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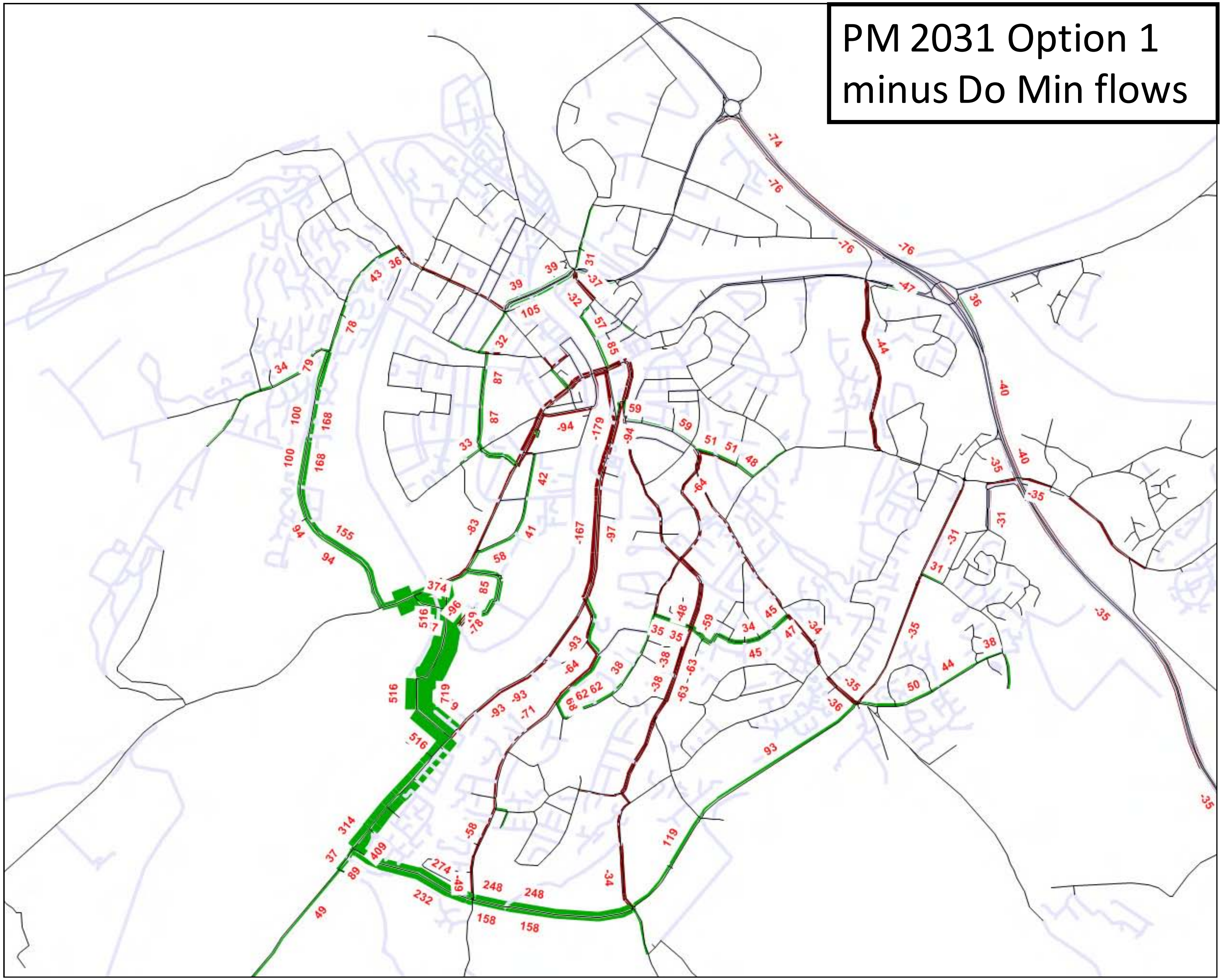

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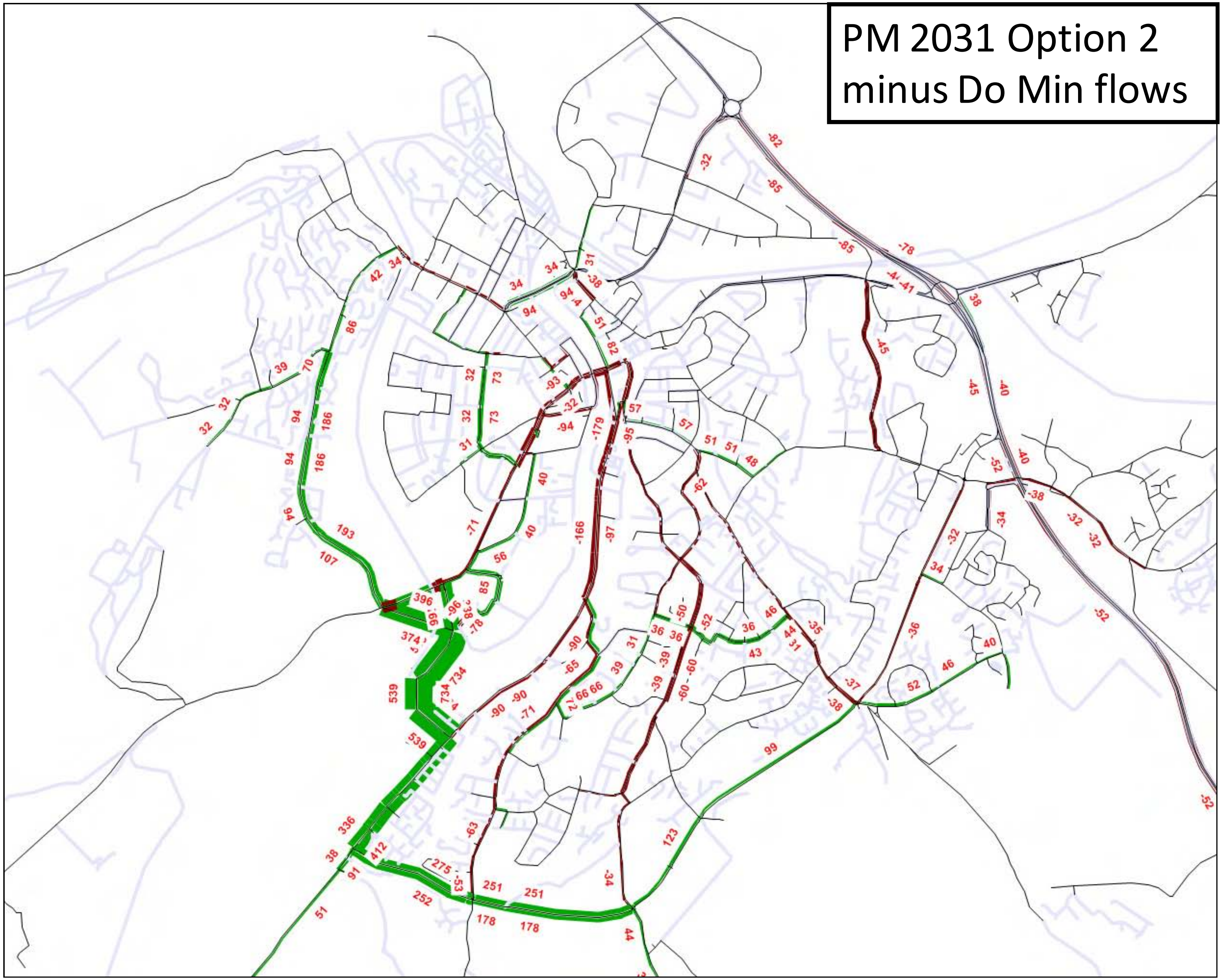

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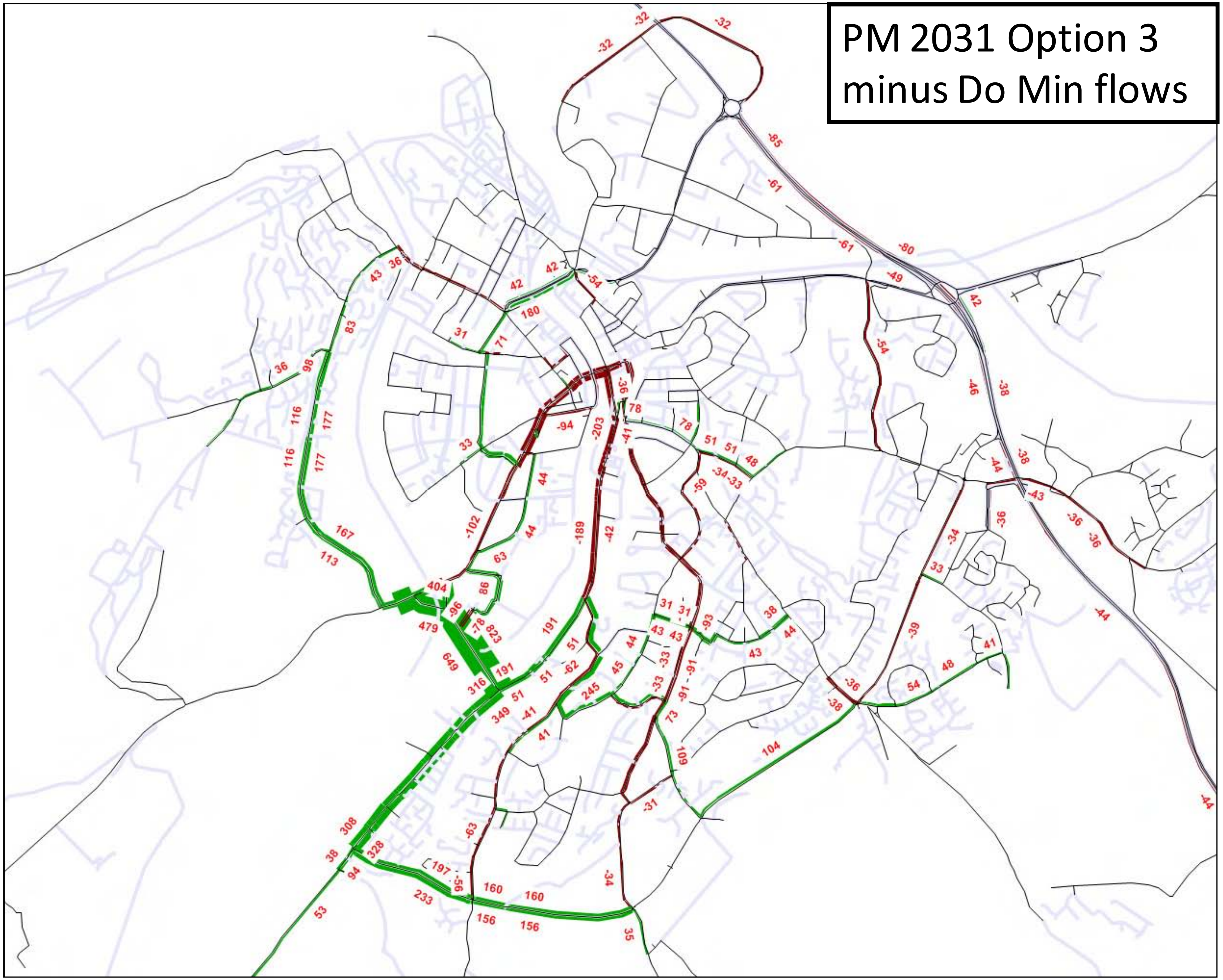

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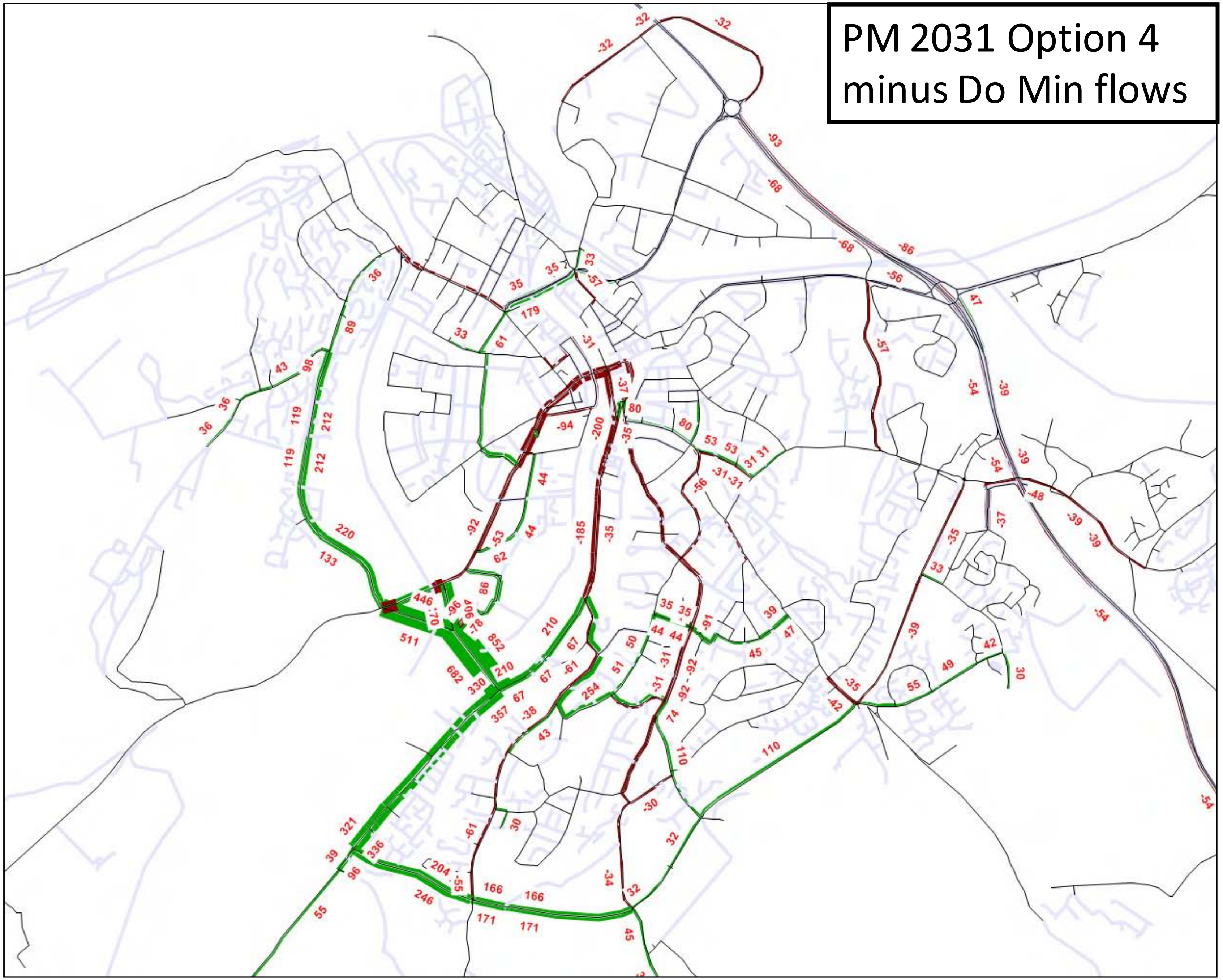

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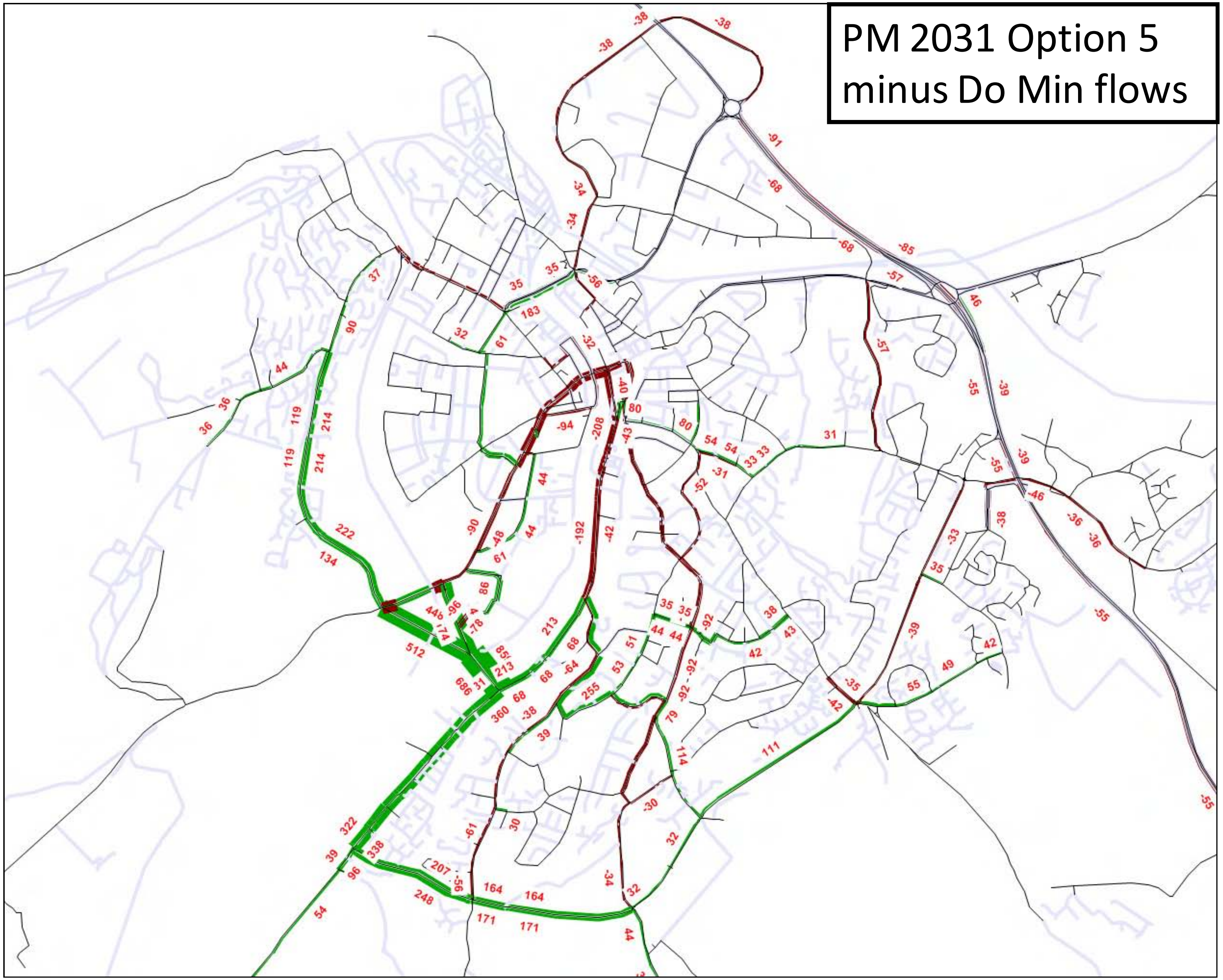

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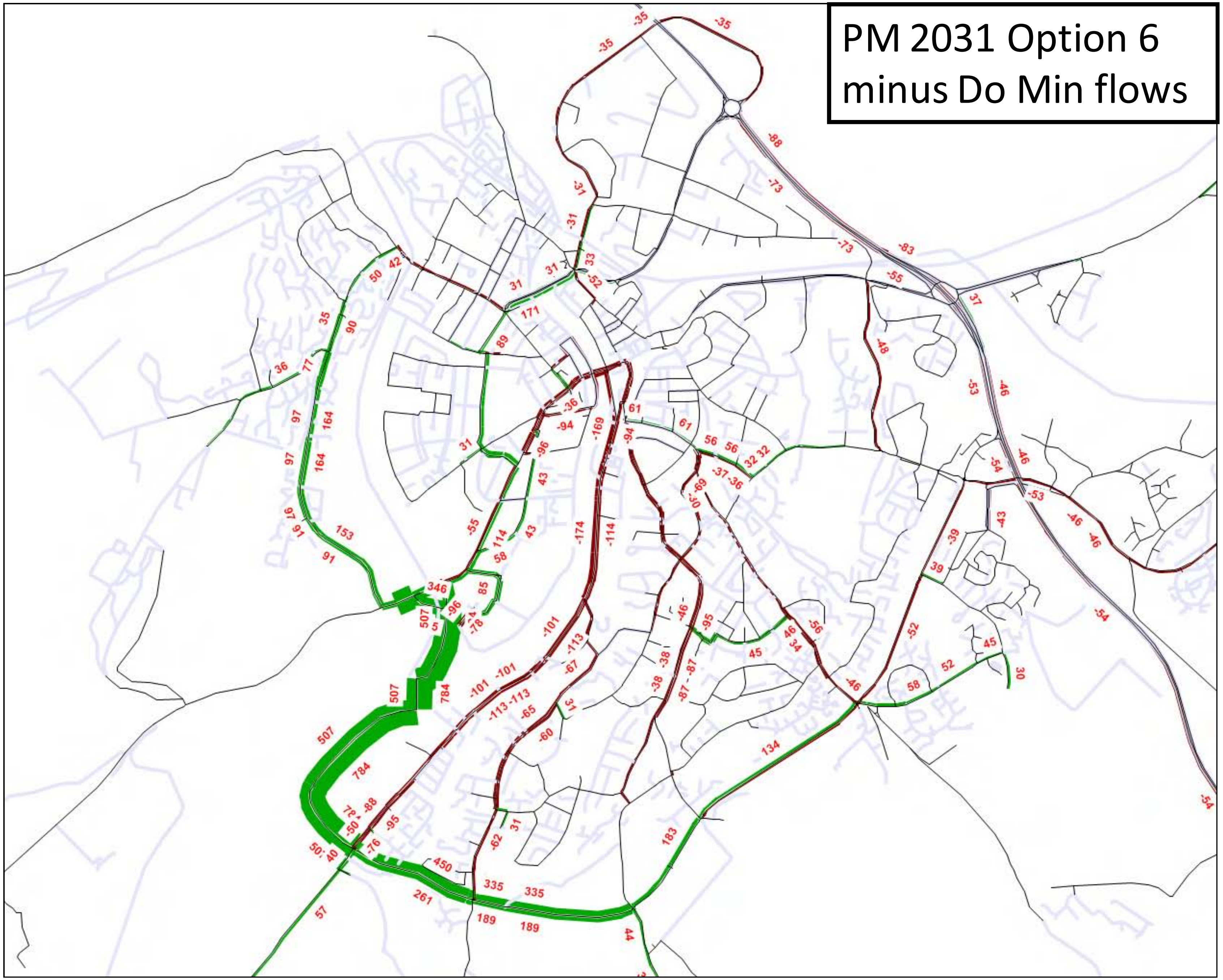

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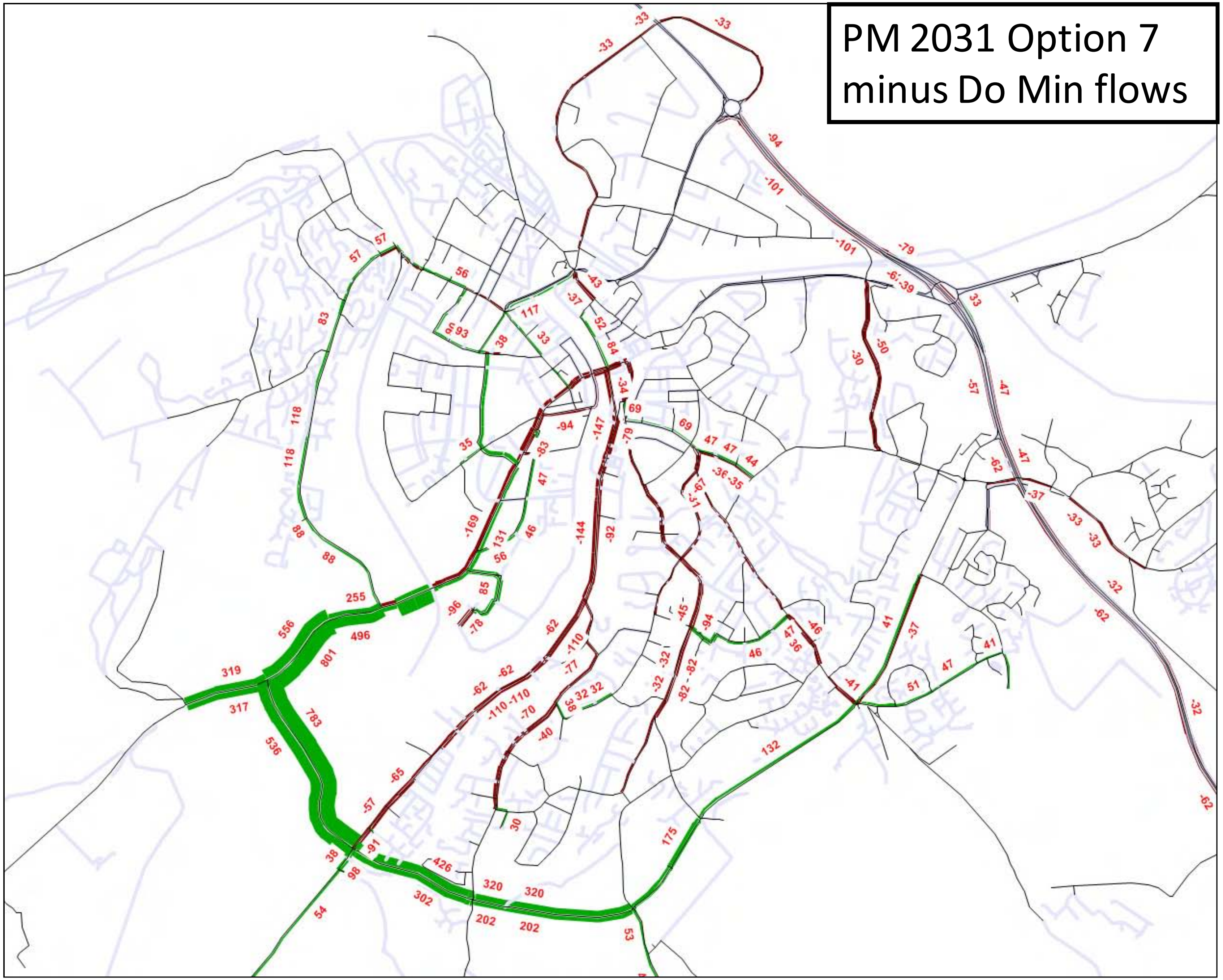

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