HIGHWAYS AGENCY

# M4 Bus Lane

## The Analysis of the Impact of the Suspension of the M4 Bus Lane

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5th April 2012

Report No: M25DBFO_RO1656HADO Version: 1

Hyder Halcrow Joint Venture

Working on behalf of the Highways Agency

In association with

An executive agency of the Department for Transport

# M4 Bus Lane

# The Analysis of the Impact of the Suspension of the M4 Bus Lane

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## GLOSSARY OF TERMS

| | |
|---|---|
| **Accident** | An incident resulting in damage or injury. |
| **After** | The period one year after the M4 Bus Lane was suspended from 1st October 2011 to 14th November 2011 when data was collected. |
| **Before** | The period prior to the M4 Bus Lane suspension from 1st October 2010 to 14th November 2011 when data was collected. |
| **Bus** | Within this report, any reference to buses also includes coaches and minibuses. |
| **Car** | Within this report, any reference to cars also includes light goods vehicles. |
| **Evening Peak Period** | The period 16:00 - 19:00hrs. |
| **HDV** | Heavy Duty Vehicle. |
| **HGV** | Heavy Goods Vehicle. |
| **Inter Peak Period** | The period 10:00 - 16:00hrs. |
| **Lane 1** | The nearside lane – closest to the hard shoulder. |
| **Lane 2** | The middle lane. |
| **Lane 3** | The offside lane – closest to the central reservation. |
| **MIDAS** | Motorway Incident Detection and Automatic Signalling system, consisting of loop detectors connected to control centres. |
| **Morning Peak Period** | The period 06:00 -10:00hrs. |
| **Off Peak Period** | The period 19:00 – 06:00hrs. |
| **Person-hour delay (phd)** | An economic measure of performance of a section of road. One person-hour is equivalent to a time saving of one minute each for sixty people. |
| **Reliability** | The reliability of journey times is measured by the variability (standard deviation) of the journey times. |
| **Shockwave** | Traffic passing through a shockwave undergoes a sudden drop in speed followed by an increase in speed, so vehicles experience intermittent stop-start conditions. The amount of time for which the speed drops increases as the shockwave spreads upstream through dense traffic |
| **Taxi** | A licensed Hackney Carriage. |
| **Throughput** | The amount of traffic passing through a given road section in a certain period. |
| **Weekday** | Average of Monday to Friday. |
| **Weekend** | Average of Saturday and Sunday. |

# Executive Summary

## Background

The former M4 Bus Lane operated eastbound into London over a distance of some 3.5 miles between Junctions 3 and 2. The motorway reduces from three lanes to two at the start of the elevated section, prior to which the third lane was previously reserved for buses, taxis and motorcycles as per the schematic in Annex A. The M4 Bus Lane from Junction 3 to 2 should not be confused with the bus lane on the M4 spur from M4 Junction 4 to 4a to Terminals 1, 2 and 3 of Heathrow Airport which remains in operation.

The reduction in capacity from three lanes to two at the start of the M4 elevated section has always been a significant cause of recurrent congestion. Before the introduction of the M4 Bus Lane, queues of static traffic in all three lanes frequently extended back towards Junction 3.

The M4 Bus Lane opened on 7 June 1999 allowing access to buses and taxis under a new speed limit of 50mph (previously it was 70mph). On 22 July 2002 motorcycles were also allowed to use the lane and the speed limit was raised to 60mph. At the time the M4 Bus Lane was established it carried approximately 7% of the total London bound traffic. It should be noted that enforcement of the M4 Bus Lane was a matter for the Metropolitan Police.

The M4 Bus Lane scheme, incorporated a number of other changes, including a lane drop at Junction 3 off slip, where the eastbound M4 was reduced from 3 to 2 lanes at the junction diverge, with one lane forming part of the offslip.

The report on the post-opening of M4 Bus Lane[1] identified a change to the congestion patterns during peak periods as queues of static traffic in all three lanes were replaced by intermittent 'shockwaves' of slow moving traffic extending to the west of Junction 3. The removal of the M4 Bus Lane should ease traffic flows between junctions 4 and 3, especially during peak periods.

## Experimental Order

The Highways Agency commenced work to suspend the M4 Bus Lane on the M4 eastbound between junction 3 and 2 in November 2010 and this report assesses the effects of its suspension. Initial modelling predicted that there would be an overall journey time saving in the Morning Peak of in the order of 30 seconds for drivers travelling eastbound on the M4 between junction 3 and junction 2.

The suspension of the M4 Bus Lane was carried out as an Experimental Order under the Road Traffic Regulation Act 1984. If evidence supports the permanent removal of the M4 Bus Lane, then the Highways Agency are committed to making a Revocation Order, following the appropriate processes, including consultation.

It should be noted that compared to the M4 Bus Lane scheme implemented in 1998/99, the suspended M4 Bus Lane incorporates many of the changes, particularly the Junction 3 slip arrangements and revised speed limits, which generated many of the benefits when the 1998/99 scheme was implemented.

During the suspension, the performance of the M4 has been monitored and this report presents detailed analysis of the data collected and includes the evidence to inform the Highways Agency's decision regarding the future of the M4 Bus Lane.

## Summary of Findings

The performance of the eastbound M4 between October and November 2010, in the 6-week period before the M4 Bus Lane was suspended, has been compared against the corresponding 6 week period in October and November 2011, exactly 12 months later, using consistent sets of traffic data that were collected in both periods. In addition an assessment has been undertaken of air quality, road traffic, noise and accident data to compare the 'before' and 'after' scenarios. The key results from these assessments are presented below.

*Traffic Flow levels*

a) Between Junction 4 and Junction 3 between 2010 and 2011

- 3% increase in traffic flows during an average weekday.
- 5% increase in traffic flows during an average weekend day.

b) On the M4 eastbound offslip at Junction 3,

- Over 29,000 vehicles leaving on an average weekday. (40% of the total flow)
- A 2% increase in the number of vehicles leaving in 2011 compared to 2010.
- Over 25,000 vehicles leaving at junction 3 on an average weekend day (38% of the total flow),
- A 2.5% increase from before suspension of the M4 Bus Lane.

c) Joining the M4 eastbound at Junction 3

- Consistent flow between 2010 and 2011 (6,500 vehicles during an average weekday).
- A 3.5% increase in traffic joining the M4 after suspension during an average weekend day, mainly during the morning peak period.

d) Between Junction 3 and Junction 2

- A reduction in traffic flows in the average weekday between 08:00 and 11:00 in 2011 following the suspension of M4 Bus Lane
- An increase in traffic flows between 17:00 and 19:00.
- At the times of maximum flow (06.00-08.00 and 16.00-17.00) flows have increased by some 5%.
- Over the course of an average weekday in 2011, there is an increase of 621 vehicles (+1.3%) compared with 2010.
- The highest hourly flow is between 17:00 and 18:00 for both years.
- Over the course of an average weekend day, between Junction 3 and Junction 2, here is an increase of 1882 vehicles (+4.1%), in 2011.

*Vehicle Proportions using the M4 between Junction 3 and 2 eastbound*

- An increase in the numbers of cars, LGVs and HGVs in 2011 during an average weekday.
- A reduction of the number of buses and taxis during an average weekday.
- Little change on an average weekend day.

- Overall, there is an increase in vehicles in 2011, following the suspension of the M4 Bus Lane, both on a weekday and at the weekend.

*Vehicle Occupancy*

- There has been little change in the occupancy of vehicles (cars, taxis, buses) compared to when the M4 Bus Lane was in operation.

*Lane Utilisation*

- In 2010 percentage utilisation by lane is the same for the average weekday and weekend day, even though traffic levels are different. Lane 3 utilisation was 10% of the traffic flow with the M4 Bus Lane.
- Following the suspension of the M4 Bus Lane, there is as expected an increase in the utilisation in lane 3 and fewer vehicles travelling in Lanes 1 and 2. Lane 3 utilisation was 25% of the traffic flow after suspension of the M4 Bus Lane.

*Journey Times*

a) Between Junction 4b and 2

  - Overall there has been a decrease in the average journey time following suspension of the M4 Bus Lane throughout the day. In the morning peak period, there is a decrease in average journey time of 44 seconds (over a total journey time of 19 minutes); in the inter peak period, a decrease in the average journey time of just over a minute; in the evening peak period, a decrease in the average journey time of 1 minute 49 seconds; and, finally, in the off peak period, a decrease in the average journey time of 1 minute 38 seconds.
  - As expected, there is an increase in the average journey time in Lane 3 following the suspension of the M4 Bus Lane. This is greatest in the morning peak period.
  - Flow-weighted journey times between junctions 4b and 2 on a weekday are reduced by an average of 1 minute 18 seconds and on an average weekend day of 2 minutes 11 seconds.

b) Between Junction 3 and 2

  - Flow weighted journey times are reduced by one minute in all weekday time periods other than the morning peak, which has an increase of 18 seconds.
  - Overall, journey times on a weekday are reduced by an average of 38 seconds.
  - During the average weekend day, there is a decrease in average journey times following the suspension of the M4 Bus Lane for all time periods, except for Lane 3.
  - Flow-weighted journey times for an average weekend day are reduced by 1 minute 43 seconds.

*Journey Time Reliability*

- In Lanes 1 and 2 the variability of the journey time is substantially less (i.e. more reliable) in 2011 than it was in 2010 before the M4 Bus Lane was suspended. This suggests that journey times in Lanes 1 and 2 are more reliable.
- In Lane 3 the journey time is less reliable than it was before the M4 Bus Lane was suspended. Nevertheless, the journey time reliability for Lane 3 is now similar to the 2011 journey time reliability for Lanes 1 and 2.

- Overall Journey Time reliability has improved following suspension of the M4 Bus Lane.

*Traffic Speeds*

- In 2011 there is an improvement in the average speed through Junction 3 and beyond Heston Services compared with 2010.
- Closer to the 3 to 2 lane merge prior to the M4 elevated section the average speeds during periods of congestion are lower than in 2010.

*Shockwaves and Queuing*

- Following suspension of the M4 Bus Lane, the shockwaves (intermittent stop start driving and intermittent queuing) have been absorbed into the general queuing at the bottleneck at the start of the elevated section, where the three lanes reduce to two
- From a car driver's perspective, on a typical morning, 6km of intermittent stop-start driving in 2010 has been replaced by up to 3km of more defined queuing in 2011. The effect of this change is also borne out in the changes in journey times.
- With the M4 Bus Lane suspended, there is additional space for queuing traffic between Junction 3 and the start of the elevated section, so the congestion no longer affects Junction 3.

*Person-hours Delay (phd)*

a) Junction 4b to 2

  - After weighting by number of people using different vehicle types the person-hours delay has reduced overall by 846 hours for the average weekday following suspension of the M4 Bus lane.
  - The person-hours delays to London taxi and bus users have increased by 155 hours for the average weekday (almost entirely in the morning peak periods) following suspension of the M4 Bus Lane.
  - The person-hours delays to all other road users has reduced by 1001 hours with savings in all time periods for cars, LGVs and HGVs following suspension of the M4 Bus Lane.
  - The calculated average journey time saving per person for an average weekday is between 16 and 98 seconds (1 minute 38 seconds) depending on the time period after suspension of the M4 Bus Lane.
  - For the average weekend day the average journey time saving per person is between 42 and 188 seconds (3 minutes 8 seconds) depending on the time period after suspension of the M4 Bus Lane.

b) Junction 3 to 2 (including the 2 lane section),

  - Following suspension of the M4 Bus Lane there is an increase in the person-hours delay of 336 hours in the morning peak period but this is outweighed by the savings accumulated during the inter peak and evening peak periods, resulting in a daily saving of 136 person-hours during an average weekday
  - During the average weekend day there are person-hour savings for all time periods after the suspension of the M4 Bus Lane for all vehicle types.

*Traffic Behaviour*

- The analysis suggests that little has changed with regards to driver behaviour with the suspension of the M4 Bus Lane between Junction 3 and Junction 2.
- The average headways on Lanes 1 and 2 are similar for both weekdays and weekends both before and after.
- The headway on Lane 3 has changed as expected with the lane open for all traffic but the headway is consistently longer than in Lanes 1 and 2, especially during the inter-peak period.

*Traffic on A4*

- There has been little change in the traffic flow on the A4 Great West Road following the suspension of the bus lane. Journey times on the A4 are similar before and after.
- There is no evidence that the suspension of the bus lane is affecting traffic on the A4.
- Both with and without the bus lane in operation, journey times via the M4 are substantially lower than via the A4 and unlikely to result in diversion to the A4.

*Air Quality Impact*

Nitrogen dioxide (NO2) concentrations at receptors in close proximity to the M4 are modelled to be higher with the suspension of the M4 Bus Lane. It is considered that this is as a result of several factors.

a) The M4 Bus Lane displaced a proportion of the HDVs (i.e. buses and coaches) away from the inside lane, to the outside lane (i.e. the M4 Bus Lane). Without the M4 Bus Lane, HDVs are restricted to the two innermost lanes, closer to sensitive receptors adjacent to the M4.
b) The average speeds on the section of the M4 adjacent to the receptors are higher in 2011 after suspension of the M4 Bus Lane.
c) Traffic levels in 2011 are higher than in 2010, which contributes to increased NO2 concentrations.

*Noise Assessment*

Noise levels between Junction 3 and Junction 2 of the M4 are predicted to be higher as a result of the M4 Bus Lane suspension. The change in noise levels ($LA_{10,\ 18\ hour}$) for the daytime would be considered to be 'minor adverse' and for night-time ($L_{night}$) would also be 'minor adverse'.

*Safety*

Prior to the suspension of the M4 Bus Lane there were 41 personal injury accidents over a three year period, with six of these resulting in serious injury. Over the one year period since the suspension of the M4 Bus Lane there have been three personal injury accidents between Junction 3 and Junction 2, all slight in nature.

## Conclusion

Flows have increased on the eastbound M4 in the last year, but despite this, journey times are now quicker overall following the suspension of the M4 Bus Lane. Journey times for buses and taxis have increased, but this has been outweighed by gains for other road users. In addition, journey times for all vehicles are slightly higher between Junctions 3 and 2 during the busiest

period (the morning peak), but this is again outweighed by benefits in between Junctions 4b and 3 and also between Junctions 3 and 2 over the rest of the day (including the evening peak).

The section upstream of the bus lane (Junction 4b to 3) is now less affected by congestion, as shockwaves no longer tail back beyond Junction 3. The merge area at the start of the M4 elevated section continues to be a source of congestion.

When the M4 Bus Lane and associated changes were introduced in 1999, analysis showed that there was a time saving for both buses and cars during peak periods, and a small time saving overall. In the intervening years, there have been changes to the traffic patterns on the M4. Daily flows into London have decreased by 4000 vehicles, and there are now substantially fewer buses and taxis than there were in 1999. The 1999 changes provided a benefit during periods of congestion, both for cars (by reducing the effect of the bottleneck where three lanes reduce to two at the start of the elevated section and the changes to the exit slip at Junction 3) and for buses and taxis (by allowing them to bypass some of the congestion). Because of the changes to traffic patterns, congestion is now less frequent and less severe than it was in 1999, and the removal of the bus lane has allowed the section to operate as a “typical” motorway, with Lane 3 used for overtaking. This has reduced journey times over most of the day.

In terms of journey times, the analysis shows that there is a small net saving in journey time/person as a result of suspending the M4 Bus Lane for all trips along the M4 between Junction 4b and Junction 2 and also for all trips only between Junction 3 and Junction 2. These journey times are also more reliable. It is recognised that the journey time impact on people travelling by buses and taxis is negative (with more bus passengers being affected than taxi passengers), but these impacts are more than outweighed by the overall benefits to all of those travelling by car, LGV and HGV.

Despite this traffic increase and more buses travelling closer to the nearside verge of the motorway, the impact on air quality and road traffic noise is minimal.

Since the M4 Bus Lane was suspended, there has been a reduction in the number of personal injury accidents between Junction 3 and Junction 2.

Overall, there has been a journey time benefit from the suspension of the bus lane and generally improved journey time reliability. The new design appears to be at least as safe as the previous layout, and although there has been a small increase in noise and emissions, this is mostly attributable to higher flows and higher speeds.

# 1 Introduction

In 1999, the Highways Agency installed approximately 3.5 miles of M4 Bus Lane on the eastbound M4 between Junction 3 and Junction 2 with the objective of reducing journey times of buses, coaches and taxis without significantly affecting other vehicles. The operation of the M4 Bus Lane was monitored some 12 months after the scheme had opened and it was considered the above objective had been met. The M4 Bus Lane scheme, incorporated a number of other changes, including a lane drop at junction 3 off slip, where the eastbound M4 was reduced from 3 to 2 lanes at the junction diverge, with one lane forming part of the offslip.

After 11 years of operation, the scheme was again the subject of review and, to enable this to be carried out, the Secretary of State for Transport temporarily suspended the M4 Bus Lane in November 2010 for an experimental period of 18-months. During this period data for 'before and after' has been collected and analysis has been carried out. This report describes the resultant analyses, which will also inform the Secretary of State for Transport as to whether the M4 Bus Lane should or should not be permanently removed.

To conduct the review, traffic data, comprising journey times, speeds and flows, were collected on the eastbound M4 into London for a six week period from 1st October to 14th November in 2010 and again for the corresponding six week period in 2011. This data was supplemented by noise, air quality and accident data.

The performance of the M4 between Junction 4b (the M25 Junction) and Junction 2 (just after the commencement of the elevated section) has been assessed by examining traffic behaviour, journey times and reliability, traffic flow composition, speeds and vehicle occupancy. The analysis has been carried out for the average journey time for a weekday and a weekend, by time period and by lane. The time periods studied were for the Morning Peak Period (06:00hrs-10:00hrs), the Evening Peak Period (16:00hrs-19:00hrs), the Inter Peak Period (10:00hrs-16:00hrs) and the Off Peak Period (19:00hrs-06:00hrs). The effect of removing the M4 Bus Lane on noise, air quality and road safety was also assessed.

## 1.1 Background

The M4 Bus Lane comprises 3.5 miles of the 3rd lane of the eastbound carriageway of the M4 between Junction 3 and Junction 2 and commenced operation on 7th June 1999, allowing access to buses and taxis under a speed limit of 50mph. The M4 Bus Lane was reserved exclusively for buses, coaches and taxis, with *"the primary aim of reducing the journey times of these vehicles without significantly affecting other vehicles."* (Monitoring of the M4 Bus Lane: The First Year; PR/T/125/2000). The scheme also included substantially revised exit slip road arrangements at Junction 3 with Lane 1 reserved for exiting traffic. On 22nd July 2002 motorcycles were also allowed to use the lane and the speed limit was raised to 60mph.

An Experimental Order under Section 9 of the Road Traffic Regulation Act 1984 was made on 8th November 2010 suspending the M4 Bus Lane from 24th December 2010. This order has the legal maximum duration of 18 months. During this period the M4

Bus Lane was reinstated for use as a normal motorway lane, thus allowing the efficiency of the M4 Bus Lane in terms of user 'throughput' to be reviewed.

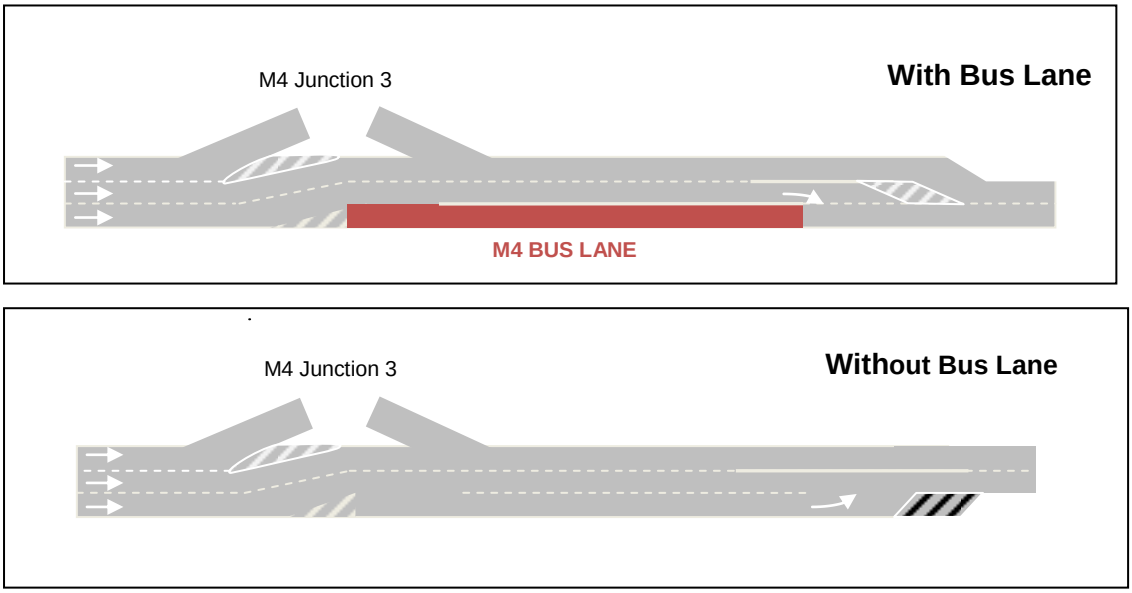
Traffic counts, air quality and noise monitoring were carried out before the Experimental Order came into operation and again afterwards for the purposes of the analysis.

Figure 1.1 presents the road layouts along the M4 eastbound with and without the M4 Bus Lane. In 2010 there is a lane drop at junction 3 with two lanes continuing through the junction and the M4 Bus Lane commences between the on and off slips. At the merge at the end of the M4 Bus Lane, immediately prior to the M4 elevated section, Lane 2 traffic flows have to give way to M4 Bus Lane traffic, and merge when lane 3 traffic permits.

In 2011, with the suspension of the M4 Bus Lane, the merge layout has been changed at the eastern end, immediately prior to the M4 elevated section such that Lane 3 traffic no longer has priority. There remains a lane drop at junction 3 with two lanes continuing through the junction and a third lane commencing between the on and off slips. At the merge location Lane 2 traffic flows merge in a standard 'zip' or 'merge in turn' arrangement with Lane 3.

In addition, between the 2010 and 2011 monitoring periods, Split Cycle Offset Optimisation Technique (SCOOT) operation was completed at M4 Junction 3 and became operational in May 2011.

**Figure 1.1: Road Layout**

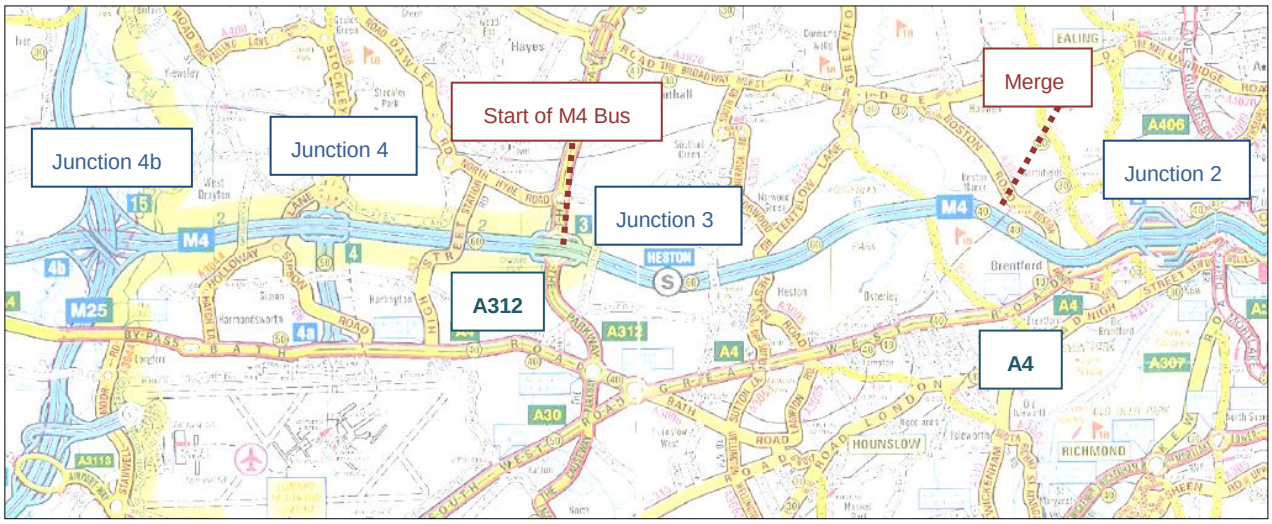



A "tiger-tail" layout diverge was initially proposed for the offslip at Junction 3 to improve safety at this diverge. During initial surveys, queuing was observed reaching back onto the mainline carriageway. To comply with standards, such merges should only be considered where there is no queuing beyond the proposed tiger-tail onto the main carriageway. Thus a "tiger-tail" layout as Junction 4 was discounted during design for this scheme.

## 1.2 Study Area

The study area comprises mainly the eastbound M4 between Junction 4b (M25 Junction) and Junction 2 (Chiswick). The study area is shown in Figure 1.2 below.

**Figure 1.2: M4 Bus Lane Study Area**




The main data source that has been used in this analysis is traffic flow and journey time data from the Highways Agency's Motorway Incident Detection and Automatic Signalling (MIDAS) system. This data is supplemented by Manual Classified Counts (MCC) data and vehicle occupancy data that was carried out by a traffic survey company.

Ten MIDAS sites from M4 Junction 4 to M4 Junction 2 were selected to process flow data as listed below in Table 1.1. The location of the sites is shown in Appendix A.

The sites were selected to allow analysis of:

a) the approach to the two lane merge, so that the extent of any delay at the merge location can be assessed;
b) the approach to Junction 3, to assess any changes prior to the M4 Bus Lane; and
c) the two lane section immediately after the merge.

**Table 1.1: Selected MIDAS sites**

| MIDAS Site | Location | Description |
|---|---|---|
| M4 / 2240B | M4 Junction 4-3 | |
| M4 / 2210B | M4 Junction 3-2 (West to East) | Prior to Heston Services |
| M4 / 2197B | | After Heston Services |
| M4 / 2193B | | |
| M4 / 2188B | | |

| MIDAS Site | Location | Description |
|---|---|---|
| M4 / 2183B | | |
| M4 / 2178B | | |
| M4 / 2173B | | |
| M4 / 2168B | | ½ mile to lane reduction. Speed limit change to 40mph. |
| M4 / 2162B | | 400 yards to lane reduction. |
| M4 / 2156B | | Start of elevated section – two lanes. |

## 1.3 Data Filtering

To ensure that the data was representative and free from error and major incidents, a data filtering exercise was carried out. Technical Note Reference M25 DBFO_RO1672JVGF_v4 describes this data filtering exercise. MIDAS data from 1st October to 14th November 2010 and the same period in 2011 were assessed, covering a total of 45 days in each period. Where significant parts of the data were missing for an individual day or there were incidents that would have distorted the results for those days they were removed from the data for assessment.

This approach resulted in 30 suitable days (67%) between 1st October 2010 and 14th November 2010 and 36 suitable days (80%) within the same period in 2011.

## 1.4 Document Structure

This report is structured as follows:

- Section 2 analyses the composition of traffic flows on the M4 Eastbound, and assesses the changes in lane utilisation by vehicle type;
- Section 3 describes the journey times for vehicles using the M4 eastbound between Junction 4b (M25) and Junction 2 and the journey time reliability;
- Section 4 considers the change in speeds along sections of the M4 eastbound and the location of the queues;
- Section 5 presents the occupancy of each type of vehicle;
- Section 6 calculates the person hour savings along the eastbound M4;
- Section 7 presents the characteristics of the traffic behaviour by reviewing the differences in the Headway distribution over the MIDAS loops;
- Section 8 discusses the traffic condition on the adjoining network (A4);
- Section 9 presents the air quality and noise impacts;
- Section 10 discusses the safety on the M4;
- Section 11 summarises the key points of the report; and

- Section 12 presents the report's conclusions.

The Figures are presented at the back of the report along with Appendix A which presents a location plan of the MIDAS loops and Appendix B which holds the Accident Plots.

# 2 Traffic Flow Composition

Traffic flows have been analysed in order to assess any change in flow levels. This was carried out using a series of MIDAS loops along the carriageway from Junction 4 to Junction 2 of the M4 eastbound. The flows were compared on an hourly basis by lane. A review of the composition of the traffic has also been carried out to see if there has been a change in the number of buses / taxis using the M4 between Junction 3 and Junction 2. In addition, there is a review of the changes in lane utilisation over the past year.

All 2010 and 2011 MIDAS flow data has been analysed by averaging the weekday / weekend MIDAS data recorded. The average flow by day type, over the study period has been calculated for this assessment in order to compare 2010 with 2011.

## 2.1 Flow Patterns and Levels

*Junction 4 to Junction 3*

*Weekday*

MIDAS loop (M4/2240B) between Junction 4 and Junction 3 has been compared to identify if there have been any changes to the flow profile on the approach to Junction 3 prior to the M4 Bus Lane section between the 'before' and 'after' scenario. During the weekday the average flow profile between 2010 and 2011 is similar, with a slight increase in flow across the day, as shown in Table 2.1 and Figure 1.

**Table 2.1: Hourly Traffic Flows for an average weekday between Junction 4 and Junction 3.**

| Hour Starting | 2010 Flow | 2011 Flow | Difference | % Difference |
|---|---|---|---|---|
| 00:00 | 543 | 577 | 34 | 6% |
| 01:00 | 356 | 382 | 26 | 7% |
| 02:00 | 319 | 320 | 1 | 0% |
| 03:00 | 341 | 362 | 21 | 6% |
| 04:00 | 637 | 681 | 44 | 7% |
| 05:00 | 1948 | 2035 | 87 | 4% |
| 06:00 | 4805 | 4971 | 166 | 3% |
| 07:00 | 4630 | 4963 | 333 | 7% |
| 08:00 | 4436 | 4556 | 120 | 3% |
| 09:00 | 4288 | 4352 | 63 | 1% |
| 10:00 | 4053 | 4066 | 12 | 0% |
| 11:00 | 3815 | 3947 | 132 | 3% |
| 12:00 | 3772 | 3877 | 105 | 3% |
| 13:00 | 3907 | 4000 | 92 | 1% |
| 14:00 | 3839 | 3963 | 123 | 3% |
| 15:00 | 4000 | 4081 | 82 | 1% |
| 16:00 | 4744 | 4845 | 101 | 1% |
| 17:00 | 5064 | 5312 | 249 | 5% |
| 18:00 | 4663 | 4958 | 295 | 6% |
| 19:00 | 4092 | 4143 | 50 | 1% |
| 20:00 | 3093 | 3130 | 37 | 1% |
| 21:00 | 2465 | 2568 | 103 | 4% |
| 22:00 | 1947 | 2013 | 66 | 3% |
| 23:00 | 1115 | 1133 | 18 | 2% |
| **TOTAL** | **72872** | **75233** | **2362** | **3%** |

Table 2.1 and Figure 1 show that during the average weekday:

- For each of the one-hour time periods, traffic flows in 2011 are higher than they were in 2010.
- The maximum hourly flow is approximately 1,800 vehicles per lane (for lanes 1 and 2) in the morning peak and Evening Peak Periods for both 2010 and 2011.
- The period of highest flows is from 06:00-09:00hrs and from 16:00-19:00hrs and there were increases in all the hourly flows in these periods.
- The total flow in 2010 is nearly 73,000, whereas in 2011 it is just over 75,000.
- Traffic levels for lane 1 and 2 are consistently high throughout the day with a dip for lane 3 during the inter peak period in both 2010 and 2011.

- There has been a 3% increase in traffic flows between Junction 4 and Junction 3 during an average weekday.

*Weekend Day*

MIDAS loop (M4/2240B) between Junction 4 and Junction 3 has also been compared to identify if there have been any changes to the flow profile on the approach to Junction 3 prior to the M4 Bus Lane section between the 'before' and 'after' scenario for the average weekend day as shown in Table 2.2 and Figure 2.

**Table 2.2: Hourly Traffic Flows for an average weekend day at between Junction 4 and Junction 3**.

| Hour Starting | 2010 Flow | 2011 Flow | Difference | % Difference |
|---|---|---|---|---|
| 00:00 | 931 | 932 | 1 | 0% |
| 01:00 | 563 | 607 | 45 | 8% |
| 02:00 | 437 | 461 | 23 | 5% |
| 03:00 | 407 | 408 | 1 | 0% |
| 04:00 | 540 | 583 | 42 | 8% |
| 05:00 | 1151 | 1177 | 26 | 2% |
| 06:00 | 1791 | 1802 | 12 | 1% |
| 07:00 | 2594 | 2603 | 9 | 0% |
| 08:00 | 3092 | 3009 | -83 | -3% |
| 09:00 | 3695 | 3571 | -124 | -3% |
| 10:00 | 4072 | 3910 | -162 | -4% |
| 11:00 | 4428 | 4432 | 4 | 0% |
| 12:00 | 4407 | 4610 | 203 | 5% |
| 13:00 | 4348 | 4657 | 310 | 7% |
| 14:00 | 3971 | 4440 | 468 | 12% |
| 15:00 | 3948 | 4398 | 451 | 11% |
| 16:00 | 4341 | 4698 | 357 | 8% |
| 17:00 | 4418 | 4656 | 238 | 5% |
| 18:00 | 4303 | 4499 | 196 | 5% |
| 19:00 | 3901 | 4352 | 451 | 12% |
| 20:00 | 3178 | 3616 | 438 | 14% |
| 21:00 | 2746 | 2961 | 215 | 8% |
| 22:00 | 2080 | 2314 | 234 | 11% |
| 23:00 | 1371 | 1482 | 111 | 8% |
| **TOTAL** | **66712** | **70177** | **3465** | **5%** |

Table 2.2 and Figure 2 show that during the average weekend day:

- In all but three of the one-hour time periods, traffic flows in 2011 are higher than they were in 2010.

- The peak flow in any one lane is just over 1,600 vehicles in 2010 but is nearer 1,800 vehicles in lane 2 in 2011 at 11:00hrs, with a more pronounced increase

in Lanes 1 and 2 between 10:00hrs and 20:00hrs compared with the average weekday.

- The total flow in 2010 is approximately 66,700 whereas in 2011 this has increased to just over 70,000.
- There is a general increase in vehicles in Lanes 1, 2 and 3 between 11:00-19:00hrs in 2011 with the M4 Bus Lane suspension.

*Summary*

Overall, there is a 3% increase in traffic flows between Junction 4 and Junction 3 during an average weekday but the analysis suggests that there is a larger increase in flow levels (5%) in 2011 over the course of the average weekend day. During an average weekend day there is over a 5% increase in traffic on the M4 visible from 13:00 onwards, while earlier in the day, between 08:00-10:00hrs traffic levels are lower in 2011 than in 2010.

*Junction 3 Off and On slips*

*Weekday*

Table 2.3 presents the average hourly flows for the off and on slips at Junction 3 for the weekday.

**Table 2.3: Hourly Traffic Flows for an average weekday for the off and on slips at Junction 3.**

| Hour Starting | Off Slip | | | Onslip | | |
|---|---|---|---|---|---|---|
| | 2010 | 2011 | Difference | 2010 | 2011 | Difference |
| 00:00 | 287 | 277 | -10 | 70 | 77 | 6 |
| 01:00 | 199 | 200 | 1 | 43 | 48 | 5 |
| 02:00 | 197 | 184 | -13 | 38 | 42 | 4 |
| 03:00 | 205 | 189 | -15 | 47 | 51 | 4 |
| 04:00 | 308 | 302 | -6 | 123 | 121 | -2 |
| 05:00 | 792 | 820 | 27 | 214 | 226 | 12 |
| 06:00 | 1628 | 1652 | 24 | 395 | 442 | 47 |
| 07:00 | 1835 | 1957 | 122 | 401 | 332 | -70 |
| 08:00 | 1892 | 1956 | 64 | 348 | 300 | -47 |
| 09:00 | 1754 | 1806 | 52 | 333 | 325 | -8 |
| 10:00 | 1570 | 1615 | 49 | 355 | 362 | 8 |
| 11:00 | 1468 | 1523 | 55 | 355 | 369 | 13 |
| 12:00 | 1517 | 1548 | 31 | 373 | 381 | 8 |
| 13:00 | 1603 | 1645 | 42 | 357 | 360 | 3 |
| 14:00 | 1615 | 1638 | 23 | 341 | 367 | 26 |
| 15:00 | 1653 | 1658 | 5 | 356 | 365 | 9 |
| 16:00 | 1839 | 1900 | 61 | 383 | 358 | -24 |
| 17:00 | 1893 | 1960 | 66 | 405 | 377 | -27 |
| 18:00 | 1747 | 1842 | 95 | 361 | 364 | 4 |
| 19:00 | 1603 | 1601 | -2 | 325 | 344 | 18 |
| 20:00 | 1197 | 1173 | -24 | 284 | 283 | -1 |
| 21:00 | 962 | 964 | 2 | 260 | 252 | -8 |
| 22:00 | 854 | 808 | -46 | 208 | 220 | 12 |
| 23:00 | 563 | 487 | -76 | 124 | 135 | 11 |
| **TOTAL** | **29181** | **29707** | **526** | **6499** | **6501** | **3** |

Table 2.3 and Figure 3 shows for the average weekday that:

- There are over 29,000 vehicles per average weekday leaving the M4 at Junction 3 in 2010 and 2011.
- There is a 2% increase in the number of vehicles using the off slip in 2011 compared to 2010, but this is a lower percentage than the increase in total traffic arriving from Junction 4.
- There is an increase in the number of vehicles leaving the M4 in the Morning Peak Period, inter peak period and Evening Peak Period, but a decrease in the off peak period.
- The number of vehicles joining the M4 at Junction 3 is consistent between 2010 and 2011, 6,500 vehicles during the average weekday, although there is

a small decrease in the number of vehicles joining the M4 between 07:00-10:00hrs and 16:00-18:00hrs.

*Weekend Day*

Table 2.4 presents the average hourly flows for the off and on slips at Junction 3 for the average weekend day.

**Table 2.4: Hourly Traffic Flows for an average weekend day for the off and on slips at Junction 3.**

| Hour Starting | Off Slip | | | Onslip | | |
|---|---|---|---|---|---|---|
| | 2010 | 2011 | Difference | 2010 | 2011 | Difference |
| 00:00 | 439 | 458 | 18 | 129 | 113 | -16 |
| 01:00 | 276 | 306 | 30 | 82 | 83 | 1 |
| 02:00 | 227 | 234 | 7 | 58 | 58 | 0 |
| 03:00 | 210 | 203 | -7 | 61 | 63 | 2 |
| 04:00 | 254 | 265 | 11 | 101 | 95 | -6 |
| 05:00 | 497 | 505 | 8 | 131 | 145 | 14 |
| 06:00 | 705 | 680 | -25 | 243 | 248 | 5 |
| 07:00 | 860 | 866 | 6 | 344 | 363 | 19 |
| 08:00 | 1054 | 1003 | -51 | 352 | 384 | 32 |
| 09:00 | 1263 | 1255 | -8 | 349 | 376 | 27 |
| 10:00 | 1405 | 1352 | -52 | 341 | 368 | 27 |
| 11:00 | 1567 | 1540 | -27 | 335 | 366 | 31 |
| 12:00 | 1671 | 1677 | 6 | 366 | 354 | -11 |
| 13:00 | 1787 | 1819 | 32 | 332 | 334 | 1 |
| 14:00 | 1636 | 1726 | 90 | 318 | 334 | 16 |
| 15:00 | 1511 | 1622 | 111 | 315 | 332 | 17 |
| 16:00 | 1568 | 1648 | 80 | 344 | 333 | -11 |
| 17:00 | 1628 | 1671 | 44 | 314 | 317 | 3 |
| 18:00 | 1662 | 1726 | 64 | 313 | 320 | 7 |
| 19:00 | 1542 | 1602 | 61 | 320 | 328 | 8 |
| 20:00 | 1221 | 1320 | 99 | 263 | 292 | 29 |
| 21:00 | 1009 | 1091 | 81 | 254 | 258 | 5 |
| 22:00 | 845 | 890 | 45 | 226 | 229 | 3 |
| 23:00 | 588 | 608 | 20 | 157 | 168 | 12 |
| **TOTAL** | **25424** | **26064** | **640** | **6050** | **6262** | **212** |

Table 2.4 and Figure 4 shows for the average weekend day that:

- There are over 25,000 vehicles per weekend day leaving the M4 at Junction 3 in 2010 and 2011.

- There is a 2.5% increase in the number of vehicles using the off slip in 2011 compared to 2010 (but a lower percentage than the increase in total traffic arriving from Junction 4).
- There is a greater increase in the number of vehicles leaving the M4 from 14:00 into the evening peak.
- There is a 3.5% increase in traffic joining the M4 on the average weekend day, seen mainly during the Morning Peak Period.

*Junction 3 to Junction 2*

A series of MIDAS loops between Junction 3 and Junction 2 have been processed for analysis. The results for all loops between Junction 3 and Junction 2 are similar as shown in Figures 5 and 6, for 2010 and 2011 respectively, therefore results for MIDAS site 2183, located between Heston Services and the three to two lane merge, will be presented as a representation of the traffic flows for before and after.

*Weekday*

Table 2.5 and Figure 7 shows the average weekday traffic flow the key points to highlight are:

- With the suspension of the M4 Bus Lane there is an increase in flow in Lane 3 of approximately 700 vehicles in the Morning Peak Period and 800 vehicles in the Evening Peak Period.
- The flow profile for lanes 1 and 2 have remained similar in 2011 to those in 2010 but in 2011 the traffic levels have decreased by approximately 200 vehicles per hour between 06:00 and 21:00.
- This results in a negligible increase in all day traffic levels in 2011 as shown in Table 2.5.

**Table 2.5: Hourly Traffic Flows for an average weekday at MIDAS loop 2183.**

| Hour Starting | 2010 Flow | 2011 Flow | Difference | % Difference |
|---|---|---|---|---|
| 00:00 | 328 | 374 | 46 | 14% |
| 01:00 | 200 | 225 | 25 | 13% |
| 02:00 | 160 | 171 | 11 | 7% |
| 03:00 | 178 | 203 | 25 | 14% |
| 04:00 | 416 | 451 | 35 | 8% |
| 05:00 | 1230 | 1280 | 50 | 4% |
| 06:00 | 3255 | 3410 | 155 | 5% |
| 07:00 | 3015 | 3198 | 182 | 6% |
| 08:00 | 2851 | 2672 | -179 | -6% |
| 09:00 | 2765 | 2696 | -69 | -2% |
| 10:00 | 2886 | 2754 | -132 | -5% |
| 11:00 | 2640 | 2688 | 49 | 2% |
| 12:00 | 2591 | 2581 | -10 | 0% |
| 13:00 | 2544 | 2549 | 5 | 0% |
| 14:00 | 2502 | 2522 | 20 | 1% |
| 15:00 | 2575 | 2574 | -1 | 0% |
| 16:00 | 3030 | 3012 | -17 | -1% |
| 17:00 | 3247 | 3396 | 149 | 5% |
| 18:00 | 3086 | 3242 | 156 | 5% |
| 19:00 | 2835 | 2779 | -55 | -2% |
| 20:00 | 2139 | 2148 | 9 | 0% |
| 21:00 | 1748 | 1780 | 32 | 2% |
| 22:00 | 1302 | 1377 | 74 | 6% |
| 23:00 | 706 | 768 | 62 | 9% |
| **TOTAL** | **48230** | **48851** | **621** | **1%** |

Table 2.5 and Figure 7 indicate that the highest flows (in excess of 3,000 vehicles per hour) occur between 06:00-08:00hrs and 16:00-19:00hrs in both years. Flows increase by some 5% in all of these periods in 2011 with the suspension of the M4 Bus Lane. There is a reduction in traffic flows in the Morning Peak Period between 08:00hrs and 11:00hrs in 2011 with the M4 Bus Lane suspension but an increase in the Evening Peak Period between 17:00hrs and 19:00hrs.

Over the course of an average weekday there is a marginal increase of 621 vehicles, (1.3%) with the suspension of the M4 Bus Lane.

*Weekend Day*

Figure 8 and Table 2.6 compares the flow profiles for before and after for the average weekend day at the same location.

**Table 2.6: Hourly Traffic Flows for an average weekend day at MIDAS loop 2183.**

| Hour Starting | 2010 Flow | 2011 Flow | Difference | % Difference |
|---|---|---|---|---|
| 00:00 | 618 | 577 | -41 | -7% |
| 01:00 | 377 | 386 | 9 | 2% |
| 02:00 | 267 | 275 | 7 | 3% |
| 03:00 | 252 | 258 | 6 | 2% |
| 04:00 | 369 | 375 | 6 | 2% |
| 05:00 | 722 | 746 | 24 | 3% |
| 06:00 | 1263 | 1288 | 25 | 2% |
| 07:00 | 2024 | 2027 | 3 | 0% |
| 08:00 | 2347 | 2300 | -47 | -2% |
| 09:00 | 2704 | 2586 | -118 | -4% |
| 10:00 | 2945 | 2811 | -135 | -5% |
| 11:00 | 2960 | 3142 | 182 | 6% |
| 12:00 | 2910 | 3147 | 237 | 8% |
| 13:00 | 2846 | 3024 | 178 | 6% |
| 14:00 | 2613 | 2912 | 299 | 11% |
| 15:00 | 2686 | 2952 | 266 | 10% |
| 16:00 | 2937 | 3219 | 282 | 10% |
| 17:00 | 3011 | 3109 | 99 | 3% |
| 18:00 | 2855 | 2967 | 82 | 3% |
| 19:00 | 2777 | 2891 | 114 | 4% |
| 20:00 | 2329 | 2480 | 151 | 6% |
| 21:00 | 2027 | 2104 | 77 | 4% |
| 22:00 | 1505 | 1596 | 91 | 6% |
| 23:00 | 945 | 1032 | 86 | 9% |
| **TOTAL** | **46320** | **48202** | **1882** | **4%** |

Table 2.6 and Figure 8 show that:

- The average weekend day profile is different to the average weekday profile.
- There is a reduction in vehicles in Lanes 1 and 2 with the suspension of the M4 Bus Lane but an increase in Lane 3.

Over the course of an average weekend day there is an increase of 1882 vehicles, 4.1%, with the suspension of the M4 Bus Lane. The highest hourly flow in 2010 is from 17:00hrs to18:00hrs, whilst in 2011 it is from 16:00hrs to 17:00hrs. From 11.00hrs to 19:00hrs, traffic levels remain consistently high in both 2010 and 2011, but it can be seen that there has been a noticeable increase in traffic flows in this time period after the suspension of the M4 Bus Lane. In all but four of the one-hour time periods, traffic flows in 2011 are higher than they were in 2010.

After the merge immediately prior to the M4 elevated section from 3 to 2 lanes, there is little change to the flow profile or the traffic levels in the weekday, as shown in Figure 9 (for MIDAS site 2156). Based on the DfT's Design Manual for Bridges and Road (Volume 5 Section 1 Part 3), the urban road capacity for a two-lane and three-lane urban motorway with standard lane widths, is 4000 vehicles and 5600 vehicles, respectively (ie:2000 and 1866 vehicles per lane). This standard capacity can be affected by the lane width, the junction movements and the percentage of HGVs and this is the case on the M4, thus the capacity is lower than for a standard urban motorway. Allowing for these factors, it may be deduced from Figure 9 that the total flows in the AM and PM peak periods on the elevated section could be near if not at the theoretical capacity of this part of the M4. The nominal change in flow profile therefore implies that the elevated section was already at capacity in the 'before' and that irrespective of upstream road layout changes, the elevated section cannot accommodate any more traffic during these periods. During the average weekend day there is an increase in traffic flow in lane 2 during the Inter Peak Period and Evening Peak Period as shown in Figure 10, which broadly correspond to the changes shown in Table 2.6.

*Comparison with 1998/1999 Traffic Flows*

In order to put this assessment into context, the 1998/99 daily traffic flows that were used to assess the implementation of the M4 Bus Lane are shown below in Table 2.7, together with those from 2010/11.

**Table 2.7: Daily Traffic Flows**

| Day | Junction 4 to 3 | | | | Junction 3 to 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | 1998* | 1999* | 2010 | 2011 | 1998* | 1999* | 2010 | 2011 |
| Sunday | 64300 | 66300 | - | - | 49700 | 51000 | - | - |
| Average Weekend Day | - | - | 66700 | 70200 | | | 46300 | 48200 |
| Monday | 72500 | 71600 | - | - | 51400 | 52200 | - | - |
| Tuesday | 74000 | 72200 | - | - | 52400 | 52800 | - | - |
| Wednesday | 74500 | 73800 | - | - | 52600 | 53800 | - | - |
| Thursday | 75700 | 74100 | - | - | 53700 | 53400 | - | - |
| Friday | 76700 | 73000 | - | - | 54400 | 53300 | - | - |
| Average Weekday | 74680 | 72940 | 72900 | 75200 | 52900 | 53100 | 48200 | 48900 |

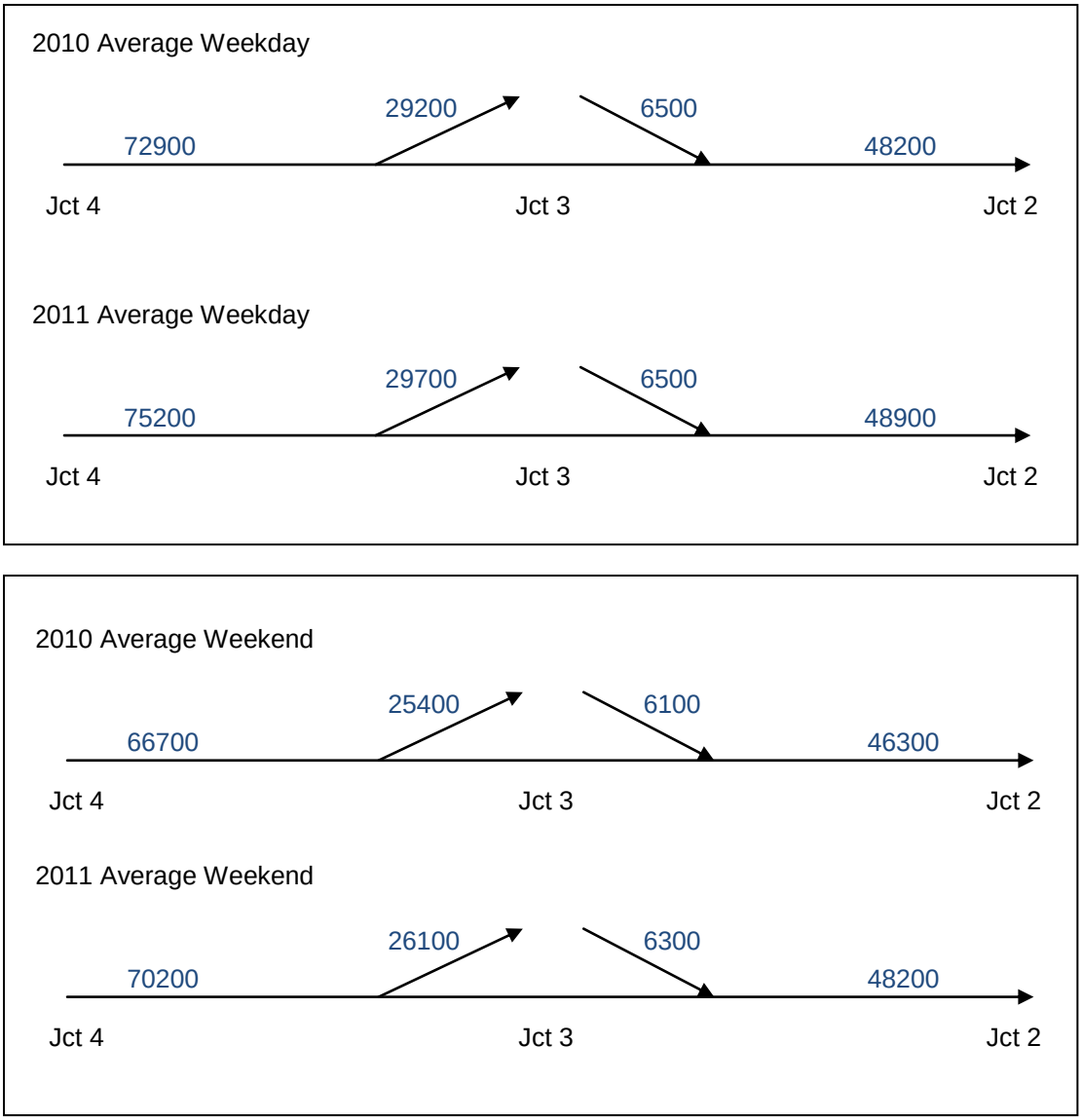
*1998/99 Traffic flows taken from the Monitoring of the M4 Bus Lane: The First Year; PR/T/125/2000

It can be seen that between 2010 and 1999 there is little change in the flows between Junction 4 and Junction 3 for the average weekday, but there are higher flows between Junction 3 and Junction 2 in 1998 and 1999 than were present in the 2010 or 2011 before or after suspension flows.

*Flow Summary*

Diagrams of the flows along the eastbound M4 for the average weekday and average weekend daily flows presented in the tables in Section 2.1 are shown in Diagram 2.1.

**Diagram 2.1: Flow Diagrams**




It can be deduced from this diagram that there is a discrepancy along the route, of between 1000 and 3000 vehicles over the 24 hour period. This is due to:

- The MIDAS loops being unable to detect all vehicles caused by some vehicles changing lane where the loops are situated and not being accurately recorded.
- Traffic exiting the M4 at Heston Services and not returning to the motorway. (The difference in flow from a MIDAS loop preceding the Services to the one immediately after them is approximately 1,000 vehicles over the 24 hour period.)

## 2.2 Composition of Traffic Flow

MIDAS data has been analysed to provide the HGV percentage along the eastbound M4. For the purposes of this calculation it has been assumed that any vehicle over 6.6m is a HGV (MIDAS categories 3 and 4).

**Table 2.8: Percentage of HGVs**

| Location | Weekday | | Weekend | |
|---|---|---|---|---|
| | 2010 | 2011 | 2010 | 2011 |
| Junction 4-3 | 6.1% | 6.7% | 3.1% | 3.4% |
| Junction 3-2 (three lanes) | 6.5% | 6.6% | 3.3% | 3.7% |

Table 2.8 shows that there has been no significant change in the percentage of HGVs using the M4 eastbound as a result of the suspension of the M4 Bus Lane.

## 2.3 Vehicle Type

A review of lane usage by different vehicle types has been carried out based on Manual Classified Counts collected between Junction 3 and Junction 2. Data was collected for five individual days during the study period (three weekdays, a Saturday and a Sunday) between the Heston Services off and on slips, from 07:00-19:00. The average number of vehicles, by lane for an average weekday is shown in Table 2.9 for 2010 (before) and 2011 (after) situations.

**Table 2.9: Vehicle Type by Lane for an Average Weekday**

| Lane | Total | Car | Taxi | LGV | HGV | Bus |
|---|---|---|---|---|---|---|
| *2010* | | | | | | |
| 1 | 12391 | 9315 | 81 | 2275 | 676 | 44 |
| 2 | 15600 | 13817 | 39 | 1644 | 72 | 28 |
| 3 | 2970 | 879 | 1668 | 20 | 4 | 400 |
| TOTAL | 30961 | 24011 | 1788 | 3939 | 752 | 472 |
| *2011* | | | | | | |
| 1 | 10391 | 7071 | 422 | 1881 | 822 | 194 |
| 2 | 13119 | 10804 | 524 | 1441 | 128 | 222 |
| 3 | 8023 | 7071 | 414 | 518 | 3 | 17 |
| TOTAL | 31532 | 24946 | 1360 | 3841 | 953 | 433 |

Table 2.9 shows that there has been a reduction in 2011 of the number of buses and taxis using the M4 between Junction 3 and Junction 2, together with an increase in the number of cars, LGVs and HGVs. Overall, there is a slight increase in the average daily number of vehicles, which is consistent with the results from the analysis of MIDAS data in Section 2.1.

Table 2.9 also shows that in 2010 there were average daily vehicles comprising 879 cars, 20 LGVs and 4 HGVs using the M4 Bus Lane when they were prohibited to do so. The suspension of the M4 Bus Lane has provided a more balanced usage of the road space.

In 1999, from 06:30-20:30 there were, for an average weekday, 2425 taxis and 575 buses observed. (Taken from Table C2 - Average weekday flows (through traffic between Junction 4 and 2), Monitoring of the M4 Bus Lane: The First Year; PR/T/125/2000). There has been a general decrease in the numbers of taxis and buses using the M4 between 1999 and 2010 with 1617 and 1378 taxis observed in 2010 and 2011 respectively.

The average number of vehicles, by lane, over an average weekend day is shown in Table 2.10 for both 2010 and 2011.

**Table 2.10: Vehicle Type by Lane for an Average Weekend Day**

| Lane | Total | Car | Taxi | LGV | HGV | Bus |
|---|---|---|---|---|---|---|
| *2010* | | | | | | |
| 1 | 8531 | 7715 | 68 | 558 | 134 | 56 |
| 2 | 10402 | 9896 | 28 | 432 | 13 | 34 |
| 3 | 2489 | 643 | 1521 | 5 | 1 | 319 |
| TOTAL | 21423 | 18254 | 1617 | 995 | 147 | 409 |
| *2011* | | | | | | |
| 1 | 7517 | 6235 | 391 | 514 | 131 | 246 |
| 2 | 9555 | 8333 | 491 | 423 | 22 | 286 |
| 3 | 5466 | 4807 | 496 | 149 | 2 | 12 |
| TOTAL | 22538 | 19375 | 1378 | 1087 | 155 | 543 |

Based on the sampled individual days, there was a decrease in the number of taxis but an increase in the number of buses between 2010 and 2011 during the average weekend day, and an overall increase in the number of vehicles travelling between Junction 3 and Junction 2. This is consistent with the results obtained from the MIDAS data reported in Section 2.1.

Average weekend day data between 1999 and 2010 is not comparable due to the differing time periods for which data were recorded.

The cause of the changes in the numbers of buses and taxis is unclear. It is considered likely that these changes are unrelated to the suspension of the M4 Bus Lane and may simply be random variation given the small sample sizes. Indeed, although bus journey times have increased during some times of the day (see section 6.2), the scale of change in journey times is considered very unlikely to lead to a significant change in bus numbers (in fact the weekend day shows increases in bus numbers which are equally considered to be random variations).

## 2.4 Lane Utilisation

The utilisation of each lane has been calculated from the Manual Classified Count data. This is shown in Table 2.11.

**Table 2.11: Lane Utilisation**

| Lane | Weekday | Weekend |
|---|---|---|
| *2010* | | |
| 1 | 40% | 40% |
| 2 | 50% | 49% |
| 3 | 10% | 11% |
| TOTAL | 100% | 100% |
| *2011* | | |
| 1 | 33% | 33% |
| 2 | 42% | 43% |
| 3 | 25% | 24% |
| TOTAL | 100% | 100% |

Table 2.11 shows that the percentage utilisation by lane is the same for the average weekday and weekend day, even though traffic levels are different in the before (2010) and after (2011) situations. With the suspension of the M4 Bus Lane, there is as expected an increase in traffic in Lane 3, together with fewer vehicles travelling in Lanes 1 and 2.

# 3 Journey Times and Reliability

Journey times are an important indicator of the performance of the M4. They are a measure of a drivers experience travelling through this section of the M4 and provide an indication of the travel time cost effects of the suspension of the M4 Bus Lane. Cost benefits are derived by both a reduction in the journey time and by improvements in the journey time reliability, allowing drivers to predict with more certainty how long their journeys will take.

Journey times have been calculated for the section of carriageway between Junction 4b (M25 Junction 15) and Junction 2 (just after the start of the elevated section) by using the MIDAS Journey Time Algorithm developed by TRL. As previously discussed, data was filtered to exclude data on days when incidents occurred, such as unexpected lane closures or accidents. This means that no account has been made of the possible benefit that buses and taxis might have had if there had been an incident obstructing, or resulting in a lane closure, in Lanes 1 and 2 before the M4 Bus Lane was suspended; however, as non-M4 Bus Lane traffic previously used the M4 Bus Lane to bypass any incident/lane closures in Lanes 1 and 2, it is considered the impact of incidents in both the 'before' and the 'after' cases would have had the same impact on the journey times of buses and taxis as on other vehicles.

The analysis has been carried out by calculating the average journey time for week/weekend day, by time period and by lane. The data has been split into weekday and weekends due to the differing nature of the daily profiles.

For the journey time analysis, the Morning Peak Period is from 06:00-10:00hrs, the Inter Peak Period is from 10:00-16:00hrs, the Evening Peak Period is from 16:00-19:00hrs and the Off Peak Period is from 19:00-06:00hrs.

Journey time reliability has been measured using the standard deviation of the journey times, calculated using the Journey Time Algorithm (see section 3.2).

Two journey time routes have been analysed: from Junction 4b to Junction 2; and from Junction 3 to Junction 2.

Junction 4b to Junction 2 has been included as it accounts for a large proportion of the journeys along this section of the M4. Journey times between Junction 4b and Junction 2 were affected by delays caused by 'Shockwave' queuing conditions resulting from traffic demand and capacity constraint issues along the M4 between the two junctions.

The journey time between Junction 3 and Junction 2 has been presented discretely, as it is the section that includes the M4 Bus Lane. But it should be noted that the Junction 3 to Junction 2 journey times are effectively only relevant to traffic joining at Junction 3 and Heston Services, which is the minority of the traffic along this section.

## 3.1 Comparison of Journey Times

*Weekday*

Table 3.1 compares the average weekday journey time by period and by lane from the M4 Junction 4b (M25) to M4 Junction 2. This is also shown pictorially in Figure 11. The 'All' lanes time are the flow weighted average of the three lanes.

**Table 3.1: Weekday Average Journey Times Junction 4b- Junction 2**

| Time Period | Lane | Average Journey Time (mm:ss) | | |
|---|---|---|---|---|
| | | 2010 | 2011 | Difference |
| 0600-1000 | Lane 1 | 21:44 | 20:04 | -01:40 |
| | Lane 2 | 18:32 | 17:54 | -00:38 |
| | Lane 3 | 10:11 | 13:20 | 03:09 |
| | All | 19:10 | 18:26 | -00.44 |
| 1000-1600 | Lane 1 | 12:48 | 11:17 | -01:31 |
| | Lane 2 | 11:08 | 10:24 | -00:44 |
| | Lane 3 | 07:02 | 07:04 | 00:02 |
| | All | 11:39 | 10:36 | -01:03 |
| 1600-1900 | Lane 1 | 17:49 | 15:29 | -02:20 |
| | Lane 2 | 15:32 | 14:04 | -01:28 |
| | Lane 3 | 09:38 | 10:11 | 00:33 |
| | All | 16:10 | 14:21 | -01:49 |
| 1900-2400 | Lane 1 | 14:09 | 11:59 | -02:10 |
| | Lane 2 | 12:34 | 11:10 | -01:24 |
| | Lane 3 | 07:57 | 08:05 | 00:08 |
| | All | 13:02 | 11:24 | -01:38 |
| 0600-2400 | All | 15:25 | 14:07 | -01:18 |

*These are theoretical journey times as cars would be in lane 3 in 2010 from Junction 4b-3 but would not be between Junctions 3-2.

Table 3.1 and Figure 11 show that:

- The journey times in the Morning Peak Period are the longest, taking on average just over 19 minutes in 2010.
- There is an increase in journey time in Lane 3 with the suspension of the M4 Bus Lane which is especially noticeable in the Morning Peak Period.
- Overall, the results show that there is a decrease in the journey time from Junction 4b to Junction 2 for all periods when considering the flow weighted average of all lanes. In the Morning Peak Period there is a decrease in journey time of 44 seconds; in the Inter Peak Period there is a decrease in

journey time of just over a minute; in the Evening Peak Period there is a decrease of 1 minute 49 seconds and finally in the Off Peak Period there is a decrease in average journey time of 1 minute 38 seconds.

- The highest average journey time in 2010 (of 21min 44sec in Lane 1) is not met in 2011.

Between the M4 Junction 3 and Junction 2 specifically, the average weekday journey time by period and by lane are shown for this smaller element of the M4 Junction 4b (M25) to M4 Junction 2 journey. This is shown in Table 3.2.

**Table 3.2: Weekday Average Journey Times for Junction 3 to Junction 2**

| Time Period | Lane | Average Journey Time (mm:ss) | | |
|---|---|---|---|---|
| | | 2010 | 2011 | Difference |
| 0600-1000 | Lane 1 | 14:47 | 14:19 | -00:28 |
| | Lane 2 | 12:40 | 12:53 | 00:13 |
| | Lane 3 | 04:28 | 08:42 | 04:14 |
| | All | 13:02 | 13:20 | 00:18 |
| 1000-1600 | Lane 1 | 08:45 | 07:30 | -01:15 |
| | Lane 2 | 07:31 | 06:55 | -00:36 |
| | Lane 3 | 03:48 | 03:56 | 00:08 |
| | All | 07:59 | 07:07 | -00:52 |
| 1600-1900 | Lane 1 | 11:18 | 09:49 | -01:29 |
| | Lane 2 | 09:55 | 09:02 | -00:53 |
| | Lane 3 | 04:11 | 05:29 | 01:18 |
| | All | 10:19 | 09:15 | -01:04 |
| 1900-2400 | Lane 1 | 09:33 | 07:59 | -01:34 |
| | Lane 2 | 08:27 | 07:31 | -00:56 |
| | Lane 3 | 03:56 | 04:38 | 00:42 |
| | All | 08:47 | 07:43 | -01:04 |
| 0600-2400 | All | 10:15 | 09:37 | -00:38 |

This shows that between Junction 3 and Junction 2:

- There is an average increase in journey time for the weekday Morning Peak Period of 18 seconds per vehicle but a decrease of about 1 minute in all other time periods.

- There is an average increase in journey time in Lane 3 of over 4 minutes in the Morning Peak Period and over one minute in the Evening Peak Period but a decrease in journey time in Lanes 1 and 2, in the latter period.

- The highest average journey time in 2010 (of 14min 47sec in Lane 1) has reduced (to 14min 19 sec) in 2011

*Weekend Day*

During the average weekend day, there is a decrease in journey time with the suspension of the M4 Bus Lane, except for Lane 3, but taking into account the flow-weighted average, this results in an overall reduction in journey time as shown in Table 3.3 and Figure 12.

It should be noted that for 2010 these Lane 3 journey times are to a degree theoretical since between Junctions 4b and 3, use of Lane 3 would have been dominated by cars while between Junctions 3 and the end of the bus lane it would have been used by buses and taxis. Consequently, actual journey times will tend to be an average of Lane 3 and Lanes 1 and 2 journey times.

**Table 3.3: Weekend Daily Average Journey Times**

| Time Period | Lane | Junction 4b-2 | | | Junction 3-2 | | |
|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | Difference | 2010 | 2011 | Difference |
| 0600-1000 | Lane 1 | 11:39 | 10:24 | -01:15 | 07:56 | 06:48 | -01:08 |
| | Lane 2 | 10:07 | 09:40 | -00:27 | 06:45 | 06:20 | -00:25 |
| | Lane 3 | 06:38 | 06:24 | -00:14 | 03:39 | 03:20 | -00:19 |
| | All | 10:37 | 09:48 | -00:49 | 07:14 | 06:27 | -00:47 |
| 1000-1600 | Lane 1 | 16:29 | 11:52 | -04:37 | 11:54 | 08:04 | -03:50 |
| | Lane 2 | 14:33 | 11:00 | -03:33 | 10:29 | 07:30 | -02:59 |
| | Lane 3 | 07:55 | 07:22 | -00:33 | 04:06 | 04:11 | 00:05 |
| | All | 15:02 | 11:10 | -03:52 | 10:53 | 07:40 | -03:13 |
| 1600-1900 | Lane 1 | 18:58 | 15:19 | -03:39 | 13:52 | 11:07 | -02:45 |
| | Lane 2 | 17:00 | 14:14 | -02:46 | 12:24 | 10:21 | -02:03 |
| | Lane 3 | 08:37 | 10:23 | 01:46 | 04:23 | 06:50 | 02:27 |
| | All | 17:16 | 14:28 | -02:48 | 12:38 | 10:37 | -02:01 |
| 1900-2400 | Lane 1 | 14:32 | 13:44 | -00:48 | 10:15 | 09:32 | -00:43 |
| | Lane 2 | 13:14 | 12:55 | -00:19 | 09:15 | 09:00 | -00:15 |
| | Lane 3 | 07:51 | 10:12 | 02:21 | 04:04 | 06:27 | 02:23 |
| | All | 13:34 | 13:19 | -00:15 | 09:32 | 09:21 | -00:11 |
| 0600-2400 | All | 14:29 | 12:18 | -02:11 | 10:21 | 08:38 | -01:43 |

Table 3.3 and Figure 12 show that:

- Between Junction 4b and Junction 2 there is an average decrease in journey time of about 2 minutes. The greatest journey time decrease is in the busiest inter peak period (nearly a 4 minute decrease).

- Between Junction 4b and Junction 2, the highest average journey time in 2010 (of 18min 58sec in Lane 1) has reduced (to 15 min 19 sec) in 2011
- Between Junction 3 and Junction 2 there is an average decrease in journey time of nearly 2 minutes to give a journey time between Junction 3 to 2 of just under 9 minutes. The greatest journey time decrease is also in the Inter Peak Period (over a 3 minute decrease).
- Between Junction 3 and Junction 2, the highest average journey time in 2010 (of 13min 52sec in Lane 1) has reduced (to 11min 7 sec) in 2011

## 3.2 Journey Time Reliability

Reliability of journey times is important as it enables drivers and passengers to predict their arrival times. This is particularly important for commercial vehicles with the advent of 'just in time' deliveries. For this assessment, the standard deviation of the journey time has been used as a measure of journey time variability. A low variability indicates a greater reliability in journey time.

The journey time reliability was calculated using the journey times derived from MIDAS loops. Individual vehicles are 'modelled' using the 1-minute speed at a series of loops (by lane) which are then translated into journey times over the required section being analysed for 15 minute periods. These one minute journey times, based on the one minute speeds, are calculated by the journey time algorithm along with a standard deviation which is calculated from the 15 individual one minute journey times, by lane. The standard deviation output by the algorithm is a coefficient of variation, i.e. standard deviation/mean, for the fifteen minute period, based on the fifteen one minute estimates of journey time calculated.

A flow-weighted average journey time for each lane has been calculated, from journey time algorithm outputs, based on the data available for each day type for each 15 minute period and applied the flow weighting to the estimate of standard deviation too.

There is no differentiation of vehicle type in the calculation of the speeds/journey times, as MIDAS does not differentiate the speeds of vehicles across each loop by vehicle type. The only data available from MIDAS by vehicle type is the one minute flow across all lanes. Therefore it is not possible to calculate a journey time by vehicle type using the algorithm.

Figure 13 presents the variability of the journey time for an average weekday for Lane 1 for both before and after scenarios between M4 Junction 3 and the merge to two lanes

It shows that throughout the 24hr period:

- The average journey time between Junction 3 and the merge is similar before and after suspension of the M4 Bus Lane in the peak periods.
- In the Inter Peak Period it is quicker on average to travel from Junction 3 to the merge with the suspension of the M4 Bus Lane.

- In 2010, with the M4 Bus Lane in operation, the variability of the journey times is substantially greater than in 2011, with the suspension of the M4 Bus Lane. In the AM peak the reliability of the journey time has halved to the order of 60 seconds in 2011 compared to 120 seconds in 2010. This indicates that journey times are more reliable along this section in lane 1 with the suspension of the M4 Bus Lane.

A similar picture is presented for Lane 2, as shown in Figure 14.

Figure 15 analyses the journey times and variability for Lane 3. As expected, the journey time for Lane 3 in 2011 is longer, especially in the Morning Peak Period. The variability of the journey time has also increased for this lane (greater unreliability in the journey time compared to 2010) but the journey time variability is of a similar order to that in Lanes 1 and 2 in 2011, reflecting the fact that the traffic mix in the suspended M4 Bus Lane in the 'after' scenario is more closely aligned to the other lanes than was the case in the 'before' scenario.

It can be assumed that the journey time reliability for the majority of London taxis and all buses has worsened from 20 seconds, in Lane 3 in 2010, to 60 seconds in the AM Peak in 2011.

# 4 Traffic Speeds

Traffic speeds were monitored to assess whether there are any speed changes as a result of the M4 Bus Lane being suspended.

Along the M4, the speed limit is 60 mph (96kph) between Junction 3 and Junction 2 and this reduces to 40mph (65 kph) just prior to the merge location from three to two lanes. There has not been any change in the speed limits between the before and after situations.

In order for a comparison between 2010 and 2011 data plots of average speed by lane and speed variability have been produced for the MIDAS loops along the M4 eastbound. The underlying patterns are inevitably the same as the journey time results, as the data used for the analysis is the same. In practice the overall journey times are likely to be of primary importance to users but it is useful to present information regarding the speed of vehicles along the route.

## 4.1 Speed patterns

*Junction 4 to Junction 3*

At the MIDAS loop located between Junction 4 and Junction 3, for the average weekday the speed profiles across the 24 hour period are fairly similar for all lanes as shown in Figure 16. The speeds for each lane are consistently between 50mph and 70mph (80kph and 120kph) except during the Morning Peak Period and Evening Peak Periods when they drop to around 25mph (40kph) in each lane.

Figure 17 shows the average speed by lane for the average weekend day. The average speeds by lane in 2011 are broadly similar to 2010, although there is no noticeable decrease in average speed around noon in 2011, as seen in 2010. The dip in average speed at 18:00 is common across both situations.

*Junction 3 to Junction 2*

Figure 18 presents the average speed by lane of the MIDAS loops between Junction 3 and Junction 2. It can be seen that:

- In 2010 the average speed during the Off Peak Period is between 55mph and 70mph (90kph and 110kph) depending on lane. This is replicated in 2011, although there is a faster average speed in Lane 3 with the suspension of the M4 Bus Lane outside of the Morning and Evening Peak Periods.
- In 2010 there is a consistent reduction in average speed to 25mph (40kph) between the Morning Peak Period (06:00–10:00hrs) and the 17:00–19:00hrs timeframe compared with the other time periods.
- In 2010 speeds in Lane 3 are higher than those in Lanes 1 and 2 and are not subject to the reduction in speed in the peak periods, unlike in 2011 where the speed profiles for each lane are similar.

- In 2011 near Junction 3, there is little variation in the average speed for any of the lanes throughout the day.
- In 2011 at the approach to the two-lane section the average speed reduces more and more in the peak periods with a minimum average speed of 10mph (20kph) recorded, which ties in with queuing location diagrams in Figures 8 and 9.
- The speed differential between Lanes 2 and 3 has reduced from 20mph (30kph) in the peak periods to almost zero.

These results suggest that in 2011, there is an improvement in average speed at the beginning of the restored three-lane section but as you get closer to the merge the speeds are lower than in 2010. This replicates the journey time improvements as shown in Section 3.

On an average weekend day between Junction 3 and Junction 2, the lowest speed is recorded at 18:00hrs for both 2010 and 2011 as presented in Figure 19. The main difference in the speed profile between the 'before' and 'after' scenarios is between 11:00-14:00hrs. The before data shows a reduction of speed in excess of 10mph (20kph) for Lanes 1 and 2. This drop in speed is only seen in the 'after' data on the approach to the merging point and the reduction in speed is not as substantial.

## 4.2 Queue Locations

A series of journeys were undertaken using private vehicles travelling between Junction 4 and Junction 2 during the Morning Peak Period. Using the Global Positioning System (GPS), journey times were recorded on three individual weekdays in both 2010 and 2011 for these journeys.

From these limited observations, it is possible to establish where speeds are reduced and where subsequent queuing occurs.

The resultant diagrams for the route from Junction 4 to Junction 2 of the M4 have been produced as shown in Figure 20 for the 'before' case and in Figure 21 for the 'after' case. These results are for individual runs on individual days and, hence, are not averages, but they can be used to help understand if there is a potential trend with regards to the locations of queuing and / or slow moving traffic. They should not be regarded as a robust assessment, but provide a representative indication of the situation.

The sections shown in yellow in the figures are where traffic congestion starts to affect vehicle speeds – this speed is known as 'Delay Speed'. Above this value, conditions are generally considered to be at 'free-flow' (subject to road geometry). As the speed restriction at Junction 4 is 70mph, 60mph at Junction 3 and reduces to 40mph at the start of the M4 elevated section, the assumed Delay Speed in this assessment has been taken as when vehicles are travelling below 40mph (65kph).

The 'Queue Speed' is the speed below which vehicles are likely to be moving in a queue - generally spaced at the minimum safe spacing for the speed of travel. Again as the speed limit is 60mph along the majority of this stretch it is assumed that the

Queue Speed in this assessment is when vehicles are travelling below 25mph (40kph). The sections in blue in the figures show where this occurs.

Figure 20 shows how the locations of queuing and reductions in speed vary between M4 Junction 4 and M4 Junction 2 before the M4 Bus Lane was suspended as well as the recorded journey time. This shows speeds that in the 'before' period there is evidence of free-flow traffic along the majority of the route between M4 Junction 4 and the M4 Junction 2, with patches of isolated queuing vehicles. The journey times of these individual runs vary from 10 to 25 minutes.

Figure 21 shows that there is more queuing between Junction 3 and Junction 2 in the Morning Peak Period after the suspension of the M4 Bus Lane. This is due to a combination of the increase in traffic flow leading up to the Morning Peak Period between Junction 3 and Junction 2 and the limited capacity of the elevated section (as discussed in Section 2.1). The journey times recorded were between 10 and 38 minutes over the course of the Morning Peak Period. On occasions, this queue was seen to extend from the merge from three lanes to two lanes back to the Heston Services (although this is based on a small sample of the weekday Morning Peak Period for three individual days). This queuing corresponds to an increase in journey time and a reduction in traffic flows after 8am between Junction 3 and Junction 2 in the Morning Peak Period. Nevertheless, overall, the Morning Peak Period journey time from Junction 4b to Junction 2 has decreased.

## 4.3 Shockwaves and Queuing

To enable the traffic conditions along the whole length of the eastbound M4, for an individual day, to be compared the Motorway Traffic Viewer (MTV) tool has been used to graphically represent the speeds and flows for each minute for each lane.

Figure 22 presents the traffic conditions for a typical weekday, (in this case, the second Tuesday in October 2010 (12$^{th}$)) and Figure 23 presents the same information for the same day but in 2011 (11$^{th}$). The horizontal axis gives time, and the vertical axis is location. The left-hand axis gives the MIDAS loop locations and the right-hand axis gives the locations of the diverge and merge for each junction. The direction of vehicle travel is down the page.

The plots present the average speeds for each minute for each lane, enabling regions of low speed to be easily identified. Slow speeds are in white, fast speeds are in black. Any missing data or periods when there was no traffic in the lane during the minute are shown in blue. In addition, the red lines on the plots represent the passage of vehicles travelling through the section, with the journey time for each journey shown in red at the bottom of the plot.

The plots are shown for the Lane 2, which can be used any vehicle type.

Figure 22 shows that with the M4 Bus Lane in operation, the queuing behaviour for general vehicles is represented by shockwaves of slow moving traffic, indicated by diagonal lines moving from bottom left to top right. The main cause of congestion with the M4 Bus Lane is shockwaves of slow moving traffic propagating back from the 2-lane elevated section and west beyond Junction 3. When traffic slows down on the elevated section for any reason during a period of high flow, a shockwave is started;

resulting in intermittent stop-start driving conditions and can on occasions reach back to congestion at the Junction 4 merge.

Figure 23 shows that with the M4 Bus Lane suspended, the shockwaves have been absorbed into the general queuing at the bottleneck where the three lanes reduce to two at the start of the elevated section.

From a car driver's perspective, on a typical morning, 6km of intermittent stop-start driving has been replaced by up to 3km of more defined queuing. The effect of this change is illustrated in the changes in journey times discussed in Section 3.

The reason for the change in behaviour is as follows:

- With the M4 Bus Lane in operation, the majority of traffic travelling through Junction 3 (a 2-lane section) remained in two lanes up to and over the elevated section. Any disturbances in flow on the elevated section caused "ripples" to travel back upstream. These ripples took some time to dissipate.
- With the M4 Bus Lane suspended, there is additional space for queuing traffic between Junction 3 and the start of the elevated section, so the congestion no longer affects Junction 3.

# 5 Vehicle Occupancy

## 5.1 Background

The vehicle occupancy surveys were carried out at the same time as the Manual Classified Counts. They were carried out over five individual days within the survey periods in both 2010 and 2011. Vehicle occupancy was recorded by vehicle type (Car; car based LGV; London Taxi; LGV and HGV; buses and coaches) by lane. The occupancy of white cars was determined as a representative sample of the car population on the M4.

For buses and coaches the percentage occupancy figure for the four different bus types was recorded being minibus, midi bus, single Decker bus and double Decker bus. This percentage was converted to an estimated number of people using the standard assumptions for the number of seats for each of the bus types, as follows:

- Minibus – 16 seats
- Midi bus – 33 seats
- Single Decker bus – 53 seats
- Double Decker bus – 72 seats

In addition, a mid point in the percentage occupancy observed was adopted in the analysis; i.e. a minibus with an average percentage occupancy of 25-49% is assumed to have an occupancy in accordance with the following formula:

Estimated occupancy = Midpoint of percentage range x assumed number of seats on a minibus

= 37.5% (25%+49%/2 (ie: percentage occupancy observed)) x 16 seats

= 6 Seats (5 passengers and 1 driver)

## 5.2 Vehicle Occupancy Analysis

The difference between vehicle count and average occupancy for the average weekday and weekend day between the November 2010 and November 2011 surveys has been calculated for comparison, as shown in Table 5.1.

It is worth noting that the difference in cars is shown for only vehicles coloured white. Given the large number of cars using the M4, it is not practical to record the occupancy of all cars and recording the occupancy of white cars only is considered standard practice to provide a representative sample of the total number of cars for the purposes of vehicle occupancy analyses.

**Table 5.1: Vehicle Occupancy Comparison**

| | Cars | Car based LGV | Taxi | LGV / HGV | Bus and Coach |
|---|---|---|---|---|---|
| *Average Weekday* | | | | | |
| Before | 1.3 | 1.3 | 2.1 | 1.2 | 20.4 |
| After | 1.3 | 1.2 | 2.0 | 1.2 | 16.6 |
| *Average Weekend* | | | | | |
| Before | 1.5 | 1.4 | 2.0 | 1.3 | 21.6 |
| After | 1.7 | 1.4 | 2.0 | 1.4 | 22.7 |

The table shows that:

- Overall, vehicle occupancy is very similar in 2010 and 2011.
- During the weekday the average vehicle occupancy of a car is 1.3 and this is the same for both 'before' and 'after'.
- The average vehicle occupancy for a taxi has a negligible change from 2.1 to 2.0 for the average weekday and is 2 for the average weekend day. All numbers include the driver.
- The average vehicle occupancy for bus and coaches has reduced from just over 20 to 16 for the average weekday; but has increased for the average weekend day. Due to the size of the sample this change is considered to be a random fluctuation in occupancy numbers.

# 6 Journey Time Savings

## 6.1 Person-Hour Savings

Person-hour savings have been calculated for all days excluding incidents, for weekdays and weekend days separately. This has been calculated for the Morning Peak; Inter Peak and Evening Peak Periods only. Detailed data such as occupancy and vehicle type was not collected during the Off Peak Period.

Person hour savings (PHS) were calculated lane by lane using the following equation:

$m_v(t)$ = *The number of minutes saved by vehicle type* $v$ *during time period* $t$.

$o_v(t)$ = *The occupancy of vehicle type* $v$ *during time period* $t$.

$n_v(t)$ = *The number of vehicles of type* $v$ *on the M4 during time period* $t$.

The number of person-hours saved per day is:

$$\text{PHS} = \sum_{v,t} \frac{m_v(t) o_v(t) n_v(t)}{60}$$

A positive value represents a saving whilst a negative represents an increase in person hours or disbenefit.

The above calculation assumes vehicle occupancy and vehicle proportions data for 2011, taken from the vehicle occupancy analysis and the lane utilisation analysis reported in Section 7 and Section 2.3 of this report.

From Junction 4b to Junction 2 for an average weekday, the calculations show that there would be a saving of 846 person-hours (a 6% saving) as shown in Table 6.1.

**Table 6.1: Average Weekday Person-Hours Saving – Junction 4b to Junction 2**

| Time | Car | London Taxi | LGV | HGV | Bus | TOTAL |
|---|---|---|---|---|---|---|
| Morning Peak | 161 | -37 | 68 | 31 | -144 | 79 |
| Inter Peak | 320 | 6 | 43 | 4 | 27 | 400 |
| Evening Peak | 346 | -5 | 28 | 0 | -2 | 367 |
| TOTAL | 827 | -36 | 139 | 35 | -119 | 846 |

The majority of the person-hour savings are produced during the Evening Peak Period, although there are savings for all time periods for the eastbound section for cars, LGVs and HGVs. There is a negative benefit of 155 hours for London Taxi and Bus users with the suspension of the M4 Bus Lane, but this is outweighed by the 1001 hours saved by other road users by its suspension.

The calculations for Junction 3 to Junction 2, shown in Table 6.2, include the two-lane section after the merge. These show a disbenefit in the Morning Peak Period but a

benefit in the Inter Peak and Evening Peak Periods. This amounts to an overall saving of 136 person-hours over the 12-hour period for an average weekday.

**Table 6.2: Average Weekday Person-Hours Saving – Junction 3 to Junction 2**

| Time | Car | London Taxi | LGV | HGV | Bus | TOTAL |
|---|---|---|---|---|---|---|
| Morning Peak | -74 | -55 | 5 | 8 | -220 | -336 |
| Inter Peak | -74 | -55 | 5 | 8 | -220 | -336 |
| Evening Peak | 179 | -21 | 16 | 0 | -9 | 165 |
| TOTAL | 364 | -75 | 55 | 11 | -219 | 136 |

For an average weekend day, there is a total of 2919 person-hours saved (a 17% saving) over a 12-hour period from Junction 4b to Junction 2. Of the person-hours saved, 2046 are attributed between Junction 3 and Junction 2 with the suspension of the M4 Bus Lane, as shown in Table 6.3 and Table 6.4 respectively.

**Table 6.3: Average Weekend Day Person-Hours Saving – Junction 4b to Junction 2**

| Time | Car | London Taxi | LGV | HGV | Bus | TOTAL |
|---|---|---|---|---|---|---|
| Morning Peak | 138 | 6 | 11 | 3 | 38 | 196 |
| Inter Peak | 1680 | 50 | 85 | 4 | 305 | 2124 |
| Evening Peak | 601 | -20 | 21 | 0 | -3 | 5999 |
| TOTAL | 2419 | 36 | 117 | 7 | 340 | 2919 |

**Table 6.4: Average Weekend Day Person-Hours Saving – Junction 3 to Junction 2**

| Time | Car | London Taxi | LGV | HGV | Bus | TOTAL |
|---|---|---|---|---|---|---|
| Morning Peak | 131 | 6 | 10 | 2 | 35 | 184 |
| Inter Peak | 1303 | 21 | 65 | 3 | 148 | 1540 |
| Evening Peak | 372 | -53 | 13 | 0 | -10 | 322 |
| TOTAL | 1806 | -26 | 88 | 5 | 173 | 2046 |

**Summary**

Overall between Junction 4b to Junction 2, there are weekday person-hours savings with the suspension of the M4 Bus Lane of 846 hours, with savings in all time periods for cars, LGVs and HGVs. However there are additional delays to London taxi and bus users. From Junction 3 to Junction 2 (including the 2 lane section), there is a person-hours delay of 336 hours (a 9% increase) in the Morning Peak Period, but this

is outweighed by the savings accumulated during the Inter Peak and Evening Peak Periods, resulting in 136 person-hour savings (a 1% saving) for an average weekday. During the average weekend day, overall there are person-hour savings for all vehicles, with the suspension of the M4 Bus Lane.

## 6.2 Journey Time Savings per Person

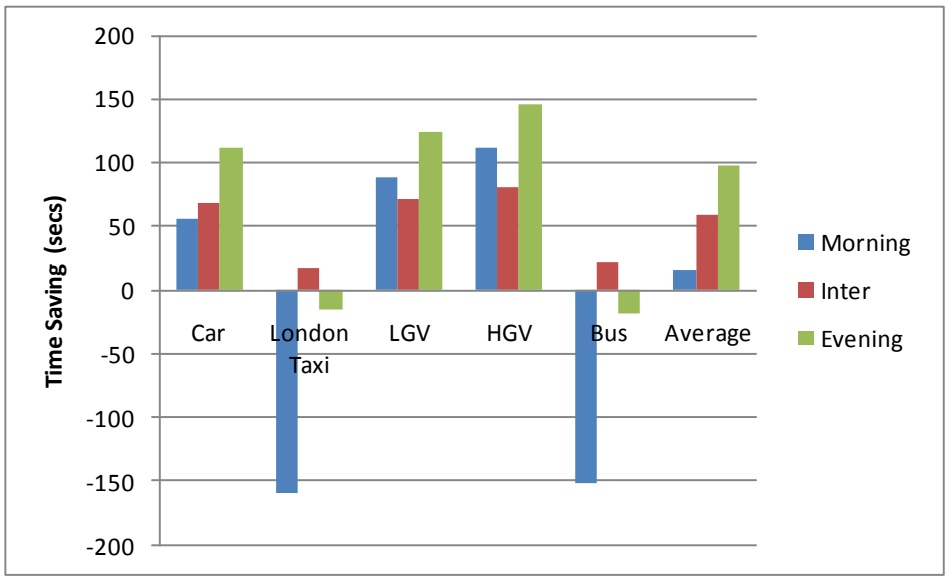
Using the person-hour savings calculation described in Section 6.1, the journey time saving per person in seconds can be produced using the following formula:

$$\frac{\textit{Person hour savings} * 3600}{\textit{Number of vehicles (per vehicle type)} * \textit{Occupancy (per vehicle type)}}$$

Table 6.5 presents the results for the average weekday, showing that there are shorter average journey times for people in cars, LGVs and HGVs but a longer journey times for taxis and buses, particularly in the morning period. Overall the average journey time saving per person for an average weekday is between 16 and 98 seconds (1 minute 38 seconds) ( a 1% and a 9% journey time saving respectively) depending on the time period.

**Table 6.5: Average Weekday Time Saving (secs) per Vehicle – Junction 4b to Junction 2**

| Time | Car | London Taxi | LGV | HGV | Bus | Average |
|---|---|---|---|---|---|---|
| Morning Peak | 56 | -159 | 89 | 111 | -152 | 16 |
| Inter Peak | 69 | 18 | 72 | 80 | 23 | 59 |
| Evening Peak | 112 | -16 | 125 | 145 | -18 | 98 |

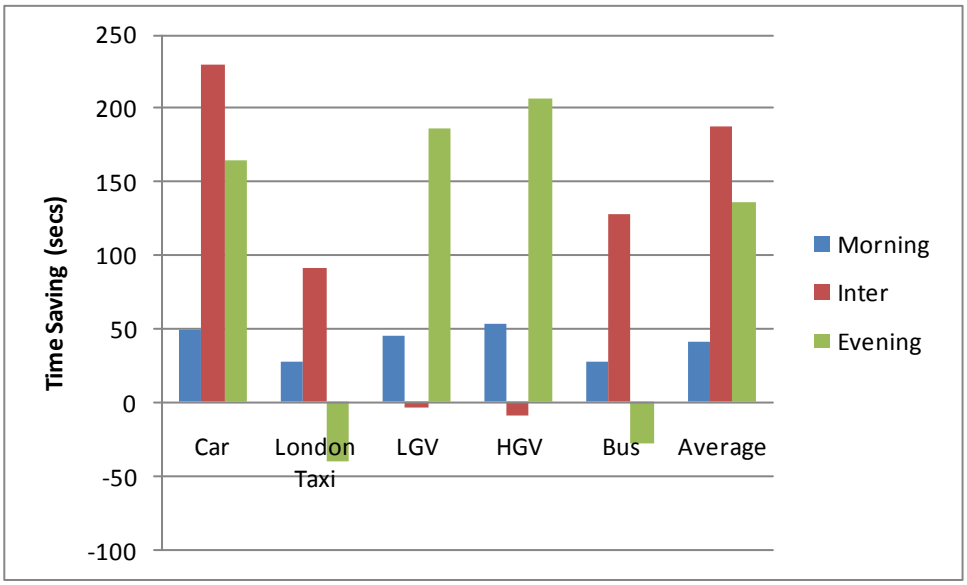



The same information is presented in Table 6.6 for the average weekend day between Junction 4b and Junction 2. This shows that there is generally an improvement in journey time with the suspension of the M4 Bus Lane, except for a

slight disbenefit for taxi and bus passengers in the Evening Peak Period. Overall, the average journey time saving per person for an average weekend day is between 42 seconds (a 7% saving) and 188 seconds (3 minutes 8 seconds), which is a 22% journey time saving, depending on the time period.

**Table 6.6: Average Weekend Day Time Saving (secs) per vehicle – Junction 4b to Junction 2**

| Time | Car | London Taxi | LGV | HGV | Bus | Average |
|---|---|---|---|---|---|---|
| Morning Peak | 49 | 27 | 45 | 53 | 28 | 42 |
| Inter Peak | 229 | 91 | -3 | -9 | 127 | 188 |
| Evening Peak | 164 | -40 | 186 | 207 | -27 | 137 |




As previously noted, a significant proportion of car users appear to have been illegally using the M4 Bus Lane in November 2010. Had these drivers complied with the legal restriction and used the slower lanes one and two, the comparison between 2010 and 2011 would not have been distorted by this factor. The analysis has these drivers inappropriately considered to be disadvantaged by the M4 Bus Lane suspension. If these users are excluded from the analysis and all cars assumed not to illegally use the M4 Bus Lane the total weekday person hour savings increase by some 24% and the weekend benefits increase by 8%. Similarly, average journey time improvements would be greater with, for example, Morning Peak weekday average time savings would increase by 150%.

The impact and costs of enforcement action have not been considered within the analysis in this report.

# 7 Characteristics of Traffic Behaviour

## 7.1 Headway Distribution

In order to assess the behaviour of the traffic before and after suspension of the M4 Bus Lane, an assessment of the headway has been carried out on the 2010 and 2011 data on the selected MIDAS loops.

The headway has been calculated as the average time, on a minute by minute basis, between vehicles passing over the loop measured in 0.1s. To aggregate this to an hourly value, the average of each minute was taken. As an outcome, the lower the value, in 0.1s, the closer together the vehicles are being driven.

## 7.2 Comparison of Driver Behaviour

Starting at the MIDAS loop prior to Junction 3, a comparison of the headway has been carried out for both average weekday and average weekend day traffic levels.

Figure 24 presents the headway in 0.1s, for MIDAS loop 2240, prior to the M4 Junction 3 and the start of the M4 Bus Lane, for an average weekday. It shows that:

- There is little change in headway between the before and after scenarios suggesting little change in driver behaviour at this location.
- The maximum average recorded headway is 12 seconds during the off peak period between 01:00 and 04:00 in Lane 1.
- Between 06:00 and 17:00 the average headway for Lanes 1 and 2 is consistently between 2 and 3 seconds. Lane 3 has a similar headway during the peak periods. In the inter peak period for Lane 3 this increases to between 3 and 4 seconds.

Figure 25 presents the headway in 0.1s for MIDAS loop 2240 for the weekend day. This shows that:

- There is little change in headway between the before and after scenarios suggesting little change in driver behaviour at this location.
- The headway profile differs slightly to the weekday with a headway of between 2 and 3 seconds between 09:00 and 20:00.

At MIDAS loop 2210, prior to Heston Services, where the M4 Bus Lane commences, there is no change in headway for Lanes 1 and 2 but there is a change for Lane 3 between before and after as shown in Figure 26.

- The headway for Lane 3 changes from an average of over 10 seconds during the Inter peak to between 7 and 9 seconds, resulting from an increase in traffic flow in this lane following the suspension of the M4 Bus Lane (see Table 2.4).
- In the peak periods the headway changes from 10 seconds to just under 5 seconds, resulting from an increase in traffic flow.

A similar picture occurs for the subsequent loops along the M4 between Junction 3 and 2 for both weekday and weekend days until the approaches to the reduction from three to two lanes.

Figure 27 shows the headway in 0.1s for MIDAS loop 2168, approximately ½ mile from the lane reduction and the speed limit change from 60mph to 40mph. This shows that:

- Between 07:00hrs and 19:00hrs with the M4 Bus Lane in place, the headway in Lane 3 is between 7 and 12 seconds; whereas, after M4 Bus Lane suspension, the headway is between 3 and 7 seconds.
- Lanes 1 and 2 are still reporting similar average headways between the 'before' and 'after' scenarios.

East of the three to two-lane merge, the headways recorded are identical on the two-lane elevated section when comparing the 2010 and 2011 figures.

## 7.3 Summary

The analysis suggests that little has changed with regards to driver behaviour with the suspension of the M4 Bus Lane between Junction 3 and Junction 2. The average headways on Lanes 1 and 2 are similar or improved for both weekdays and weekend days. The headway on Lane 3 has changed as expected with the lane open for all traffic but the headway is consistently higher than in Lanes 1 and 2, especially during the Inter Peak Period. This is linked to the changes in traffic flow by lane.

# 8 Traffic Conditions of the Local Road Network

One of the possible effects of the suspension of the M4 Bus Lane might be changes in traffic flow on the local road network. A comparison of traffic flow on the A4 Great West Road, which runs parallel to the M4 between Junction 3 and Junction 2, has been carried out to see if there was any impact on the local road network. As data for October and November for 2011 is not available, a comparison has been made to February and March 2011 data. The corresponding traffic data, taken from the MCC counts, on the M4 over this period shows a 2.6% (800 vehicles) increase in average weekday traffic flows and a 3.4% (1100 vehicle) decrease in average daily weekend traffic flows. Given these similar traffic levels (indeed slightly higher) one might expect that if suspension of the M4 Bus Lane caused additional delays or other problems that this would impact on the parallel A4.

## 8.1 A4 Flows

Figure 28 presents the comparison between average weekday traffic flows on the A4 eastbound for October and November 2010 and February and March 2011. The Figure shows that:

- The maximum flow is over 2000 vehicles occurring at 08:00hrs.
- There is very little difference in the flow profiles between the flows for 2010; with the M4 Bus Lane in operation; and for 2011; with the M4 Bus Lane suspended.

Figure 29 shows the same information but for the average daily weekend traffic flows. This shows that:

- There were higher average daily weekend flows in October and November 2010. At 13:00hrs this was approximately an additional 200 vehicles compared with 2011.
- The flow profiles and peak hours are identical between 2010 and 2011.

These results suggest that in the weekday there is little change in the traffic flow with the suspension of the M4 Bus Lane; and on weekends there is a reduction in traffic flow on the A4 in 2011 when the M4 Bus Lane has been suspended but, overall, there is no evidence that the suspension of the M4 Bus Lane has affected the traffic on the A4.

## 8.2 A4 Journey Times

For both the November 2010 and 2011 journey time surveys, surveys were carried out from the M4 Junction 4 to the M4 Junction 2; starting on the M4 at Junction 4 but leaving at Junction 3 and using the A312 and A4 in the eastbound direction. These were carried out on three individual weekday morning peaks. These surveys provided an indication of the journey times along the A4 in comparison to those on the eastbound M4.

Using the average of the AM journey times a comparison between the 'before' and 'after' comparison can be made as shown in Figure 8.1.

**Figure 8.1: Average Journey Times.**

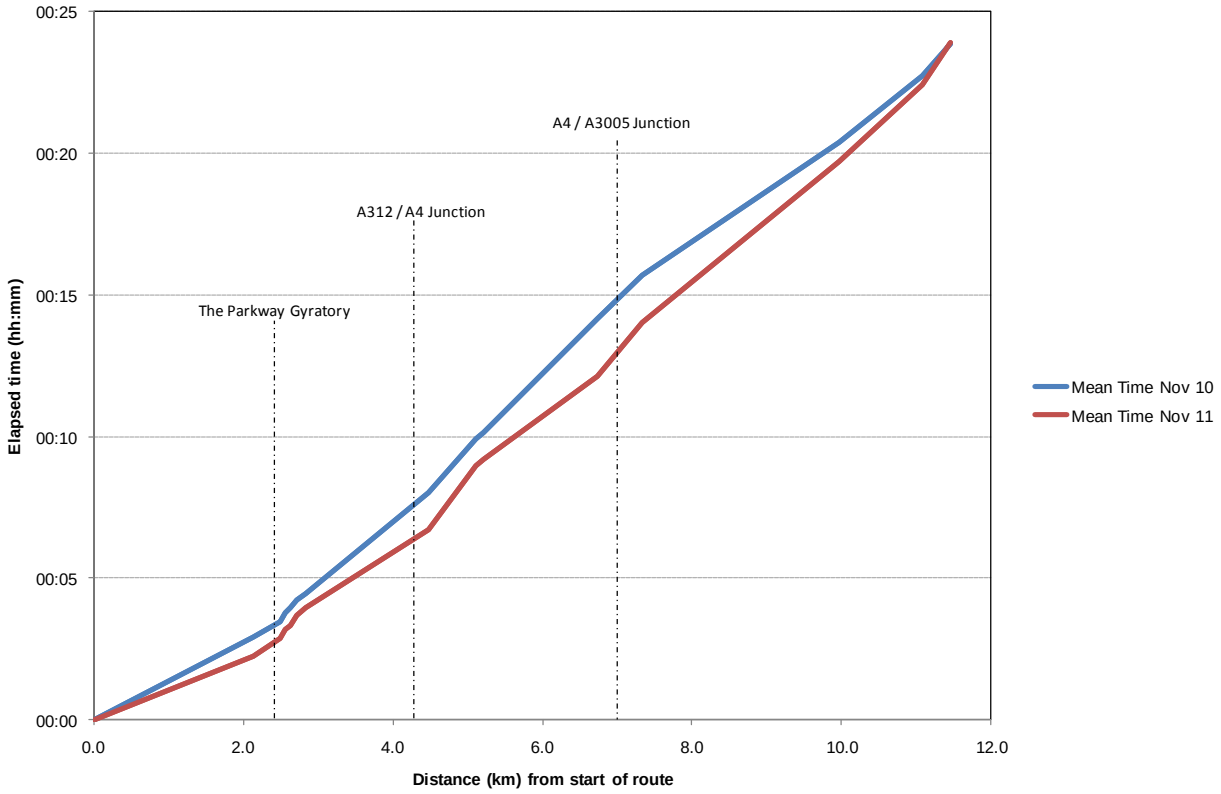



Figure 8.1 suggests that via the A4 the average journey time from the M4 Junction 3 to the M4 Junction 2 would be approximately 20 minutes. In the morning period the journey time on the M4 between Junction 3 and Junction 2 (taken from Table 3.2) is just over 13 minutes. Based on these average figures using the A4 as an alternative to the M4 between Junction 3 and Junction 2 would take approximately 7 minutes longer.

The figure also shows overall that the journey times are similar between the 'before' and 'after' situation, which implies that there is no evidence that the suspension of the M4 Bus Lane has had any impact on the A4.

# 9 Environmental Impacts

## 9.1 Air Quality

An assessment of the air quality impacts of the suspension of the M4 Bus Lane has been carried out by reviewing nitrogen dioxide ($NO_2$) concentrations at nearby sensitive receptors. These are reported on in the Air Quality Study, (Report Number 0001-UA003263-NHR-04-M4). A summary of the methodology and results are shown within this section.

The study area, which covered Norwood Green, North Hyde and Heston, was selected as it includes the residential properties which border the M4 where the M4 Bus Lane was.

The assessment was undertaken using the atmospheric dispersion modelling package ADMS-Roads, developed by Cambridge Environmental Research Consultants Ltd (CERC), to predict $NO_2$ concentrations at sensitive receptor locations for the before and after suspension of the M4 Bus Lane situation based on the physical monitoring undertaken..

The London Borough of Hounslow (LBH) has declared an AQMA for $NO_2$ for the whole borough, which includes the site of the M4 Bus Lane. LBH currently operates an extensive network of continuous and diffusion tube monitoring sites. However, there are few monitoring sites in close proximity to the M4 within the study area, therefore additional $NO_2$ diffusion tube monitoring was undertaken at locations close to the M4 to enable model verification.

The same traffic data for 2010 (with the M4 Bus Lane) and 2011 (without the M4 Bus Lane) has been obtained from actual traffic counts available from the Motorway Incident Detection and Automatic Signalling (MIDAS) loop detectors, as reported in previous chapters, and contains traffic flows for each lane of the M4 carriageway. Traffic data has been provided for the section of the M4 within the study area only, and did not include local roads. This is considered sufficient to assess the impacts of the M4 Bus Lane as the lane's suspension has not impacted on traffic flows on the local road network.

The change in $NO_2$ concentrations as a result of the M4 Bus Lane are presented in Table 9.1.

**Table 9.1: Changes in $NO_2$ Concentrations at Receptor Locations as a Result of the M4 Bus Lane**

| Receptor | Location | Annual Mean $NO_2$ ($\mu g/m^3$) | | |
|---|---|---|---|---|
| | | With M4 Bus Lane | Without M4 Bus Lane | Difference |
| R1 | Residential property off Osterley Lane | 37.4 | 37.9 | 0.5 |
| R2 | Residential property on Oxford Avenue | 50.0 | 51.3 | 1.3 |
| R3 | Residential property on Winchester Avenue | 48.4 | 49.0 | 0.6 |

| Receptor | Location | Annual Mean $NO_2$ ($\mu g/m^3$) | | |
|---|---|---|---|---|
| | | With M4 Bus Lane | Without M4 Bus Lane | Difference |
| R4 | Residential property on The Alders | 46.0 | 47.1 | 1.1 |
| R5 | Residential property on Grange Close | 57.1 | 58.8 | 1.7 |
| R6 | Residential property on Heston Grange | 49.3 | 49.9 | 0.6 |

As can be seen in Table 9.1 $NO_2$ concentrations at receptors in close proximity to the M4 are predicted to be higher with the suspension of the M4 Bus Lane. It is considered that this is as a result of several factors.

- The M4 Bus Lane displaced a proportion of the total Heavy Duty Vehicles (HDV i.e. buses and coaches) away from the inside lane, to the outside lane (i.e. the M4 Bus Lane), however, without the M4 Bus Lane, all HDVs are restricted to the two innermost lanes, which are closer to sensitive receptors adjacent to the M4.
- The traffic data indicates that the average speeds on the section of the M4 adjacent to the receptors are higher in 2011 without the M4 Bus Lane in operation. This would also have contributed to an increase in $NO_2$ concentrations at receptor locations in close proximity to the M4.
- There has been an increase in traffic using this section of the M4 between 2010 and 2011, which contributes to increased $NO_2$ concentrations.

## 9.2 Noise

Using available traffic data, a basic noise level has been predicted for two scenarios (i.e. with and without the M4 Bus Lane) following the calculation methods in the '*Calculation of Road Traffic Noise'* (CRTN). The Calculation of Road Traffic Noise (CRTN) is the standard UK procedure for defining measurement and calculation methods for assessing road traffic noise. The change in noise level has been used to establish the need for a more detailed noise assessment in accordance with Design Manual for Roads and Bridges (DMRB) as reported on in the Noise Impact Study (Report Number 0002-UA003263-NHR-01-M4).

Traffic data has been provided for the section of the M4 within the study corridor. This is considered sufficient to assess the impacts of the M4 Bus Lane as the lane's suspension has not impacted on traffic flows on the local road network.

A basic noise level has been calculated for each hour ($LA_{10,\ 1\ hour}$) for the With M4 Bus Lane Scenario (2010) and Without M4 Bus Lane Scenario (2011) using the calculation methodology set out in CRTN. A correction has been applied for percentage HDVs and traffic speeds. The $L_{A10,\ 18\ hour}$ has also been calculated for both scenarios by obtaining the arithmetic average of the LA10, 1 hour levels.

Noise levels between Junction 3 and Junction 2 of the M4 are predicted to be higher as a result of the M4 Bus Lane's suspension. The increase in noise level has been assessed in terms of the DMRB classification for magnitude of impacts when

assessing traffic noise in the short term. In terms of the DMRB classification, the change in noise levels ($L_{A10,\ 18\ hour}$) for the daytime would be considered to be 'Minor Adverse' and for night-time ($L_{night}$) would also be 'Minor Adverse'.

The increase in noise levels can be attributed to the increase in average speed and the increase in HDVs travelling in Lanes 1 and 2 after the suspension of the M4 Bus Lane and traffic growth.

# 10 Safety

This section summarises the Highway Safety Business Case of the M4 Bus Lane with the suspension of the M4 Bus Lane as documented in M25DBFO_RT1348JVDO.

From the 36 months of validated accident data provided before the suspension of the M4 Bus Lane there were 41 reported Personal Injury Accidents (PIAs) on the eastbound carriageway. Six of these resulted in serious injury. The plots of the accidents can be found in Appendix B.

Between 26th November 2010 and 31st July 2011 data, our operational records indicates that there have been three reported PIAs on the eastbound carriageway; all of which resulted in a slight injury.

The three post M4 Bus Lane suspension PIA accidents occurred between Junction 3 on-slip and the motorway services off-slip, all were shunt incidents, although no pattern can be identified between them.

# 11 Summary of Findings

The performance of the eastbound M4 between October and November 2010, in the 6-week period before the M4 Bus Lane was suspended, has been compared against the corresponding 6 week period in October and November 2011, exactly 12 months later, using consistent sets of traffic data that were collected in both periods. In addition an assessment has been undertaken of air quality, road traffic, noise and accident data to compare the 'before' and 'after' scenarios. The key results from these assessments are presented below.

## *11.1 Traffic Flow levels*

a) Between Junction 4 and Junction 3 between 2010 and 2011

- 3% increase in traffic flows during an average weekday.
- 5% increase in traffic flows during an average weekend day.

b) On the M4 eastbound offslip at Junction 3,

- Over 29,000 vehicles leaving on an average weekday. (40% of the total flow)
- A 2% increase in the number of vehicles leaving in 2011 compared to 2010.
- Over 25,000 vehicles leaving at junction 3 on an average weekend day (38% of the total flow),
- A 2.5% increase from before suspension of the M4 Bus Lane.

c) Joining the M4 eastbound at Junction 3

- Consistent flow between 2010 and 2011 (6,500 vehicles during an average weekday).
- A 3.5% increase in traffic joining the M4 after suspension during an average weekend day, mainly during the morning peak period.

d) Between Junction 3 and Junction 2

- A reduction in traffic flows in the average weekday between 08:00 and 11:00 in 2011 following the suspension of M4 Bus Lane
- An increase in traffic flows between 17:00 and 19:00.
- At the times of maximum flow (06.00-08.00 and 16.00-17.00) flows have increased by some 5%.
- Over the course of an average weekday in 2011, there is an increase of 621 vehicles (+1.3%) compared with 2010.
- The highest hourly flow is between 17:00 and 18:00 for both years.
- Over the course of an average weekend day, between Junction 3 and Junction 2, here is an increase of 1882 vehicles (+4.1%), in 2011.

## *11.2 Vehicle Proportions*

- An increase in the numbers of cars, LGVs and HGVs in 2011 during an average weekday.
- A reduction of the number of buses and taxis during an average weekday.
- Little change on an average weekend day.
- Overall, there is an increase in vehicles in 2011, following the suspension of the M4 Bus Lane, both on a weekday and at the weekend.

### *11.3 Vehicle Occupancy*

- There has been little change in the occupancy of vehicles (cars, taxis, buses) compared to when the M4 Bus Lane was in operation.

### *11.4 Lane Utilisation*

- In 2010 percentage utilisation by lane is the same for the average weekday and weekend day, even though traffic levels are different. Lane 3 utilisation was 10% of the traffic flow with the M4 Bus Lane.
- Following the suspension of the M4 Bus Lane, there is as expected an increase in the utilisation in lane 3 and fewer vehicles travelling in Lanes 1 and 2. Lane 3 utilisation was 25% of the traffic flow after suspension of the M4 Bus Lane.

### *11.5 Journey Times*

a) Between Junction 4b and 2

- Overall there has been a decrease in the average journey time following suspension of the M4 Bus Lane throughout the day. In the morning peak period, there is a decrease in average journey time of 44 seconds (over a total journey time of 19 minutes); in the inter peak period, a decrease in the average journey time of just over a minute; in the evening peak period, a decrease in the average journey time of 1 minute 49 seconds; and, finally, in the off peak period, a decrease in the average journey time of 1 minute 38 seconds.
- As expected, there is an increase in the average journey time in Lane 3 following the suspension of the M4 Bus Lane. This is greatest in the morning peak period.
- Flow-weighted journey times between junctions 4b and 2 on a weekday are reduced by an average of 1 minute 18 seconds and on an average weekend day of 2 minutes 11 seconds.

b) Between Junction 3 and 2

- Flow weighted journey times are reduced by one minute in all weekday time periods other than the morning peak, which has an increase of 18 seconds.
- Overall, journey times on a weekday are reduced by an average of 38 seconds.
- During the average weekend day, there is a decrease in average journey times following the suspension of the M4 Bus Lane for all time periods, except for Lane 3.
- Flow-weighted journey times for an average weekend day are reduced by 1 minute 43 seconds.

### *11.6 Journey Time Reliability*

- In Lanes 1 and 2 the variability of the journey time is substantially less (i.e. more reliable) in 2011 than it was in 2010 before the M4 Bus Lane was suspended. This suggests that journey times in Lanes 1 and 2 are more reliable.
- In Lane 3 the journey time is less reliable than it was before the M4 Bus Lane was suspended. Nevertheless, the journey time reliability for Lane 3 is now similar to the 2011 journey time reliability for Lanes 1 and 2.
- Overall Journey Time reliability has improved following suspension of the M4 Bus Lane.

*11.7 Traffic Speeds*

- In 2011 there is an improvement in the average speed through Junction 3 and beyond Heston Services compared with 2010.
- Closer to the 3 to 2 lane merge prior to the M4 elevated section the average speeds during periods of congestion are lower than in 2010.

*11.8 Shockwaves and Queuing*

- Following suspension of the M4 Bus Lane, the shockwaves (intermittent stop start driving and intermittent queuing) have been absorbed into the general queuing at the bottleneck at the start of the elevated section, where the three lanes reduce to two
- From a car driver's perspective, on a typical morning, 6km of intermittent stop-start driving in 2010 has been replaced by up to 3km of more defined queuing in 2011. The effect of this change is also borne out in the changes in journey times.
- With the M4 Bus Lane suspended, there is additional space for queuing traffic between Junction 3 and the start of the elevated section, so the congestion no longer affects Junction 3.

*11.9 Person-hours Delay (phd)*

a) Junction 4b to 2

- After weighting by number of people using different vehicle types the person-hours delay has reduced overall by 846 hours for the average weekday following suspension of the M4 Bus lane.
- The person-hours delays to London taxi and bus users have increased by 155 hours for the average weekday (almost entirely in the morning peak periods) following suspension of the M4 Bus Lane.
- The person-hours delays to all other road users has reduced by 1001 hours with savings in all time periods for cars, LGVs and HGVs following suspension of the M4 Bus Lane.
- The calculated average journey time saving per person for an average weekday is between 16 and 98 seconds (1 minute 38 seconds) depending on the time period after suspension of the M4 Bus Lane.
- For the average weekend day the average journey time saving per person is between 42 and 188 seconds (3 minutes 8 seconds) depending on the time period after suspension of the M4 Bus Lane.

b) Junction 3 to 2 (including the 2 lane section),

- Following suspension of the M4 Bus Lane there is an increase in the person-hours delay of 336 hours in the morning peak period but this is outweighed by the savings accumulated during the inter peak and evening peak periods, resulting in a daily saving of 136 person-hours during an average weekday
- During the average weekend day there are person-hour savings for all time periods after the suspension of the M4 Bus Lane for all vehicle types.

*11.10 Traffic Behaviour*

- The analysis suggests that little has changed with regards to driver behaviour with the suspension of the M4 Bus Lane between Junction 3 and Junction 2.
- The average headways on Lanes 1 and 2 are similar for both weekdays and weekends both before and after.

- The headway on Lane 3 has changed as expected with the lane open for all traffic but the headway is consistently longer than in Lanes 1 and 2, especially during the inter-peak period.

*11.11 Traffic on A4*

- There has been little change in the traffic flow on the A4 Great West Road following the suspension of the bus lane. Journey times on the A4 are similar before and after.
- There is no evidence that the suspension of the bus lane is affecting traffic on the A4.
- Both with and without the bus lane in operation, journey times via the M4 are substantially lower than via the A4 and unlikely to result in diversion to the A4.

*11.12 Air Quality Impact*

Nitrogen dioxide (NO2) concentrations at receptors in close proximity to the M4 are modelled to be higher with the suspension of the M4 Bus Lane. It is considered that this is as a result of several factors.

a) The M4 Bus Lane displaced a proportion of the HDVs (i.e. buses and coaches) away from the inside lane, to the outside lane (i.e. the M4 Bus Lane). Without the M4 Bus Lane, HDVs are restricted to the two innermost lanes, closer to sensitive receptors adjacent to the M4.
b) The average speeds on the section of the M4 adjacent to the receptors are higher in 2011 after suspension of the M4 Bus Lane.
c) Traffic levels in 2011 are higher than in 2010, which contributes to increased NO2 concentrations.

*11.13 Noise Assessment*

Noise levels between Junction 3 and Junction 2 of the M4 are predicted to be higher as a result of the M4 Bus Lane suspension. The change in noise levels ($LA_{10,\ 18\ hour}$) for the daytime would be considered to be 'minor adverse' and for night-time ($L_{night}$) would also be 'minor adverse'.

*11.14 Safety*

Prior to the suspension of the M4 Bus Lane there were 41 personal injury accidents over a three year period, with six of these resulting in serious injury. Over the one year period since the suspension of the M4 Bus Lane there have been three personal injury accidents between Junction 3 and Junction 2, all slight in nature.

# 12 Conclusion

Flows have increased on the eastbound M4 in the last year, but despite this, journey times are now quicker overall following the suspension of the M4 Bus Lane. Journey times for buses and taxis have increased, but this has been outweighed by gains for other road users. In addition, journey times for all vehicles are slightly higher between Junctions 3 and 2 during the busiest period (the morning peak), but this is again outweighed by benefits in between Junctions 4b and 3 and also between Junctions 3 and 2 over the rest of the day (including the evening peak).

The section upstream of the bus lane (Junction 4b to 3) is now less affected by congestion, as shockwaves no longer tail back beyond Junction 3. The merge area at the start of the M4 elevated section continues to be a source of congestion.

When the M4 Bus Lane and associated changes were introduced in 1999, analysis showed that there was a time saving for both buses and cars during peak periods, and a small time saving overall. In the intervening years, there have been changes to the traffic patterns on the M4. Daily flows into London have decreased by 4000 vehicles, and there are now substantially fewer buses and taxis than there were in 1999. The 1999 changes provided a benefit during periods of congestion, both for cars (by reducing the effect of the bottleneck where three lanes reduce to two at the start of the elevated section and the changes to the exit slip at Junction 3) and for buses and taxis (by allowing them to bypass some of the congestion). Because of the changes to traffic patterns, congestion is now less frequent and less severe than it was in 1999, and the removal of the bus lane has allowed the section to operate as a “typical” motorway, with Lane 3 used for overtaking. This has reduced journey times over most of the day.

In terms of journey times, the analysis shows that there is a small net saving in journey time/person as a result of suspending the M4 Bus Lane for all trips along the M4 between Junction 4b and Junction 2 and also for all trips only between Junction 3 and Junction 2. These journey times are also more reliable. It is recognised that the journey time impact on people travelling by buses and taxis is negative (with more bus passengers being affected than taxi passengers), but these impacts are more than outweighed by the overall benefits to all of those travelling by car, LGV and HGV.

Despite this traffic increase and more buses travelling closer to the nearside verge of the motorway, the impact on air quality and road traffic noise is minimal.

Since the M4 Bus Lane was suspended, there has been a reduction in the number of personal injury accidents between Junction 3 and Junction.

Overall, there has been a journey time benefit from the suspension of the bus lane and generally improved journey time reliability. The new design appears to be at least as safe as the previous layout, and although there has been a small increase in noise and emissions, this is mostly attributable to higher flows and higher speeds.

* Monitoring of the M4 Bus Lane: ‘The First Year’ report – Transport Research Laboratory (PR/T/125/2000 T801

# FIGURES

**Figure 1: Junction 4 - 3 Flow Profile – Average Weekday**

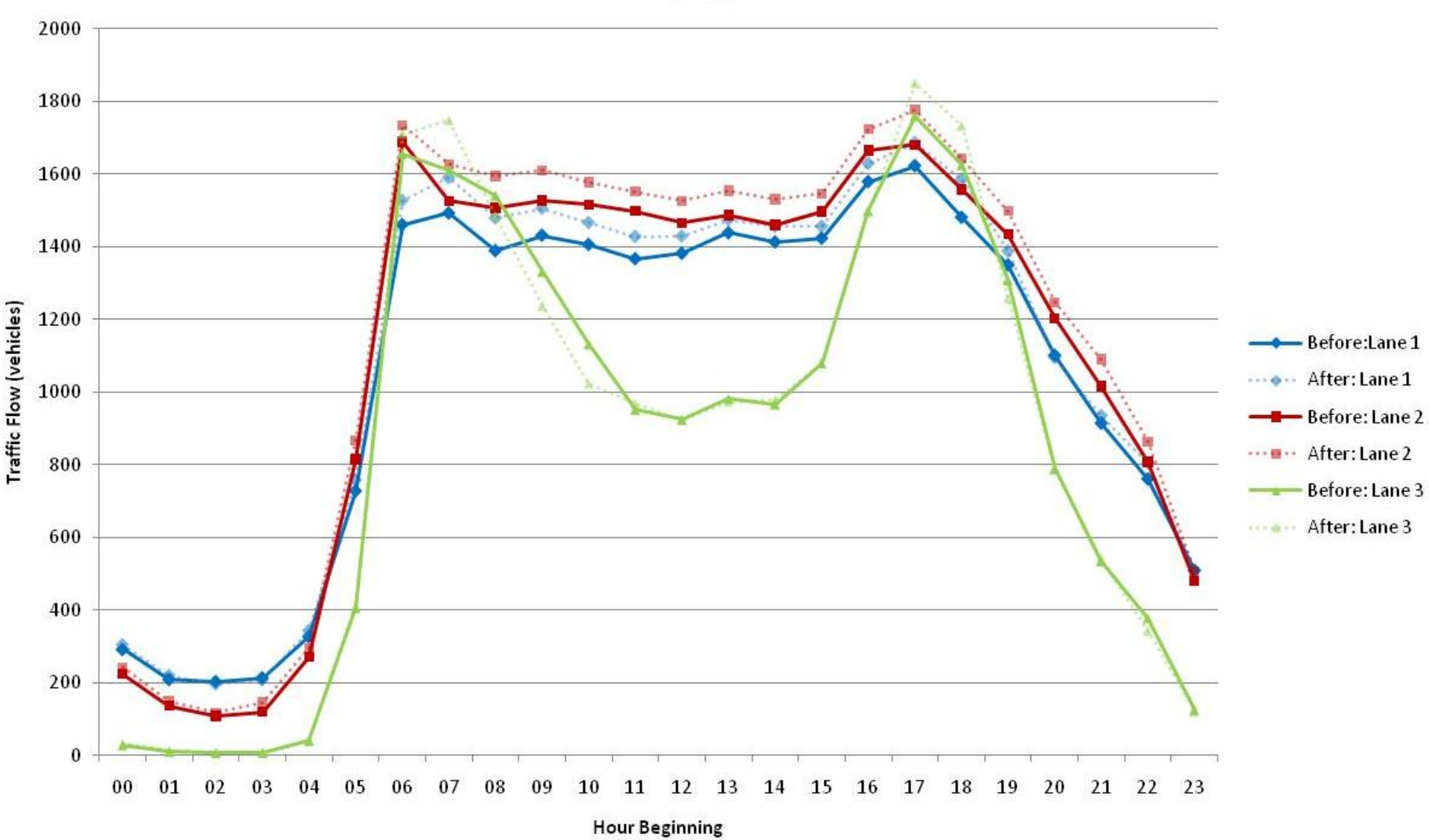


**Figure 2: Junction 4 - 3 Flow Profile – Average Weekend**

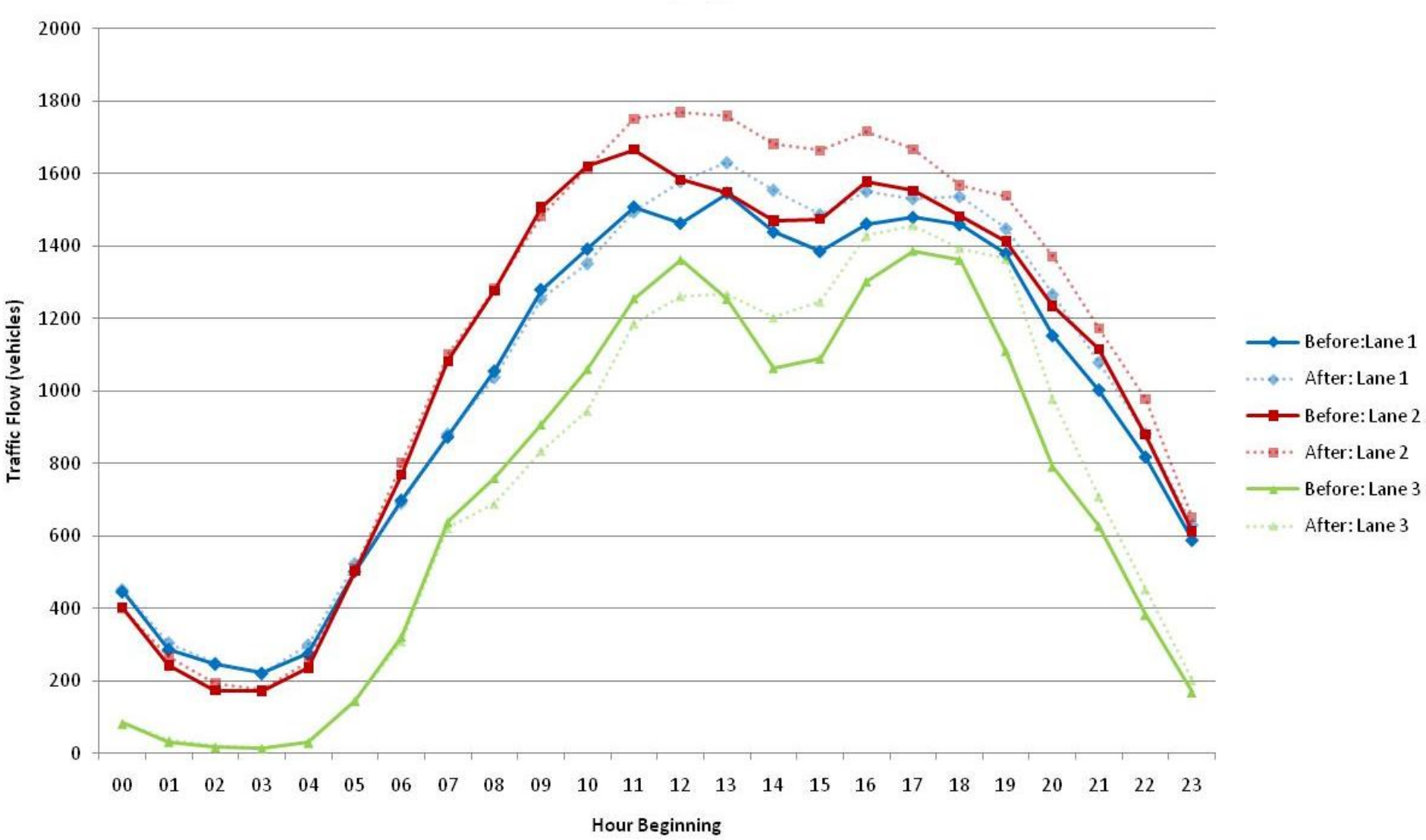


**Figure 3: Junction 3 Off and Onslip Flow Profile – Average Weekday**

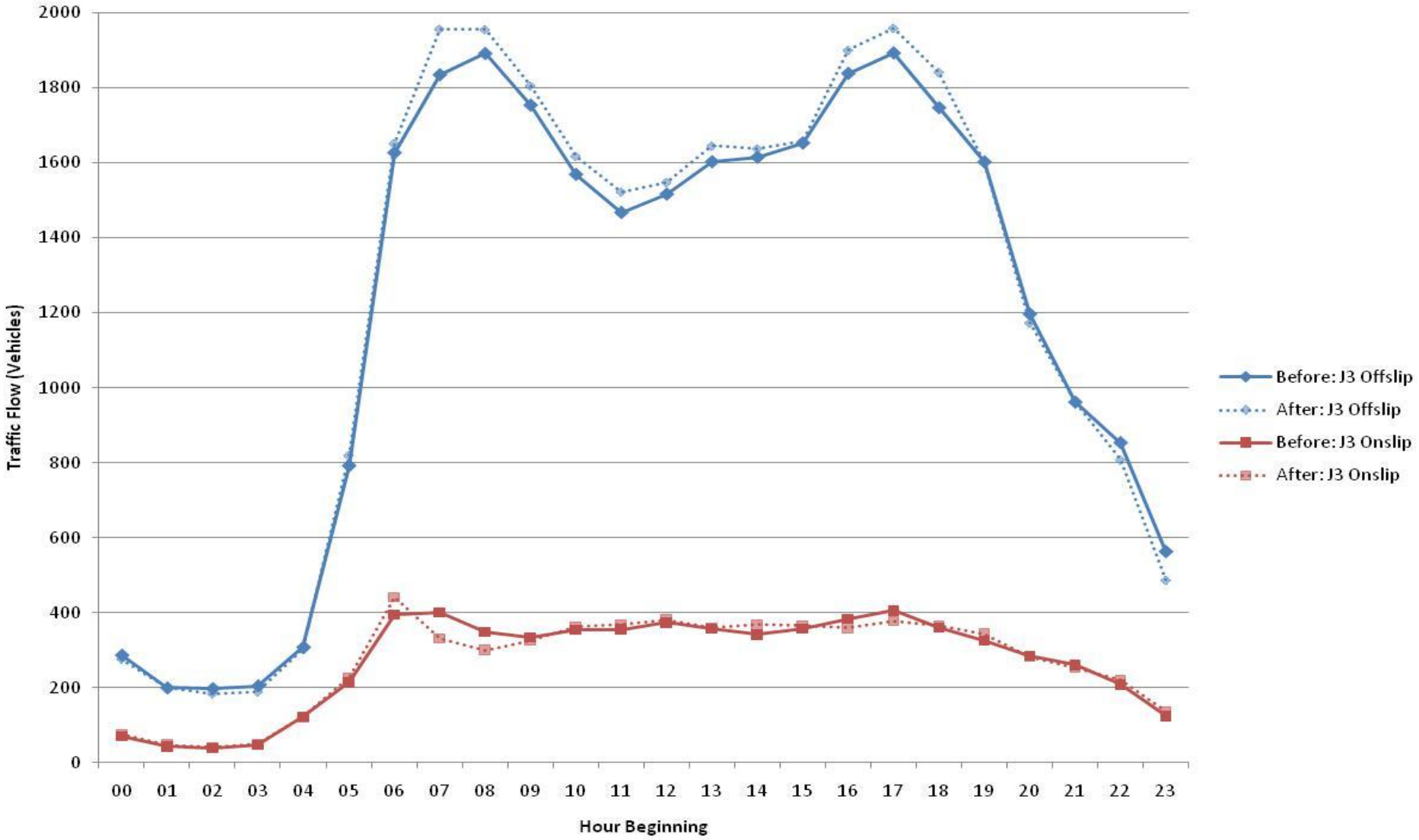


**Figure 4: Junction 3 Off and Onslip Flow Profile – Average Weekend Day**

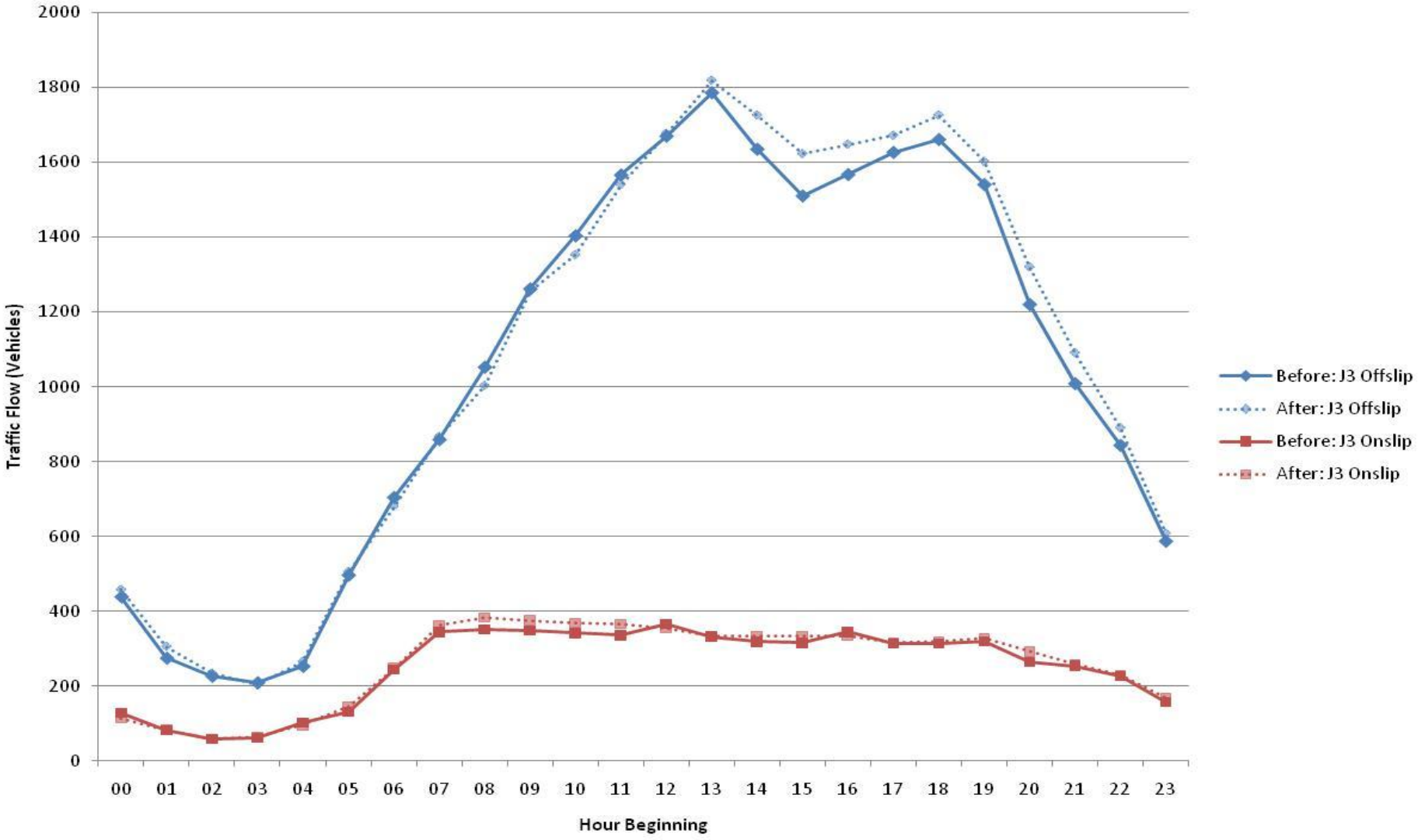


**Figure 5: Junction 3 - 2 Flow Profile – 2010 Average Weekday All Loops**

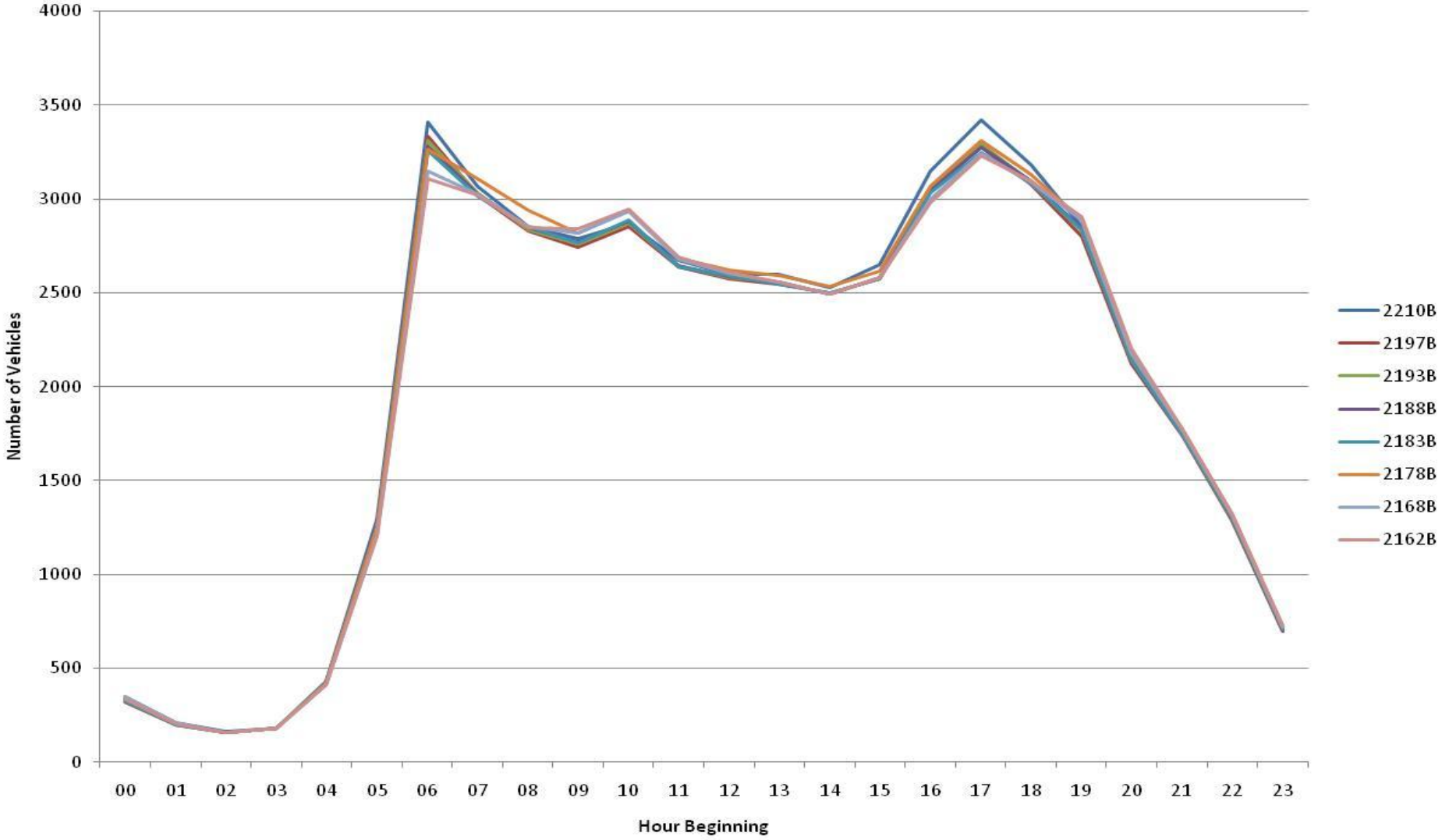


**Figure 6: Junction 3 - 2 Flow Profile – 2011 Average Weekday All Loops**

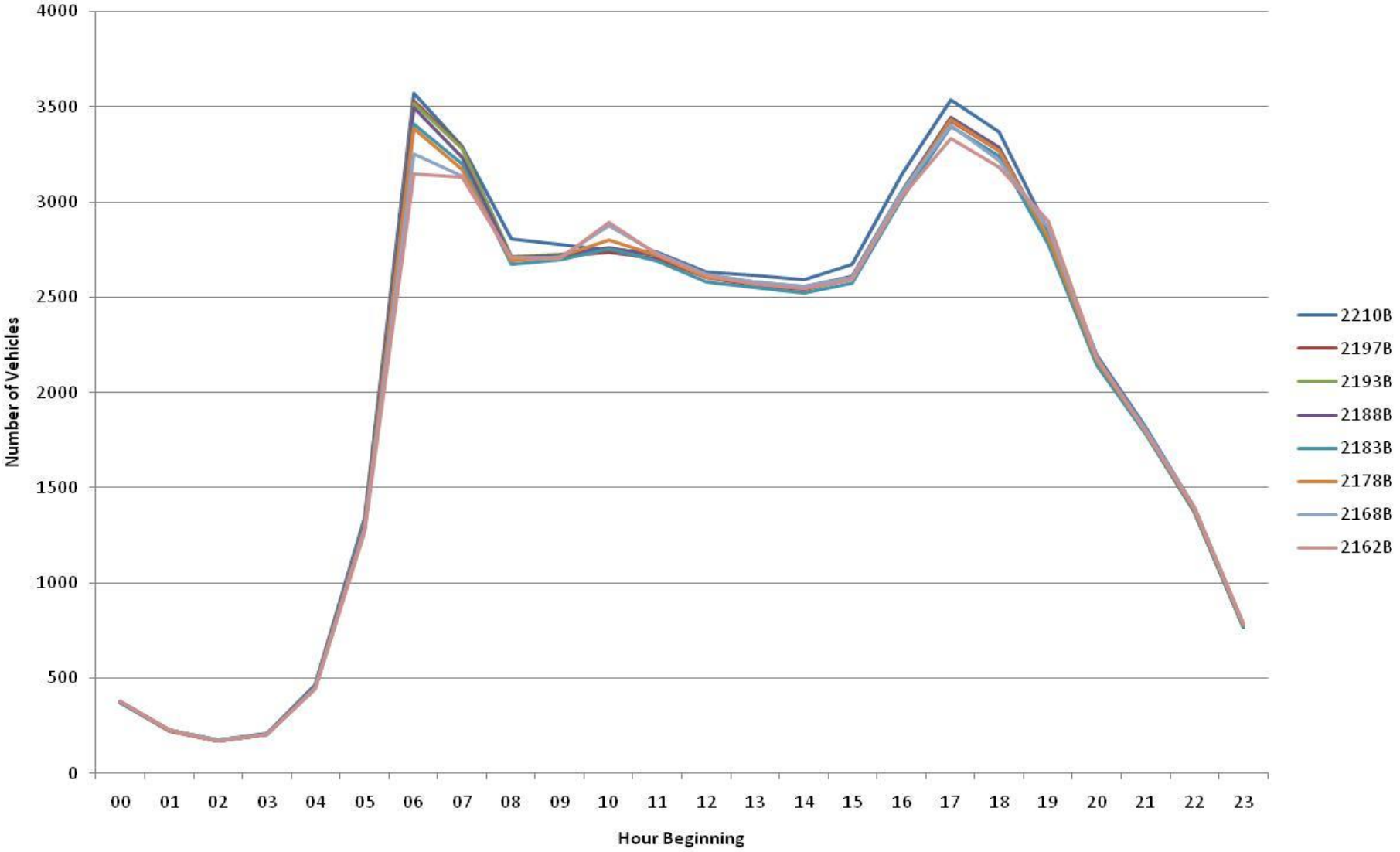


**Figure 7: Junction 3 - 2 Flow Profile – Average Weekday (MIDAS loop 2183)**

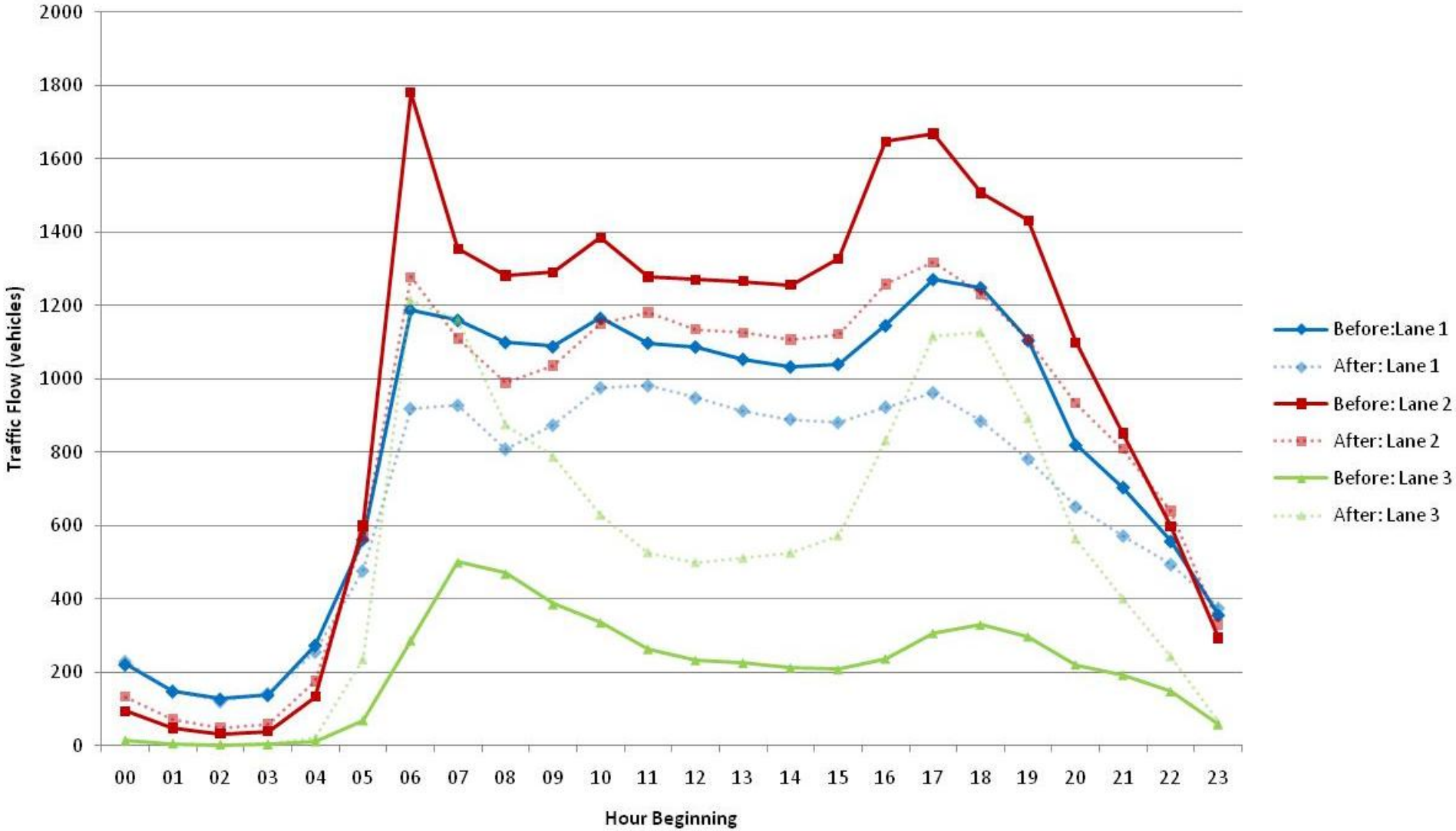


**Figure 8: Junction 3 - 2 Flow Profile – Average Weekend (MIDAS loop 2183)**

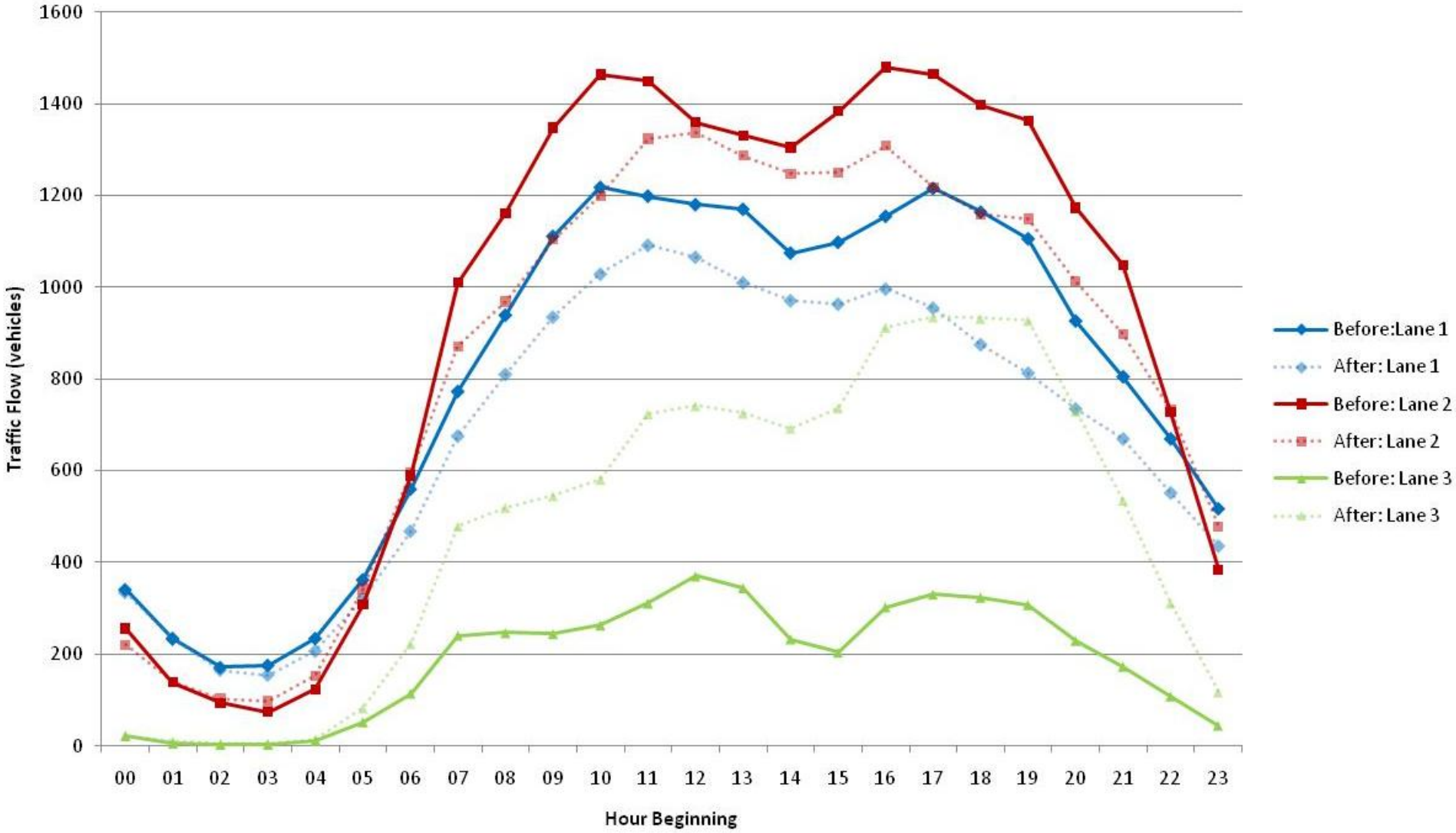


**Figure 9: Junction 3 - 2 Flow Profile – Average Weekday (two lane section)**

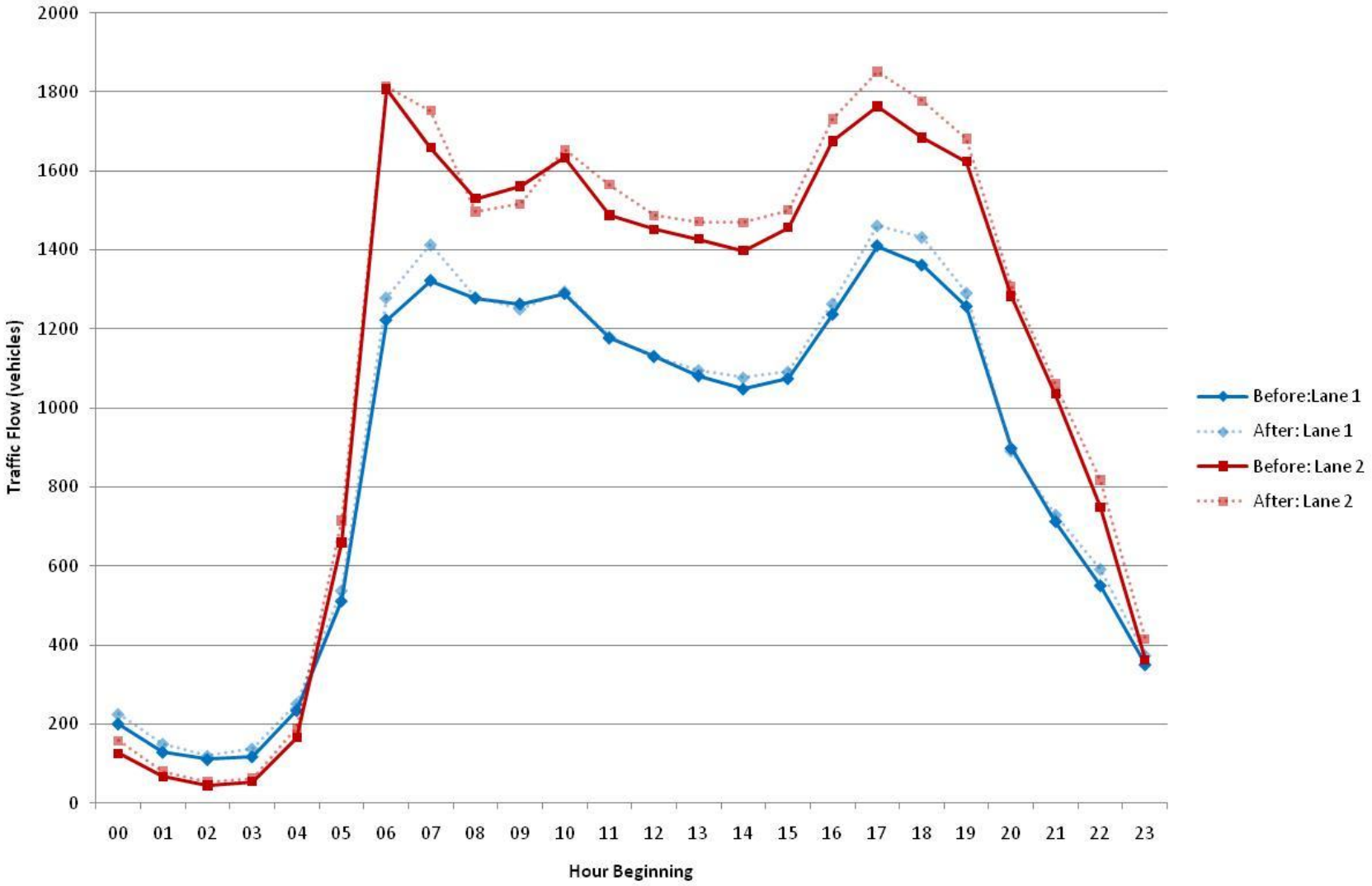


**Figure 10: Junction 3 - 2 Flow Profile – Average Weekend (two lane section)**

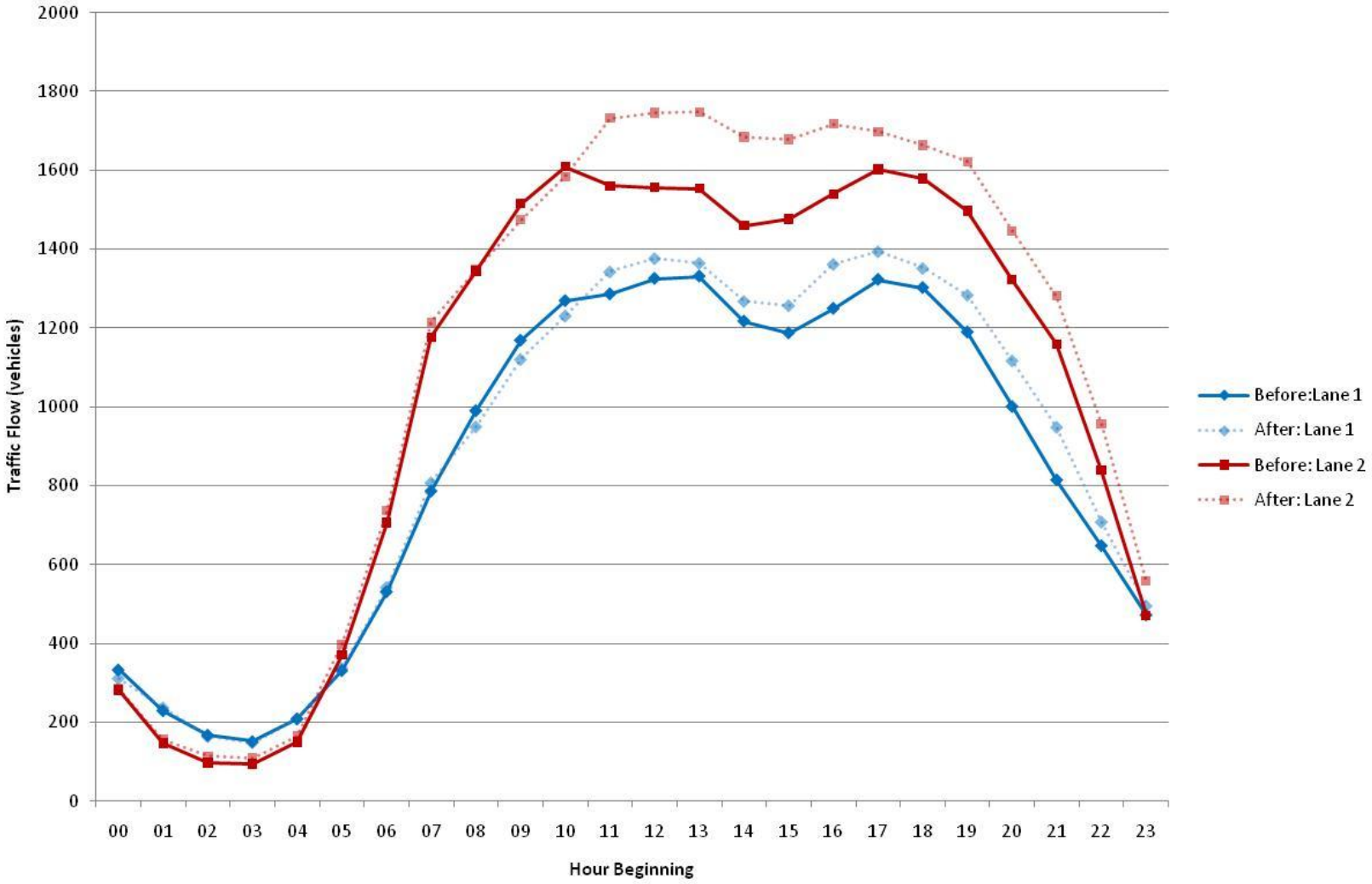


**Figure 11: Weekday Average Journey Time by time period and by lane**

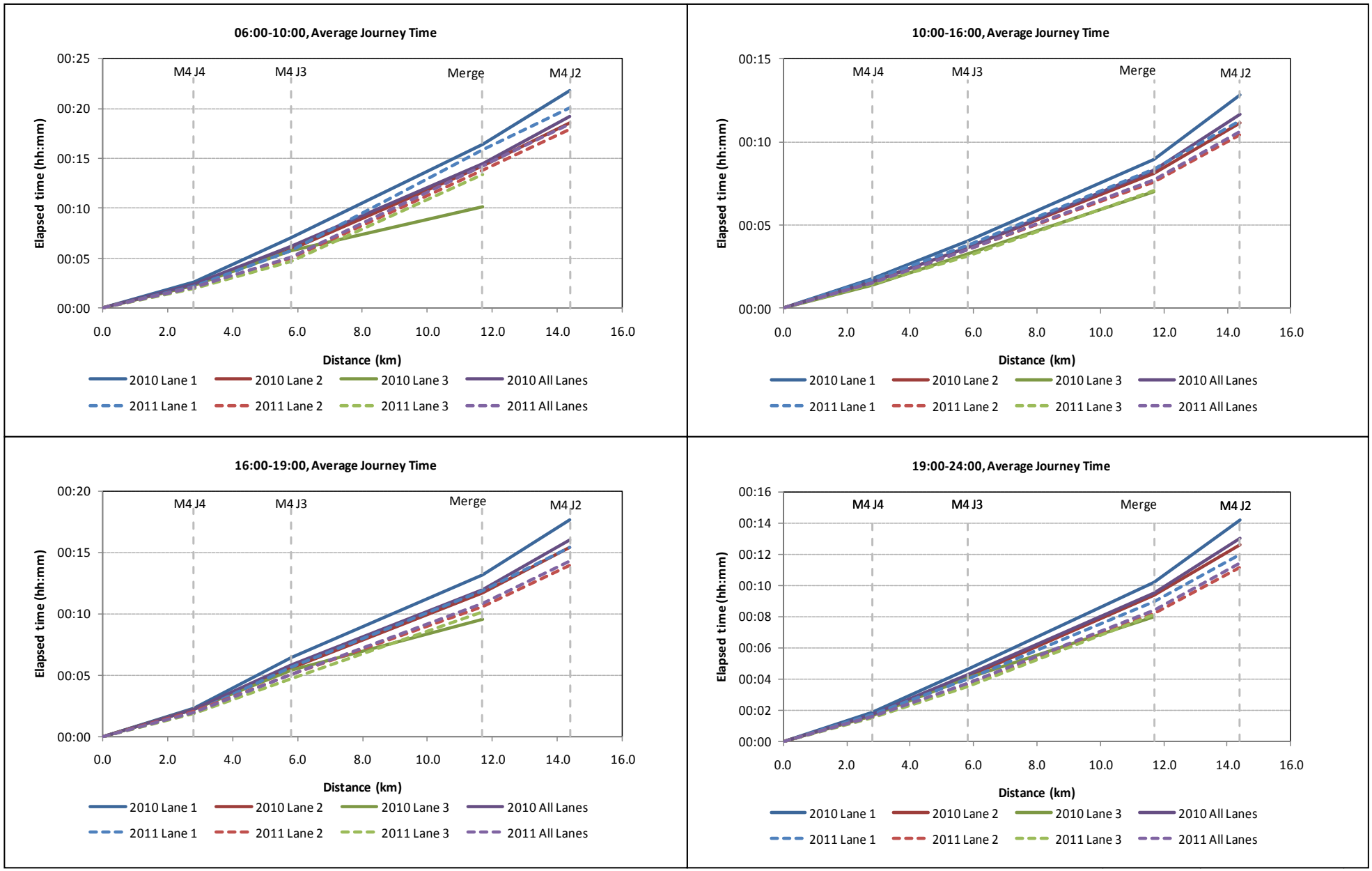


**Figure 12: Weekend Average Journey Time by time period and by lane**

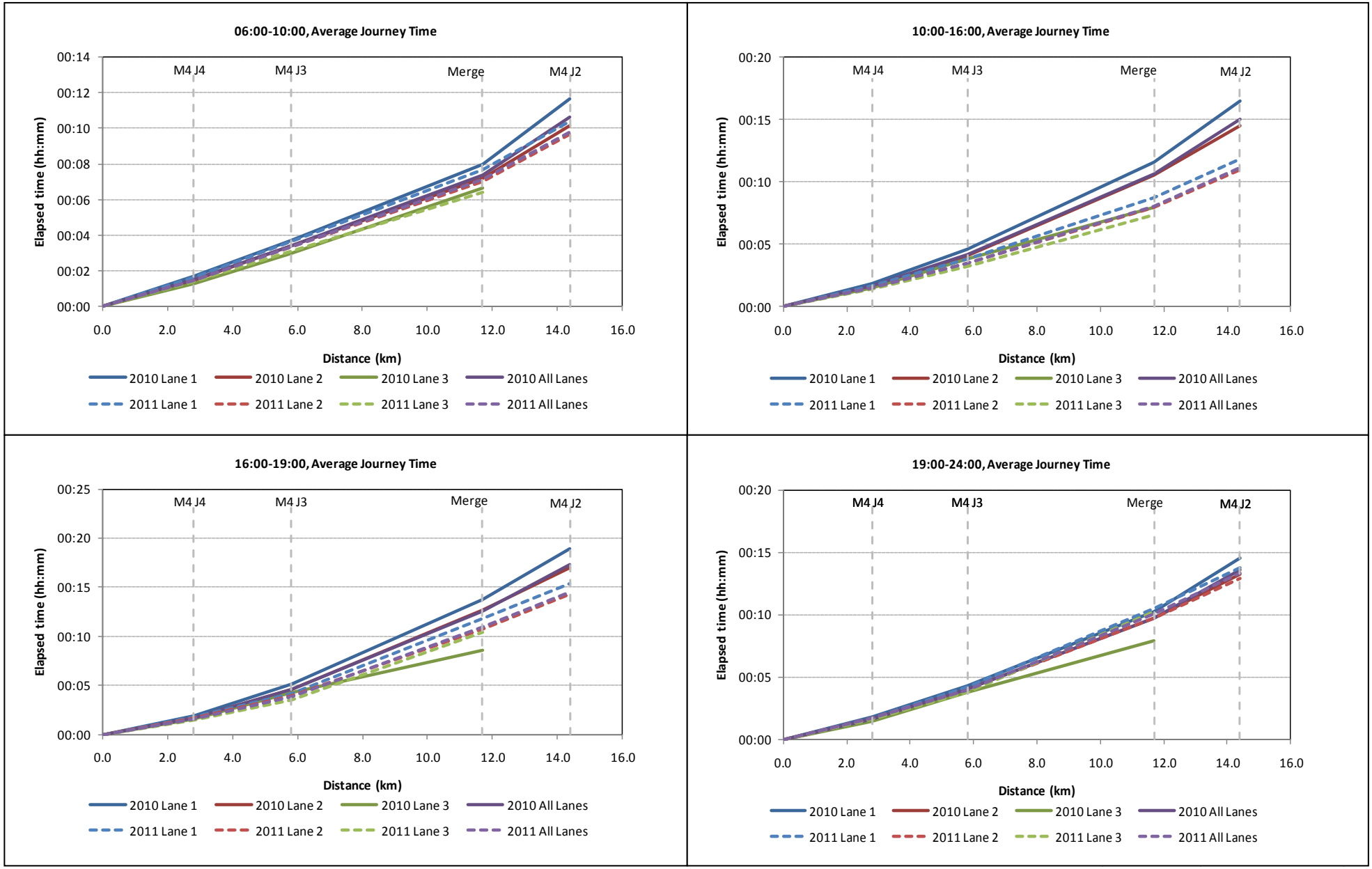


**Figure 13: Average Weekday Journey Time Reliability – Lane 1; M4 Junction 3 to Merge**

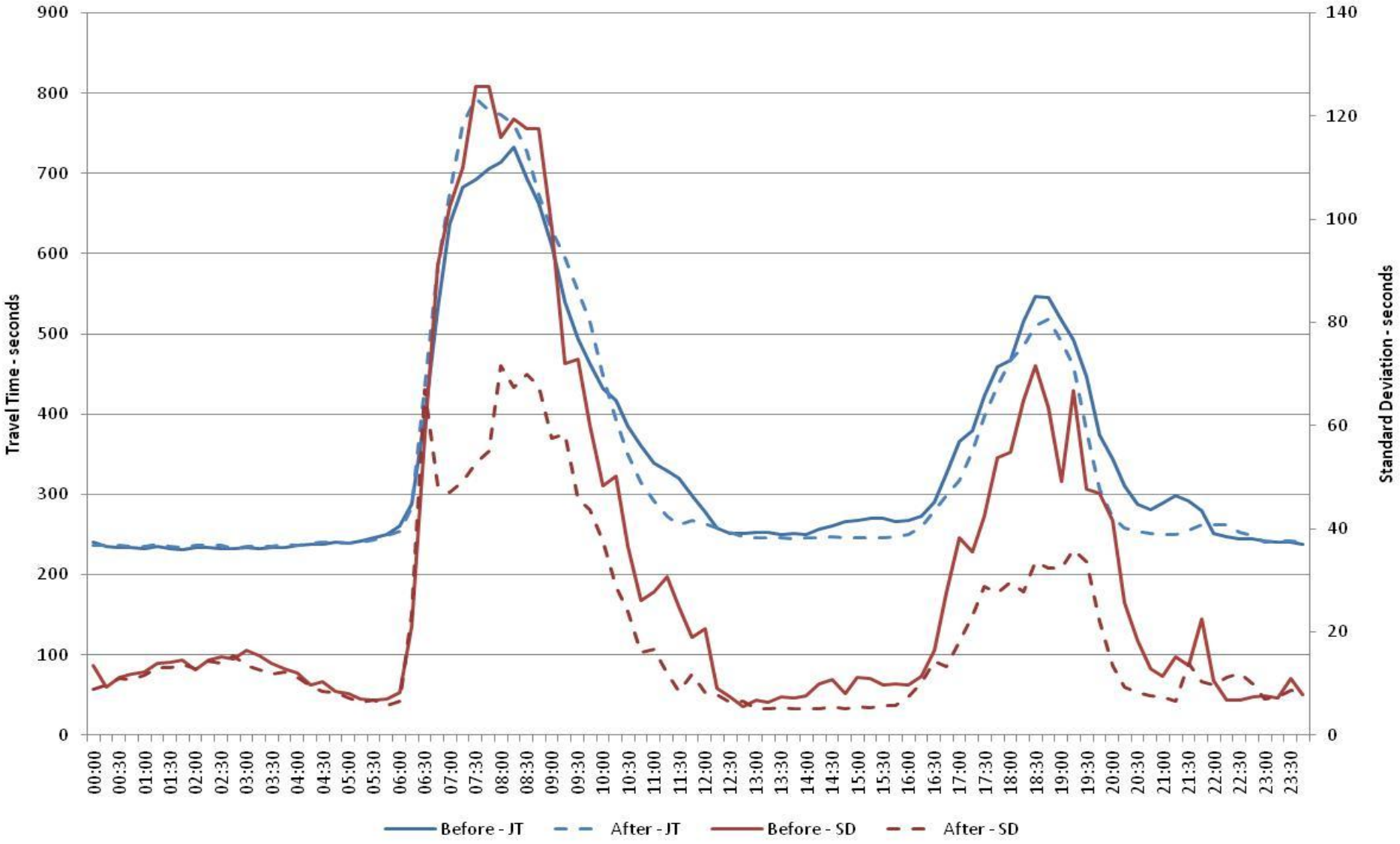


**Figure 14: Average Weekday Journey Time Reliability – Lane 2; M4 Junction 3 to Merge**

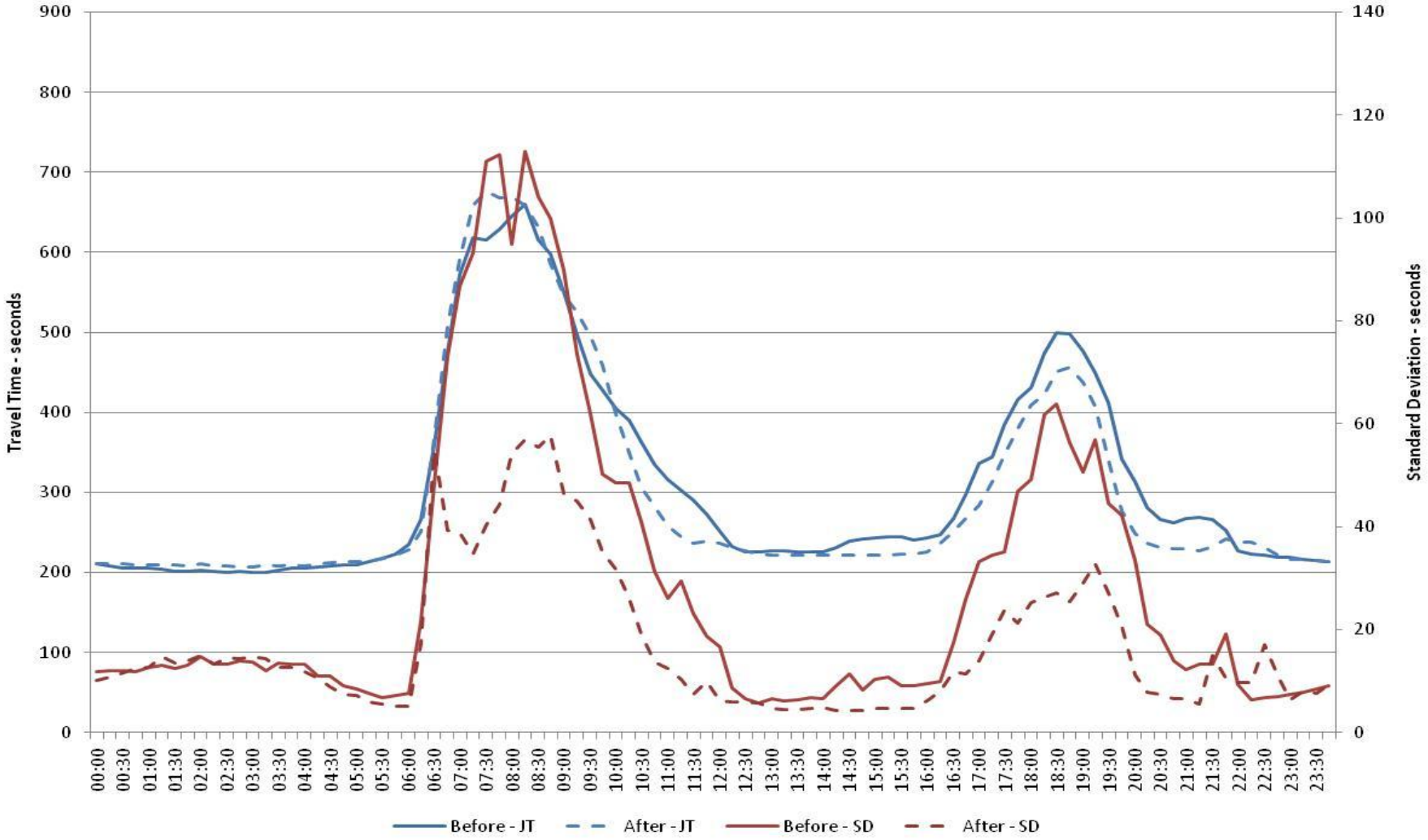


**Figure 15: Average Weekday Journey Time Reliability – Lane 3; M4 Junction 3 to Merge**

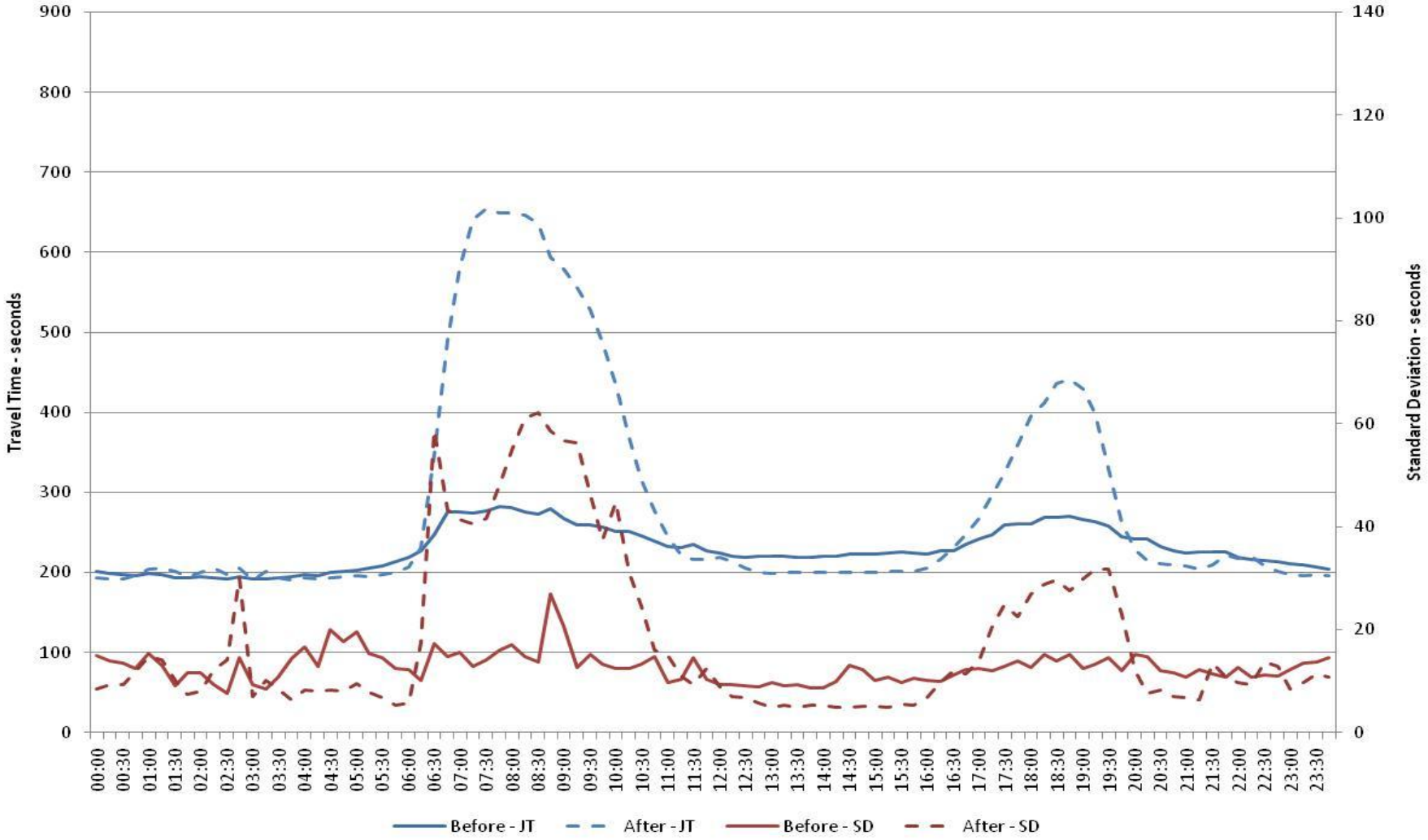


**Figure 16: Average Weekday Speed by Lane Junction 4-3**

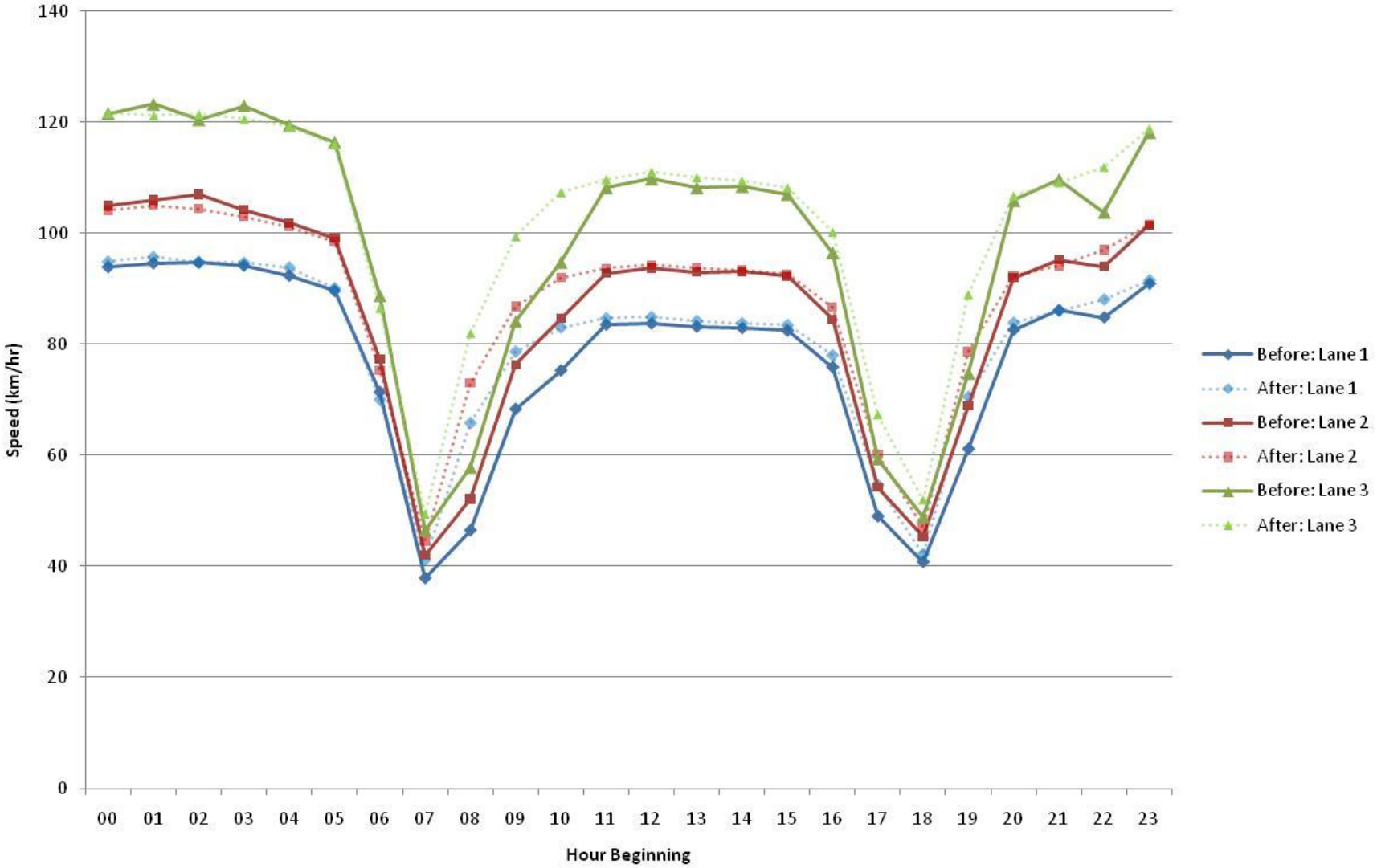


**Figure 17: Average Weekend Speed by Lane Junction 4-3**

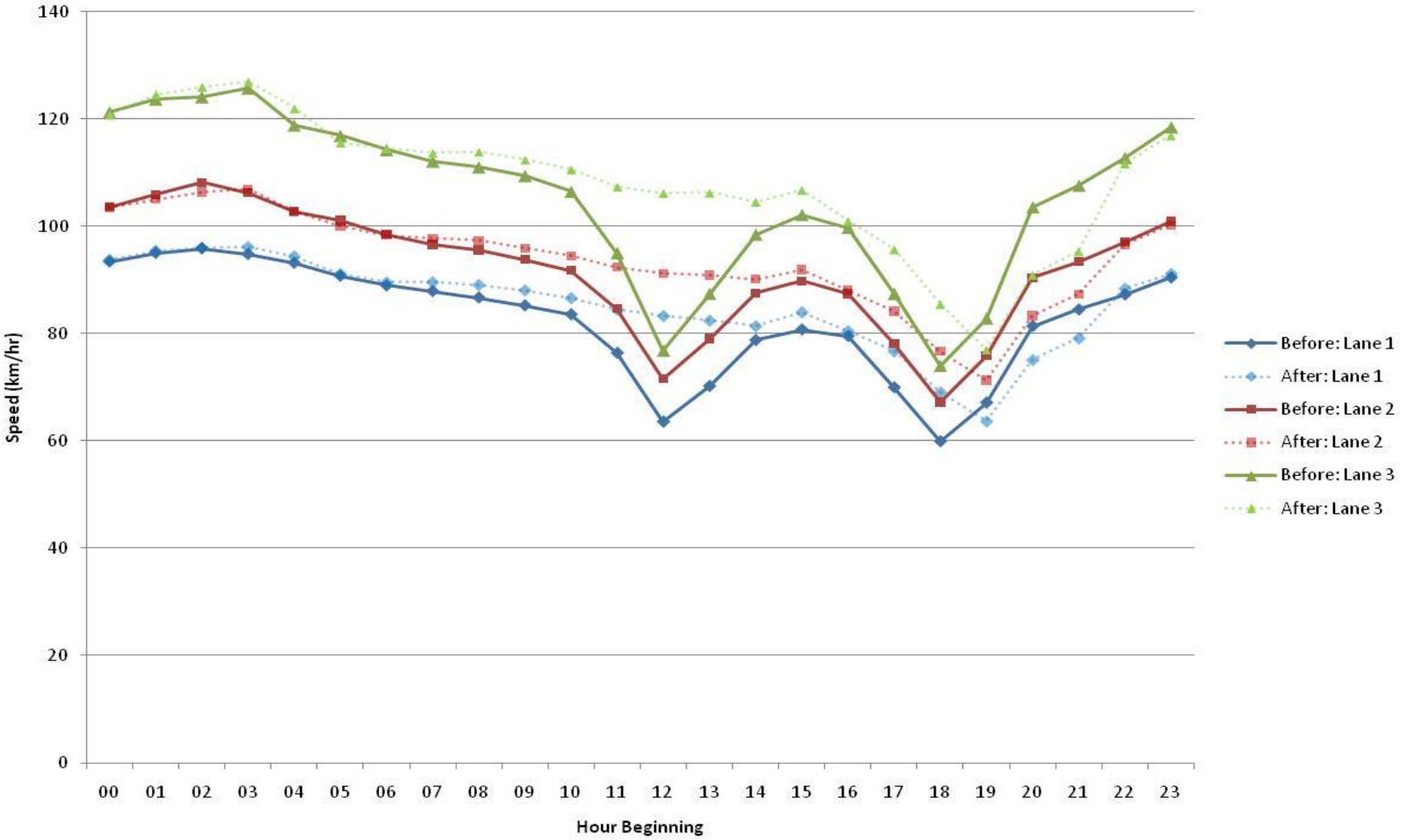


**Figure 18: Weekday Average speed by Lane – Sequence from Junction 3-2 (I-r)**

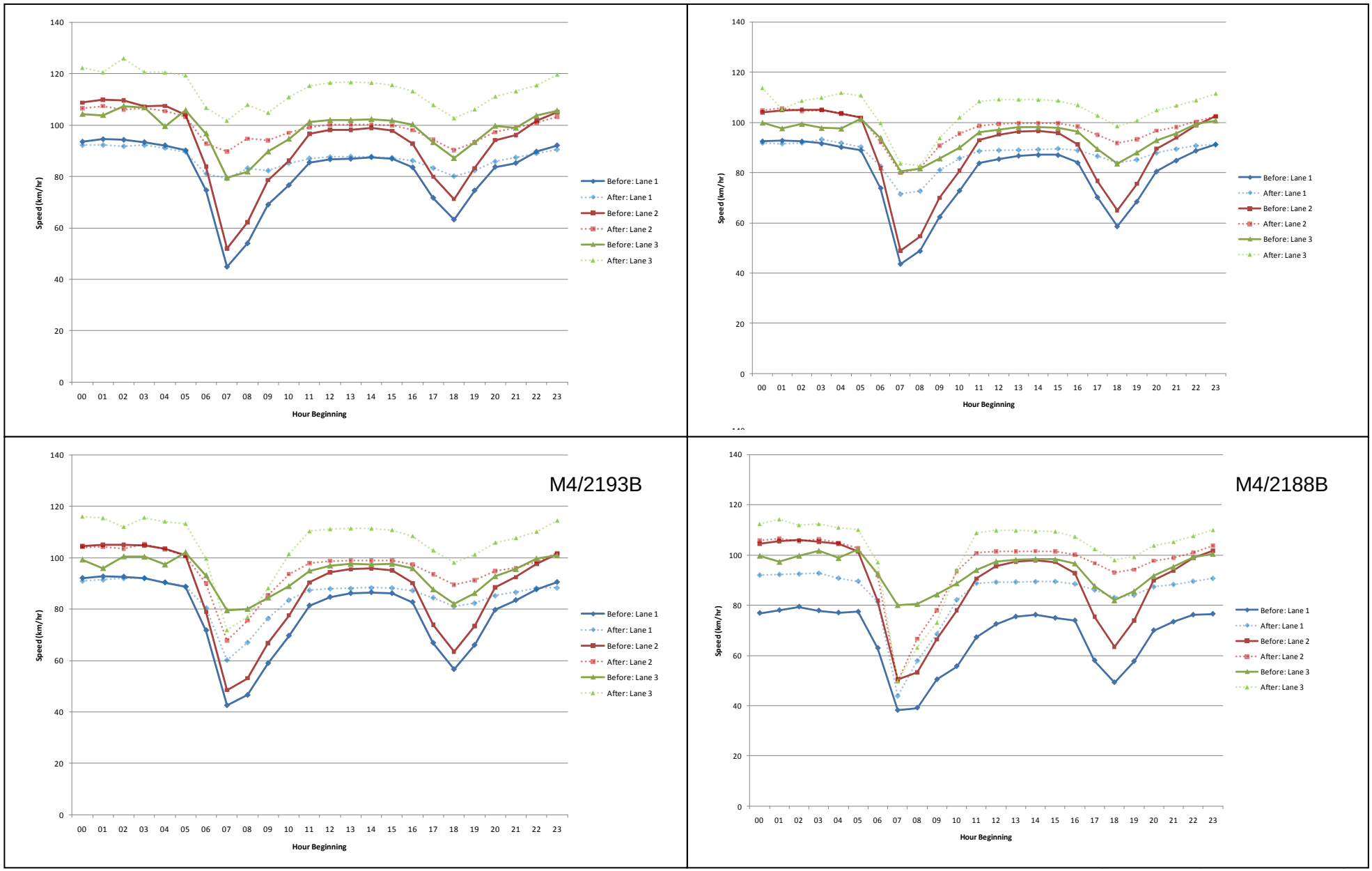


**Figure 18 (cont): Weekday Average speed by Lane – Sequence from Junction 3-2 (l-r)**

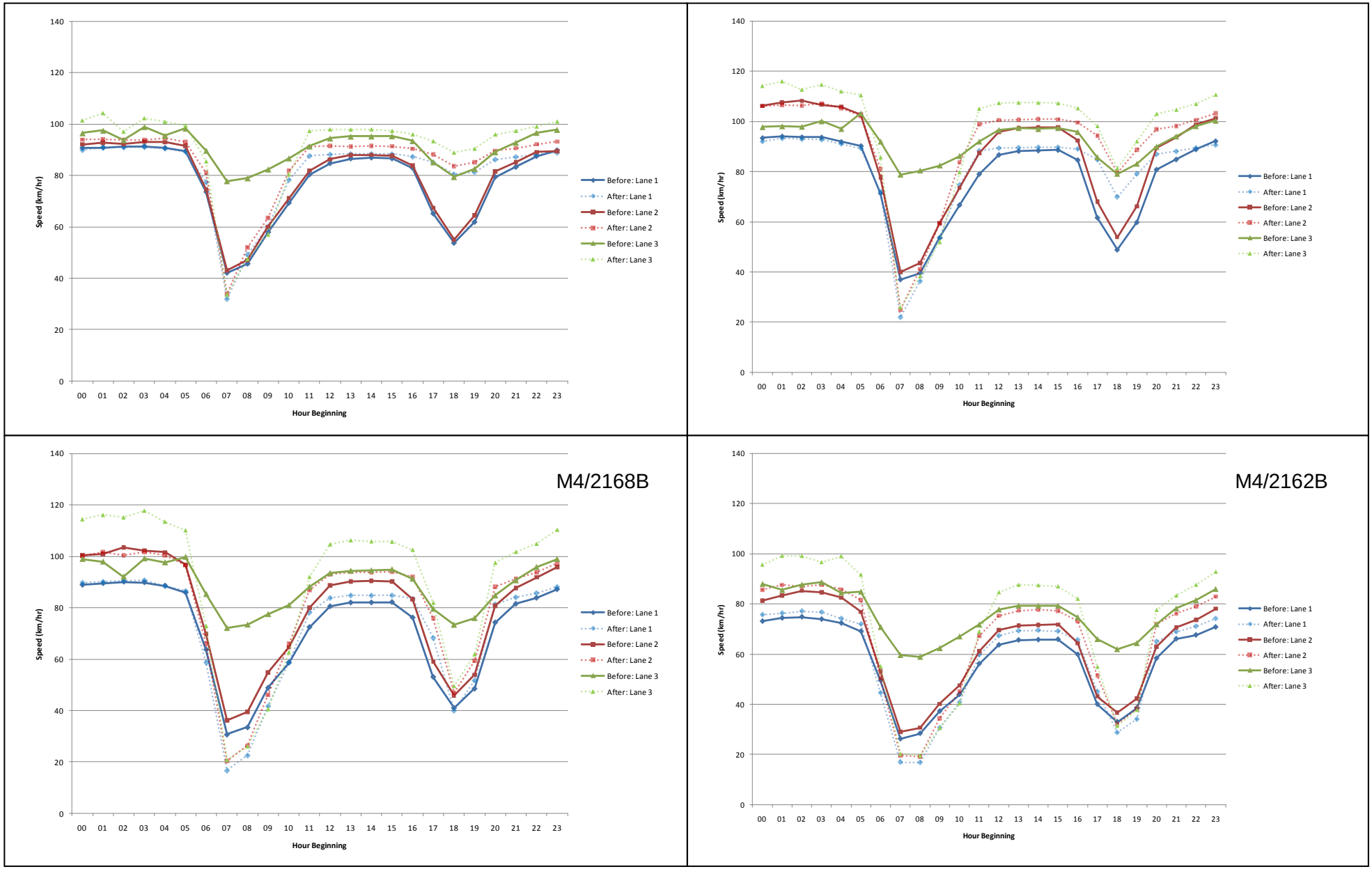
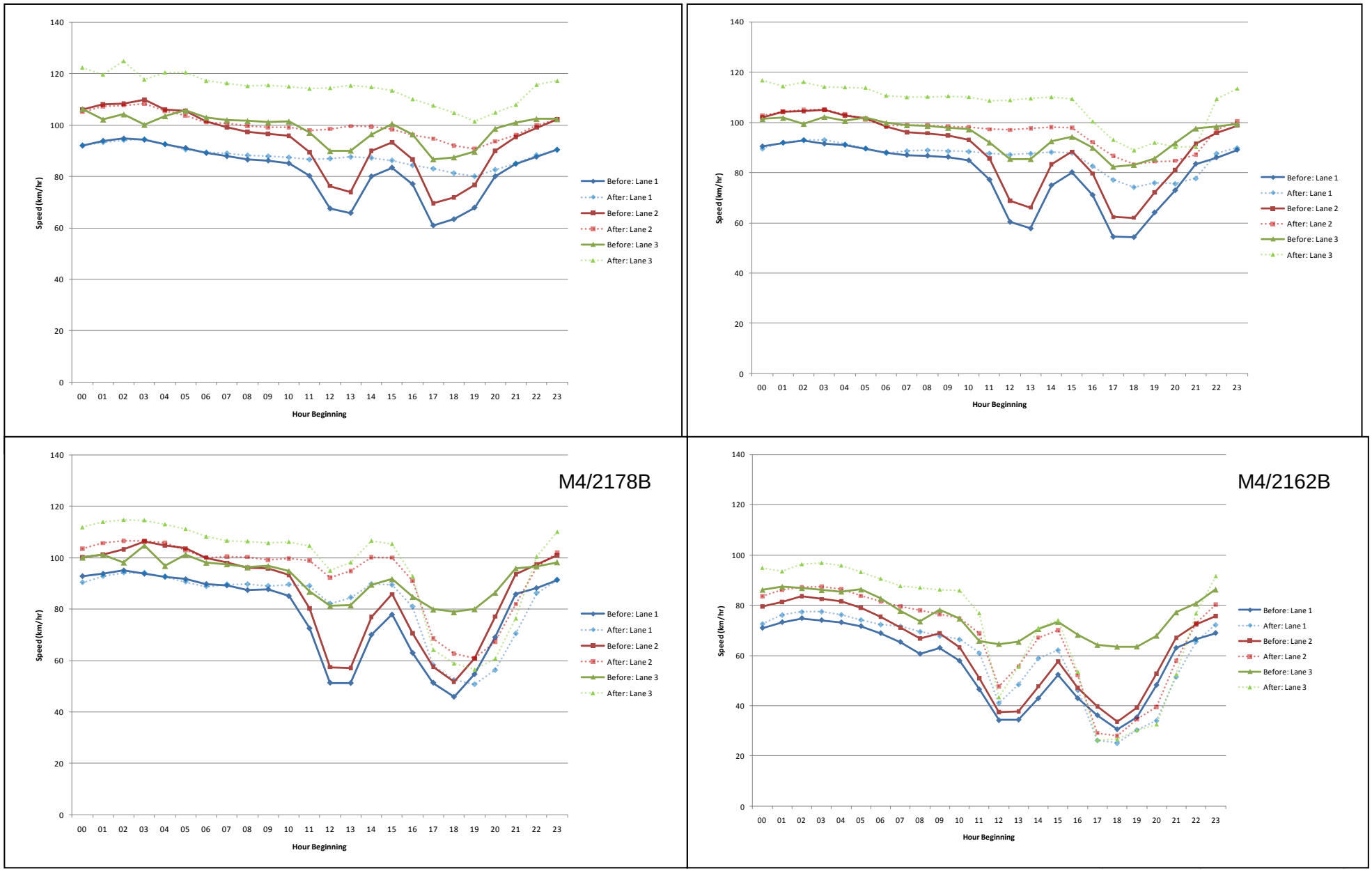


**Figure 19: Weekend Average speed by Lane – Junction 3-2**



## Figure 20: Queue Locations 'Before'

*(Timing Points - 1. M4 J4 Onslip; 2. M4 J3 Offslip; 3. M4 J3 Start of M4 Bus Lane; 4. M4 J3 Onslip; 5. M4 Heston Services Offslip; 6. M4 Heston Services Onslip; 7. M4 End of M4 Bus Lane; 8. M4 J2 Offslip)*

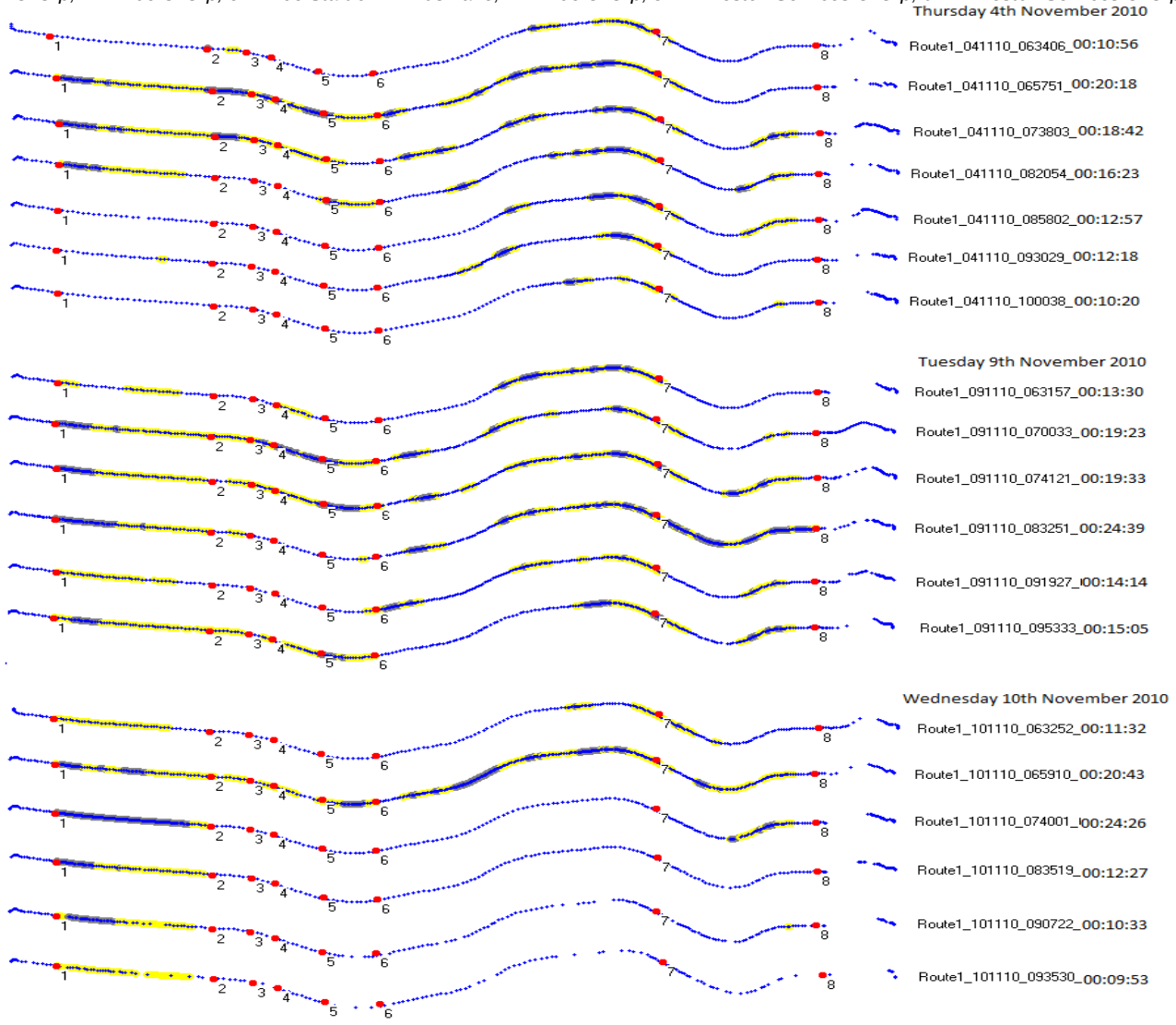


**Figure 21: Queue Locations 'After'**

*(Timing Points - 1. M4 J4 Onslip; 2. M4 J3 Offslip; 3. M4 J3 Start of M4 Bus Lane; 4. M4 J3 Onslip; 5. M4 Heston Services Offslip; 6. M4 Heston Services Onslip; 7. M4 End of M4 Bus Lane; 8. M4 J2 Offslip)*

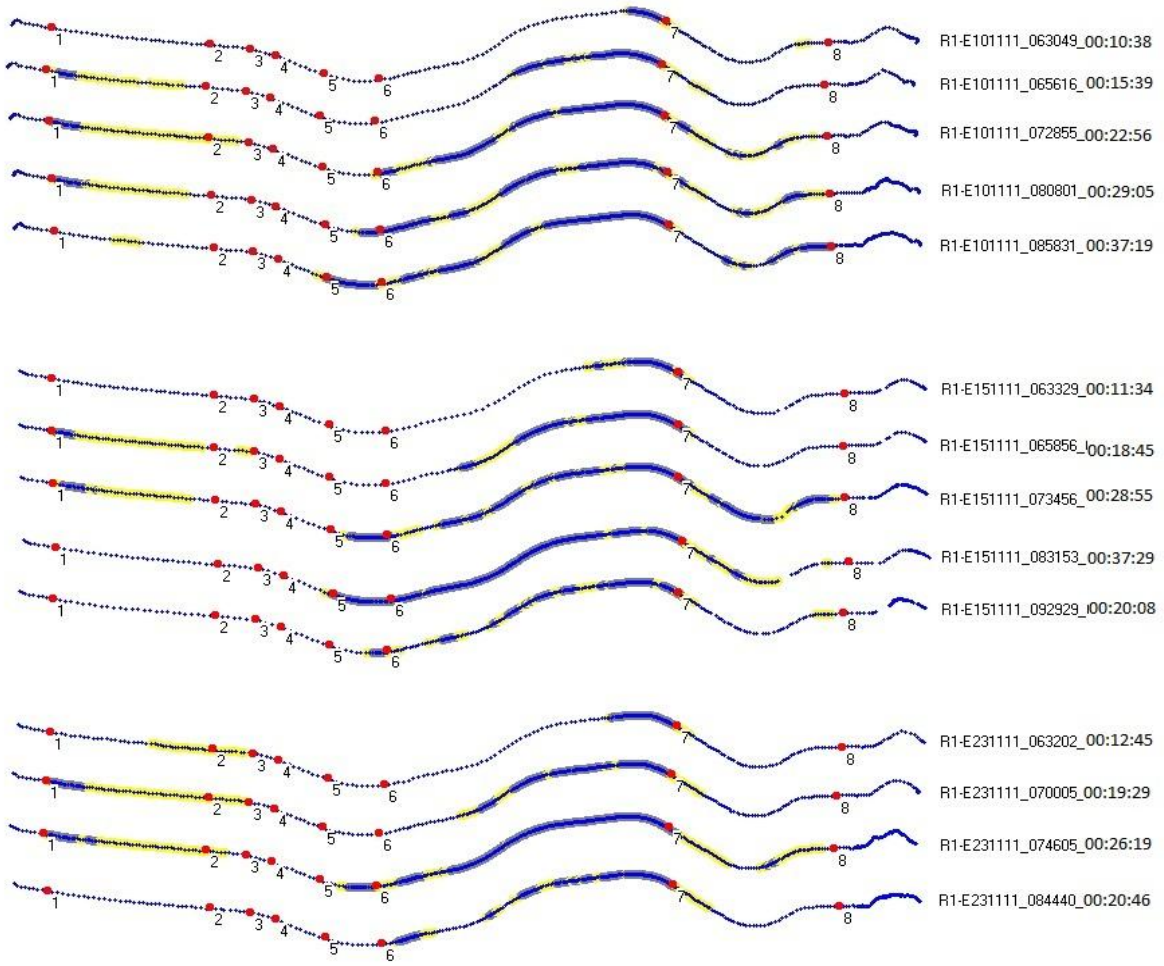


**Figure 22: Traffic patterns with the M4 Bus Lane in operation - 2010**

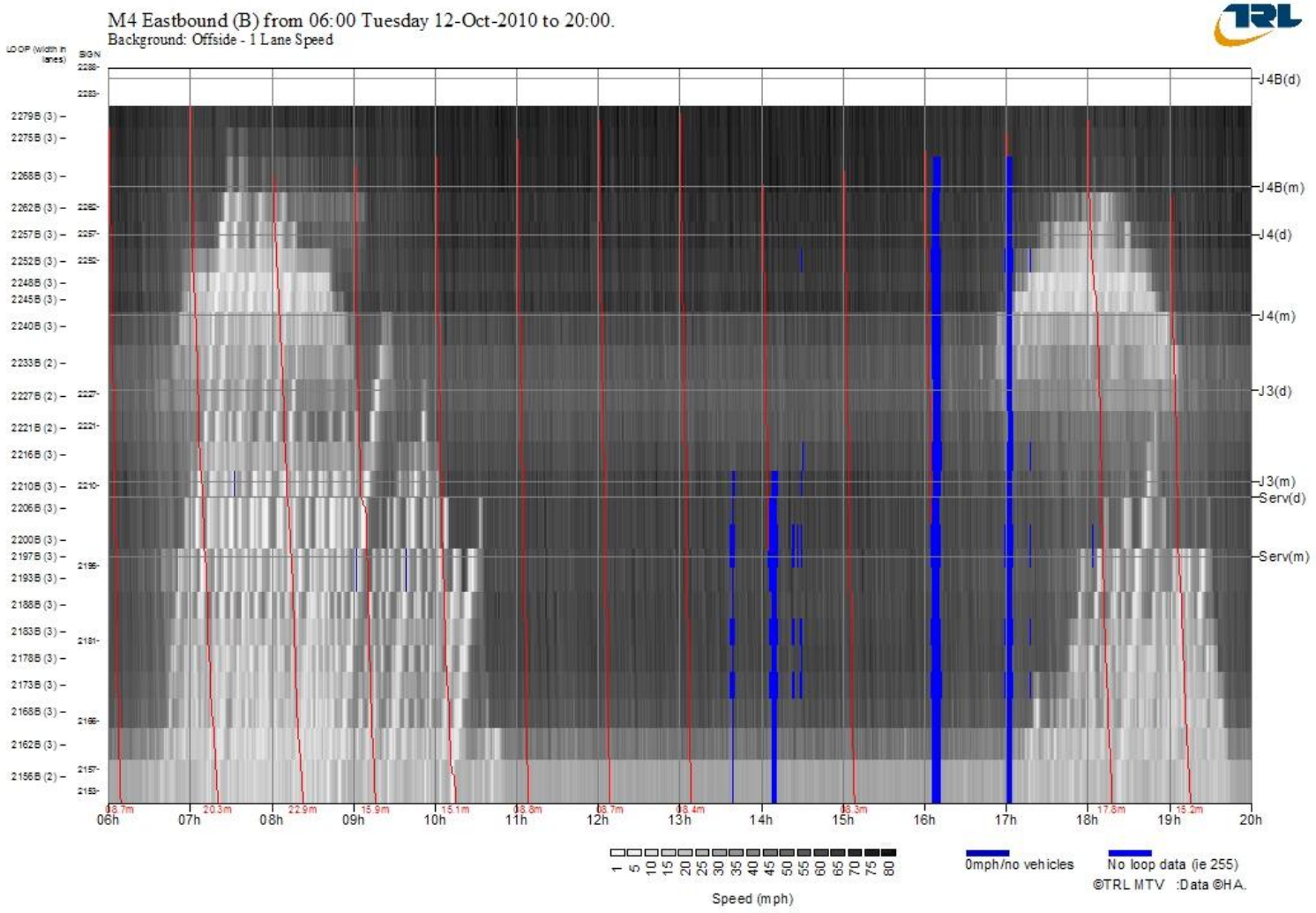


**Figure 23: Traffic patterns with the suspension of the M4 Bus Lane - 2011**

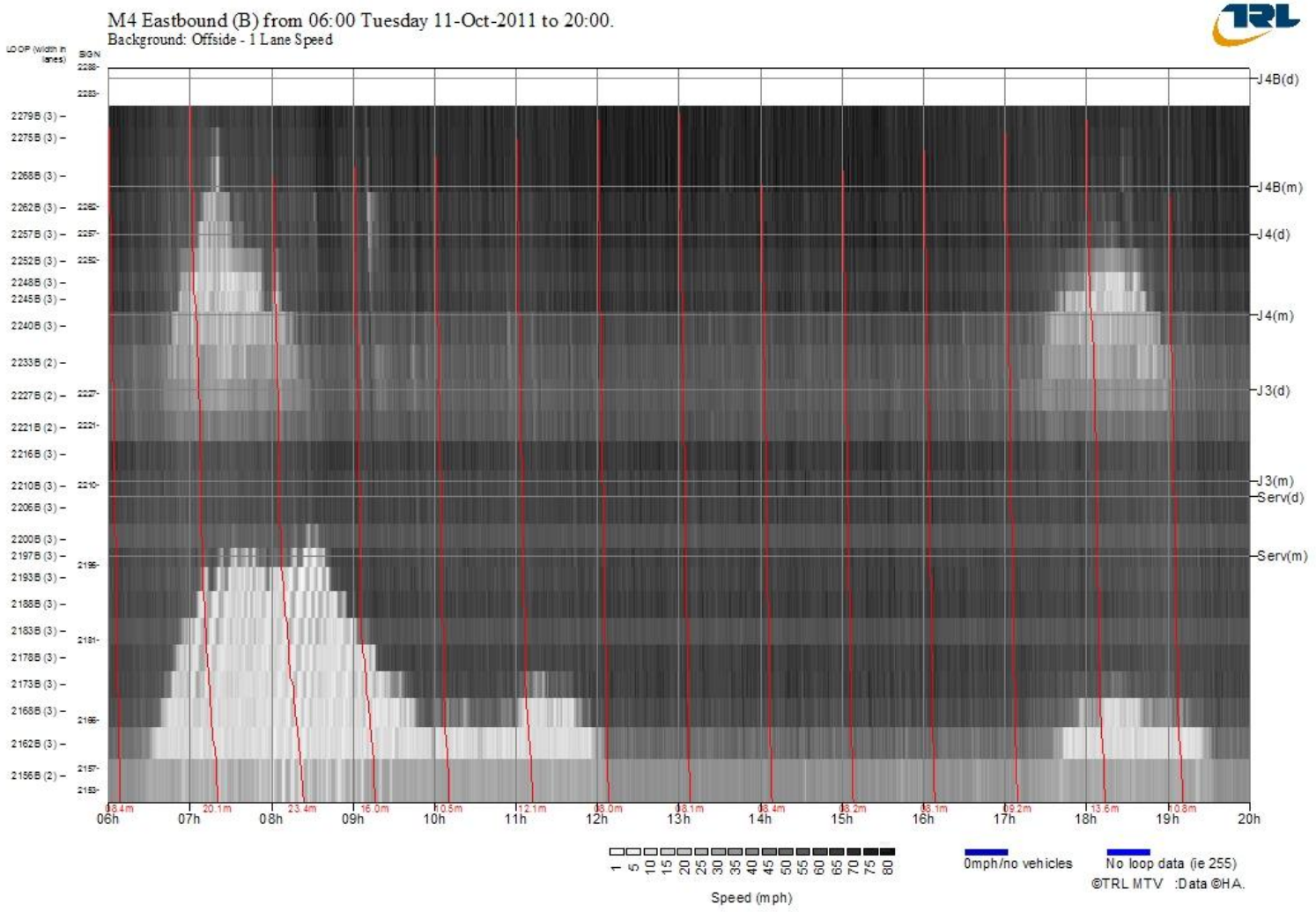


**Figure 24: Average Weekday Headway for MIDAS loop 2240 – prior to M4 Junction 3**

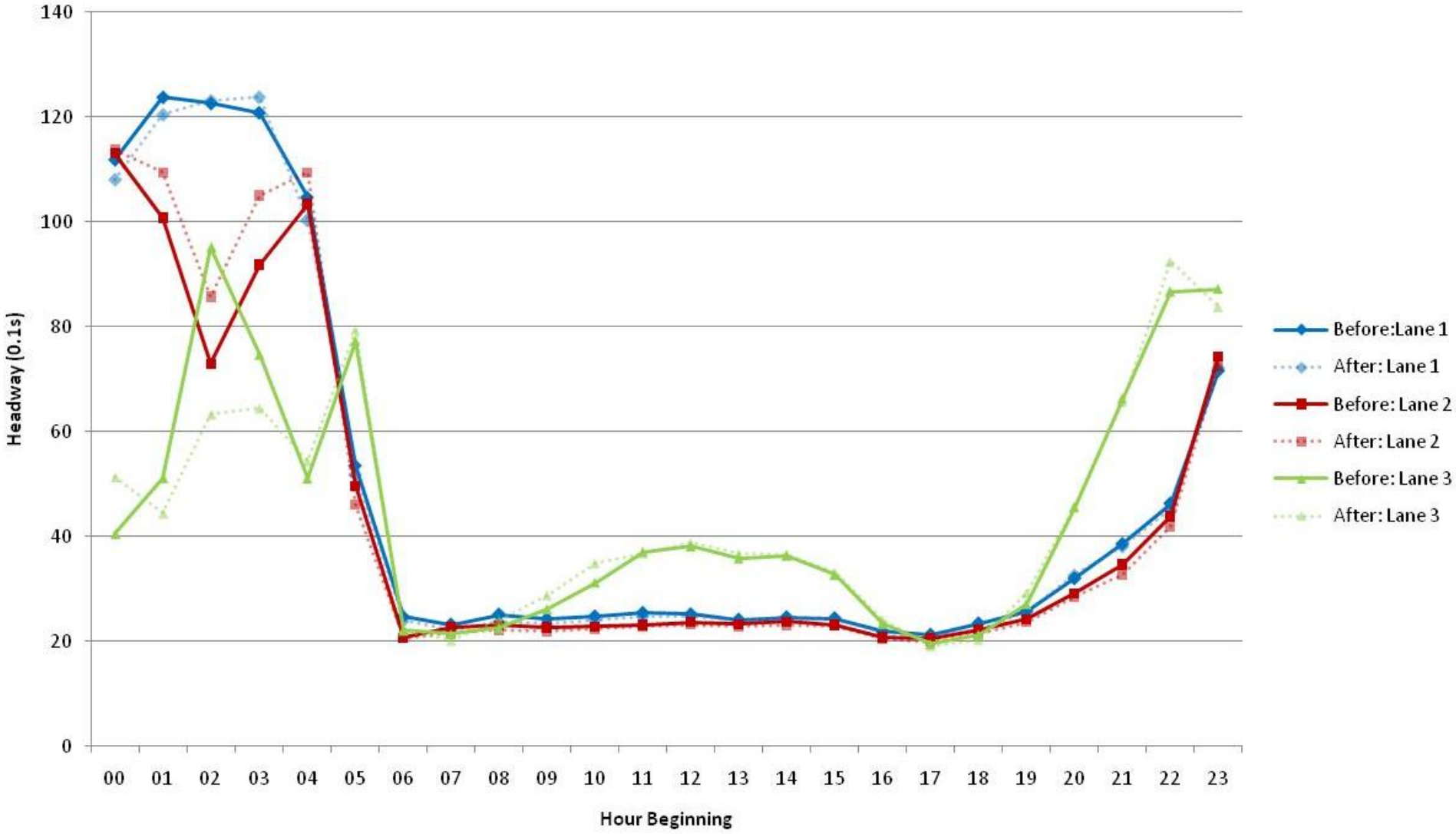


**Figure 25: Average Weekend Headway for MIDAS loop 2240 – prior to M4 Junction 3**

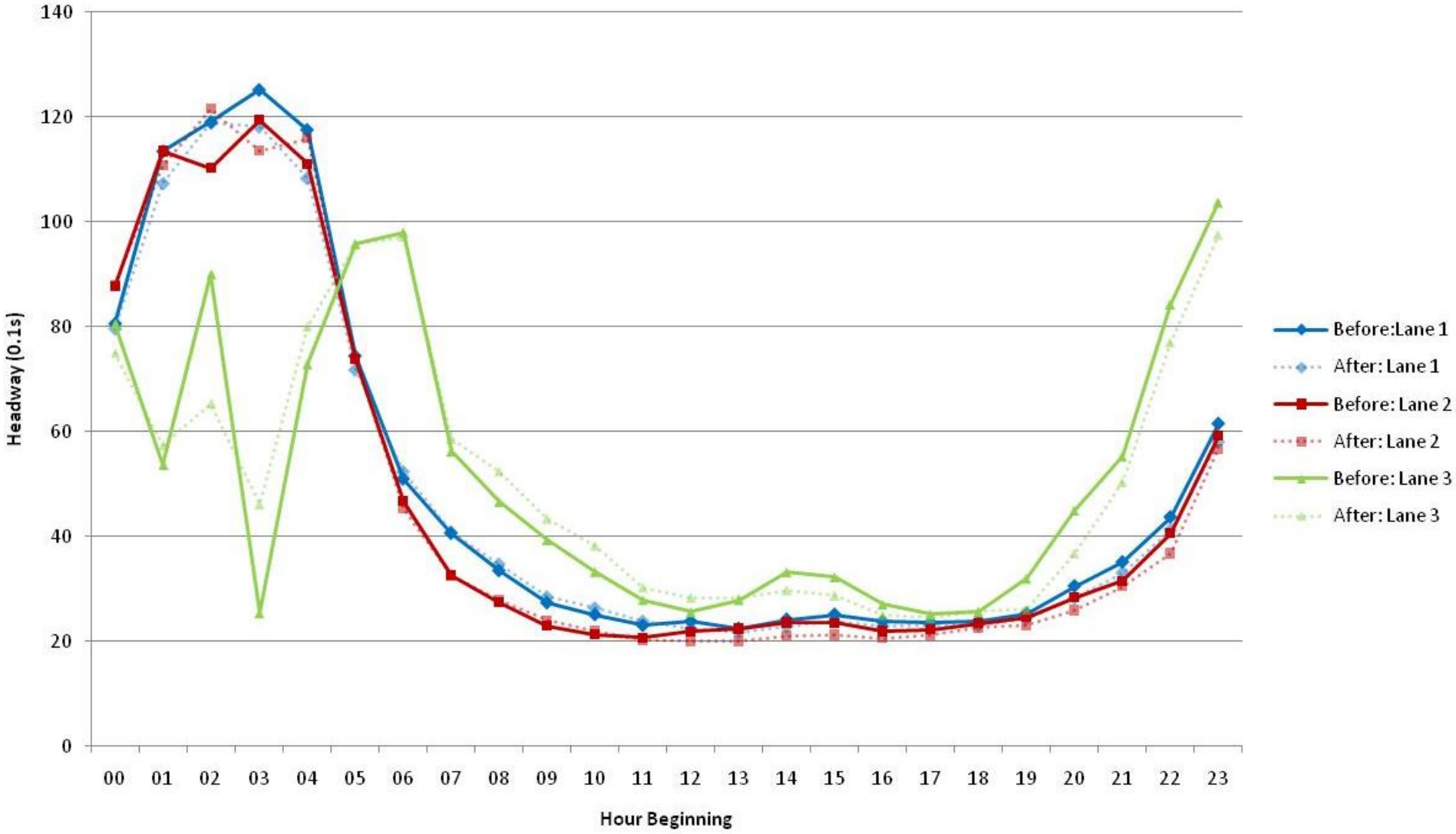


**Figure 26: Average Weekday Headway for MIDAS loop 2210 – start of the M4 Bus Lane**

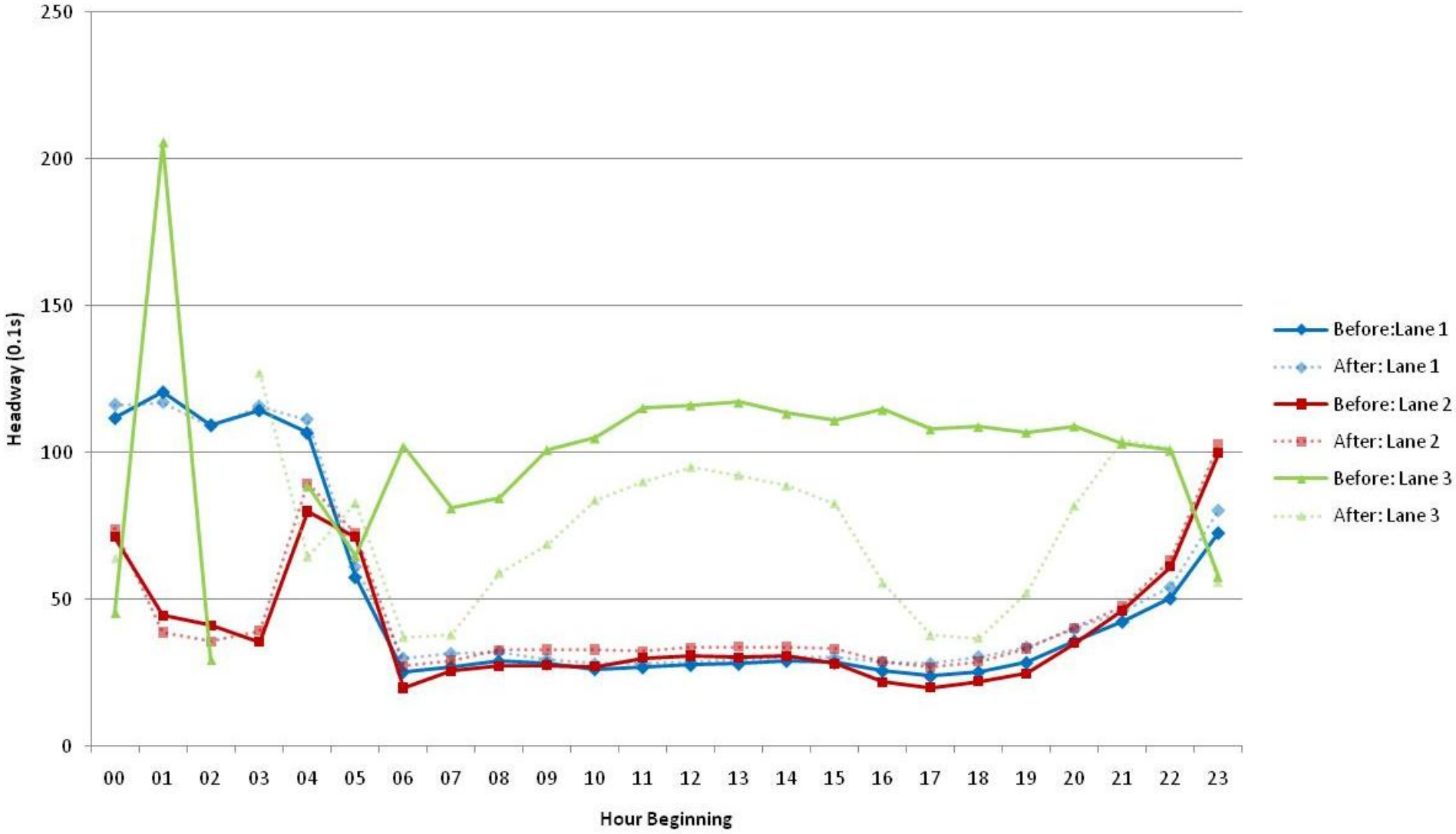


**Figure 27: Average Weekday Headway for MIDAS loop 2168 – ½ mile to merge from 3 to 2 lanes**

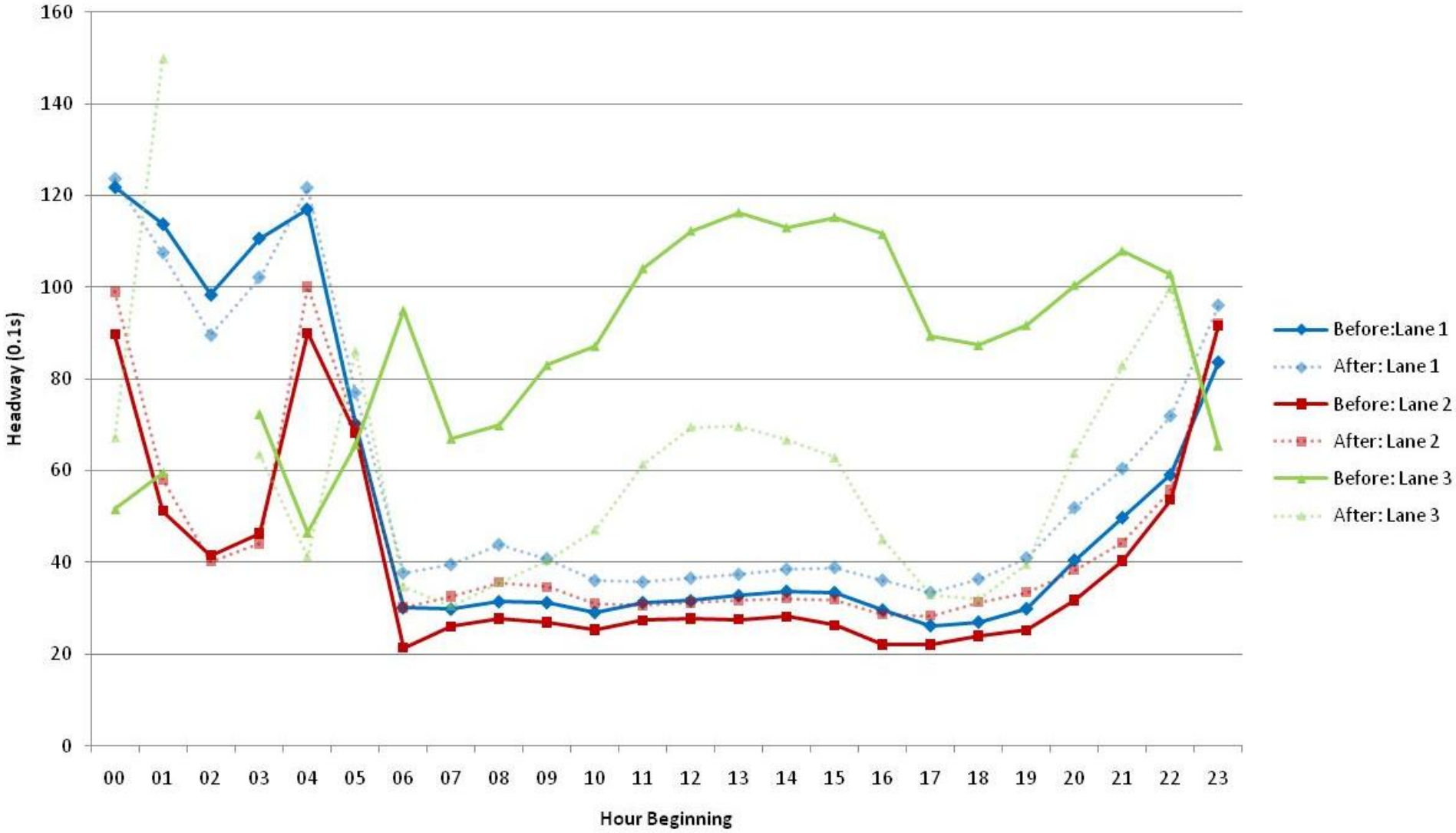


**Figure 28: Average Weekday Flow Comparison on the A4 Great West Road**

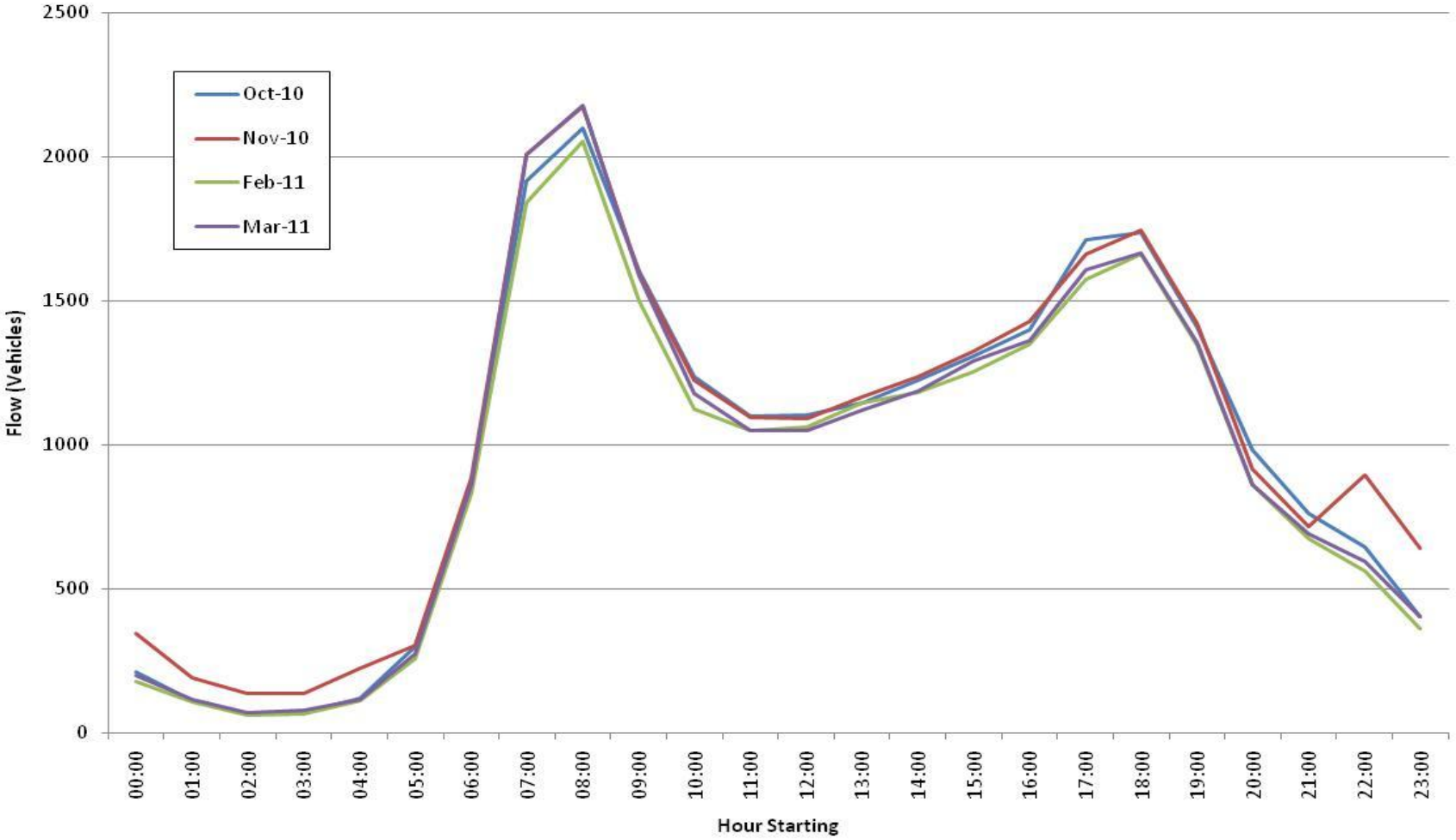
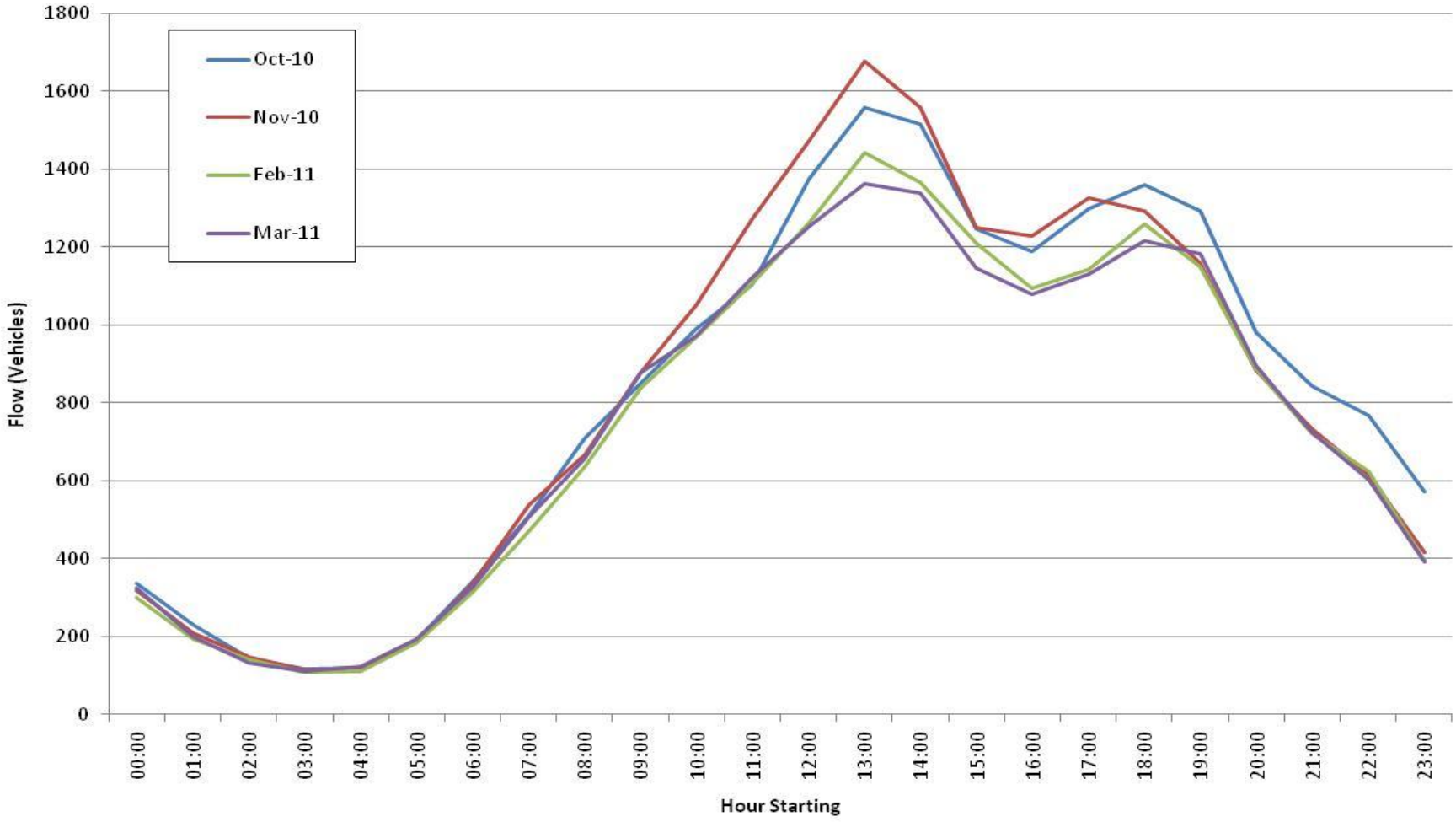


**Figure 29: Average Weekend Flow Comparison on the A4 Great West Road**



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# Appendix A

## MIDAS Loop Locations

# Appendix B

## Accident Locations