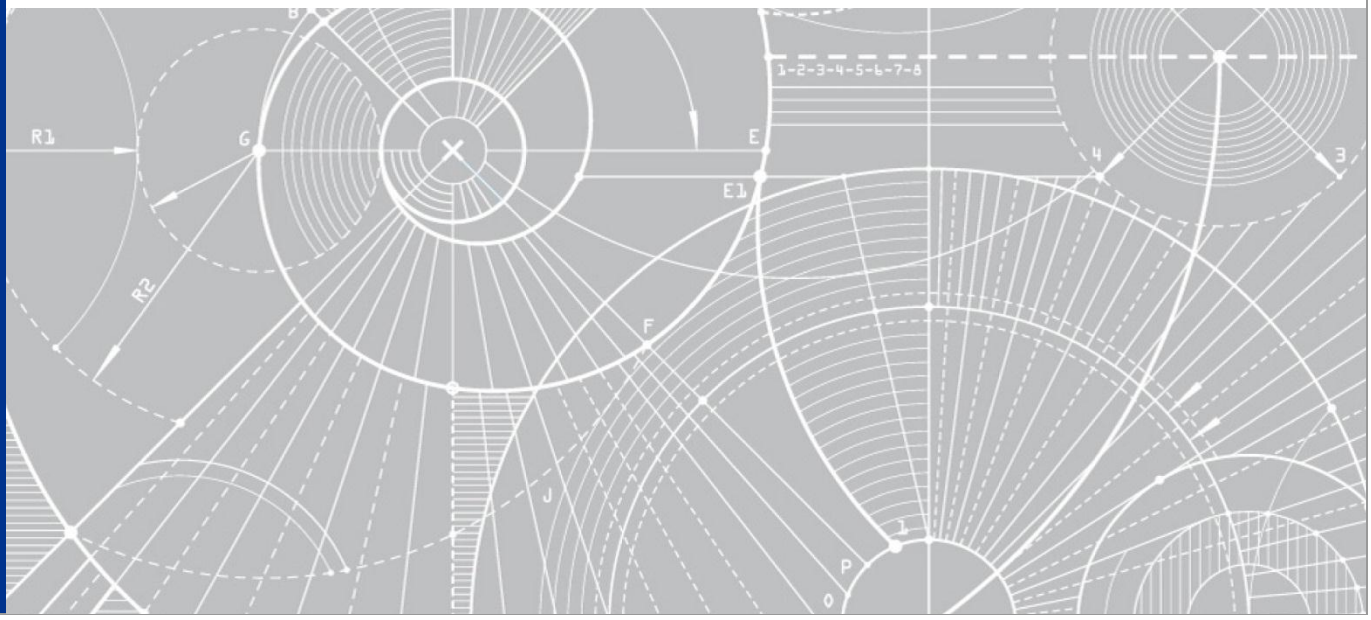
# Appraisal Framework Module 4. Surface Access: Resilience Study

AIRPORTS COMMISSION

May 2015

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# Contents

# 1. Introduction

## 1.1 Background

1.1.1 The Airports Commission (AC) was established in 2012 by the UK Government to examine the need for additional UK airport capacity and to recommend how any additional capacity requirements can be met in the short, medium and long-term. The AC is due to submit a Final Report to the UK Government by the summer of 2015, assessing the environmental, economic and social costs and benefits of various solutions to increase airport capacity, considering operational, commercial and technical viability.

1.1.2 Shortly after its inception, the AC issued tenders for support contracts to engage independent technical advice on a range of aspects of the Commission's work. Jacobs together with sub-consultants Leigh Fisher and Bickerdike Allen Partners were appointed as the sole supplier on the Airport Operations, Logistics and Engineering Support Contract (ref: RM1082), which runs throughout the AC's lifespan up until the summer of 2015.

1.1.3 A key milestone in the AC's operational life was the delivery in December 2013 of an Interim Report. Following a general call for evidence, the Interim Report detailed the results of analysis of the capacity implications of forecast growth in UK aviation demand and a preliminary appraisal on a long-list of proposals put forward by scheme promoters to address the UK's long-term aviation connectivity and capacity needs – this work is described as Phase 1. The associated appraisal process identified three short-listed options, two focussed on expanding Heathrow Airport and one on expanding Gatwick.

1.1.4 These short-listed options were then subsequently further developed and appraised during a Phase 2 assessment, which was published for consultation on the 11th November 2014. The Phase 2 assessment with respect to surface access constituted a static appraisal using spreadsheet-based demand-forecasting models, which were developed primarily to assess the surface transport capacity implications of each expansion option. Following feedback from the AC's surface access stakeholders (the Department for Transport (DfT), the Highways Agency (HA), Network Rail (NR), and Transport for London (TfL)), further assessment of the surface access implications of the three expansion options, involving dynamic modelling, was undertaken during the Phase 2 consultation period, which ended on the 3rd February 2015.

## 1.2 Public Consultation

1.2.1 The aforementioned Phase 2 consultation resulted in the AC receiving approximately 75,000 responses on the three short-listed options for expansion at Heathrow and Gatwick. The sources of the responses were wide-ranging and included (but were not limited to) members of the public, businesses, scheme promotors, local government, and campaign groups. The consultation covered a broad spectrum of issues relating to potential expansion at Heathrow and Gatwick, including surface access provision.

1.2.2 Following an initial review of the responses by the AC, Jacobs were provided with a list of those received from the consultees in Table 1-1. The AC's Secretariat considered that these respondents raised issues that required support from Jacobs to address. A review of the responses by Jacobs identified approximately 600 comments relating to surface access.

**Table 1-1: Reviewed Consultee Responses**

| Consultee |
|---|
| Buckinghamshire County Council |
| Charlwood Parish Council |
| Crawley Borough Council |
| East Sussex County Council |
| easyJet |
| Fiona Mactaggart MP |
| Gatwick Area Conservation Campaign |
| Gatwick Airport Limited |
| Haywards Heath Town Council |
| Heathrow Airport Limited |
| Heathrow Hub Limited |
| Horsham District Council |
| Hounslow Council |
| Independent Transport Commission |
| Kent County Council |
| Mid Sussex District Council |
| Network Rail |
| Reigate & Banstead Borough Council |
| Richmond Heathrow Campaign |
| Royal Borough of Kensington & Chelsea |
| Royal Borough of Windsor & Maidenhead |
| Slough Borough Council |
| Surrey County Council |
| Tandridge District Council |
| Transport for London |
| Virgin Atlantic |
| West Sussex County Council |

1.2.3 Each of the comments were recorded and categorised by their content. This approach allowed for the identification of recurring themes within the comments and made it possible to understand some of the key areas of concern for consultees. The approach informed the need for any additional analysis that would be required to support earlier phases of work such that the issues raised by the consultees could be suitably addressed.

1.2.4 Following an initial review of the surface access comments the AC identified four areas of additional analysis. These were as follows:

- Surface access freight impacts at Heathrow and Gatwick;
- Road and rail resilience impacts at Heathrow and Gatwick;
- Demand management impacts at Heathrow;
- Road capacity sensitivity impacts.

1.2.5 This report focuses on the second area of additional analysis on **highway and rail resilience**, and will provide advice to the Commission on the highway and public transport network resilience of the shortlisted airport expansion schemes.

**Summary of comments on resilience**

1.2.6 From all consultation response documents provided, Jacobs identified a total of 21 comments specifically relating to the AC analysis of surface access resilience. For reference, these comments have been included in their entirety in Appendix A. Comments were received from NR, Heathrow Airport Limited (HAL) and Gatwick Airport Limited (GAL).

1.2.7 The comments received from the airport operators focussed on the issue that resilience analysis was carried out for Gatwick Airport, but not for either of the two shortlisted Heathrow Airport schemes. The comments received from NR related to a range of performance and resilience issues affecting the Great Western Main Line (GWML) and the Brighton Main Line (BML) both at present and in future.

# 2. Assessment methodology

## 2.1 Highway network

2.1.1 To assess resilience of the highway network serving each airport expansion scheme, a two part approach was adopted, as follows:

- Firstly, a review and qualitative evaluation of the highway network serving each airport in each expansion scenario was carried out. For each primary direction of travel to and from the airport, a number of reasonable alternative travel routes were identified. Resilience was then evaluated based on a high level multi-criteria analysis (MCA) of each primary direction of travel, considering the number of available travel routes, likely travel time and total capacity;

- Secondly, the historic frequency of major disruptive incident occurrences and the likely airport travel impact was assessed at two key locations that are highly congested and carry large volumes of airport-bound traffic. Incident frequency analysis was carried out using Highways Agency journey time data recorded between 2004 and 2014. Airport travel impact was assessed by carrying out highway assignment model runs with localised capacity reductions to simulate the occurrence of a disruptive incident.

2.1.2 This assessment methodology provides both an understanding of highway infrastructure serving each airport and its properties relating to resilience as well as the likelihood and impact of a disruptive incident in a critical location.

## 2.2 Rail

2.2.1 Rail performance on the routes serving both airports was analysed over a five-year time period to identify underlying performance trends, from 2010/1 to 2014/5[1]. The analysis considers NR's national performance and then compares the results at regional level. This is followed by an assessment of individual train operator services that call at either Heathrow or Gatwick airports.

2.2.2 NR and London Underground (LU) provided information for the following train services:

- Heathrow Airport:
  - Heathrow Connect services;
  - Heathrow Express (HEX) services;
  - First Great Western (FGW) services on the GWML: Services do not currently operate to Heathrow Airport but operate in the Thames Valley area – the performance indicators therefore assess how passengers travelling between Reading and Paddington are affected by service delays, which may be relevant for the provision of future services to Heathrow, including Crossrail and Western Rail Access (WRA);
  - South West Trains: Services do not currently operate to Heathrow Airport but if Southern Rail Access (SRA) is provided in future the main connection between the airport and Central London would likely utilise the Windsor Lines through either Richmond or Hounslow;
  - Piccadilly Line: LU measures service performance differently from the heavy rail services calling at the airports. The data reflects average platform waiting and journey time and unplanned line suspensions. With the data provided it has only been possible to comment on the results, as the reasons for any reliability failures were not available for review;
- London Gatwick:

[1] It should be noted that the performance information for 2014/2015 is up to industry period 12 only as the year has not yet ended.

- Southern Trains;
- Thameslink;
- FGW services on the North Downs Line (NDL): services that operate between Reading and London Gatwick via Redhill.

2.2.3 To ensure a holistic review was undertaken the following performance indicators were reviewed:

- Cancellations and Significant Lateness (CaSL): defined as the number and percentage of passenger trains that are cancelled in part or full, or arrive at their final destination more than 30 minutes later than the advertised timetable – for the purposes of this study, CaSL was identified as the key performance measure impacting on airport passengers using the rail network.
- Total minutes delay: defined as the total minutes of delay recorded on services excluding those subject to CaSL i.e. the extent to which low-level delays of less than 30 minutes impact on service performance – total delay includes Train Operating Company (TOC) delays (the direct responsibility of the train operator), TOC on TOC delays (when a train operator's delay directly affects the performance of other train operators), and NR delays (the direct responsibility of NR).
- The impact of Network Enhancement Projects (NEPs): The percentage of delay minutes and level of CaSL that were attributed to NEPs (for example the Thameslink and Crossrail works programmes) as opposed to other causes – the Thameslink programme was identified separately in the analysis due to specific comments received from GAL during the Phase 2 consultation.

# 3. Highway resilience analysis

## 3.1 Heathrow North West Runway

3.1.1 Heathrow Airport is well connected to the London Strategic Road network, positioned immediately south east of M25 Junction 15 and bordered by the M25 to the west and the M4 to the north, with direct access to the airport provided by each of these roads.

**Incident impact assessment – journey time analysis**

3.1.2 To assess the likelihood of a disruptive incident occurring on the strategic road network leading to and from Heathrow Airport, analysis of historic travel time data was undertaken to identify the rate at which disruptions currently occur. Disruptions were identified on the basis of average hourly travel speed, assuming a significant reduction in speed as an indication of an incident. Incidents were categorised by severity based on the observed average travel speed, as follows – no attempt was made to identify the cause of incidents:

- Very minor: travel speed <= 40km/hr;
- Minor: travel speed <= 30 km/hr;
- Moderate: travel speed <= 20 km/hr;
- Severe: travel speed <= 15 km/hr;
- Very severe: travel speed <= 10 km/hr.

3.1.3 The occurrence of incidents was identified based on absolute travel speed rather than a relative reduction from posted speed because, when outside of free flow conditions, highway speed flow relationships are not dependent to a significant extent on posted speed.

3.1.4 Journey time data was obtained from the Highways Agency online journey time database[2] on an hourly average basis for the period between 2005 and 2014 at the following locations:

- M25 north (J15 to J18);
- M25 south (J10 to J15);
- M4 east (J1 to M25 J15);
- M4 west (M25 J15 to J8).

3.1.5 Table 3-1, Table 3-2, Figure 3-1 and Figure 3-2 illustrate the results of the journey time data analysis, showing the annual occurrence rate for each incident category.

**Table 3-1: Annual disruptive incident rate - travel towards Heathrow**

| | Location | | | |
|---|---|---|---|---|
| **Incident category** | **M25 north** | **M25 south** | **M4 east** | **M4 west** |
| **Very severe** | 1.2 | 2.4 | 5.8 | 2.5 |
| **Severe** | 7.6 | 11.3 | 19.9 | 9.4 |
| **Moderate** | 20.8 | 36.4 | 43.1 | 18.2 |
| **Minor** | 87.8 | 145.2 | 222.3 | 40 |
| **Very Minor** | 190.4 | 254.8 | 344.8 | 93.2 |

[2] https://jtdb.hatris.co.uk

**Table 3-2: Annual disruptive incident rate - travel from Heathrow**

| | Location | | | |
|---|---|---|---|---|
| **Incident category** | **M25 north** | **M25 south** | **M4 east** | **M4 west** |
| **Very severe** | 1 | 1.6 | 3.6 | 1.9 |
| **Severe** | 5.7 | 6.7 | 29.7 | 6.4 |
| **Moderate** | 19.9 | 21 | 72.7 | 12.7 |
| **Minor** | 99.2 | 127.4 | 302.4 | 42.4 |
| **Very Minor** | 171.1 | 265.8 | 503.1 | 90.3 |

**Figure 3-1: Annual disruptive incident rate - travel towards Heathrow**

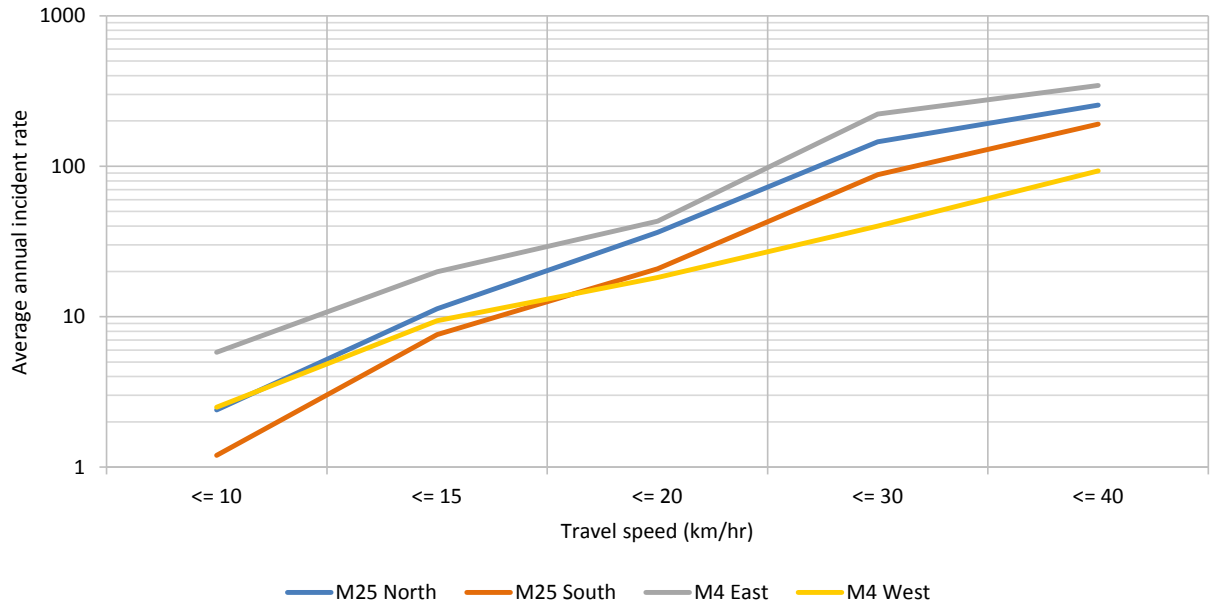
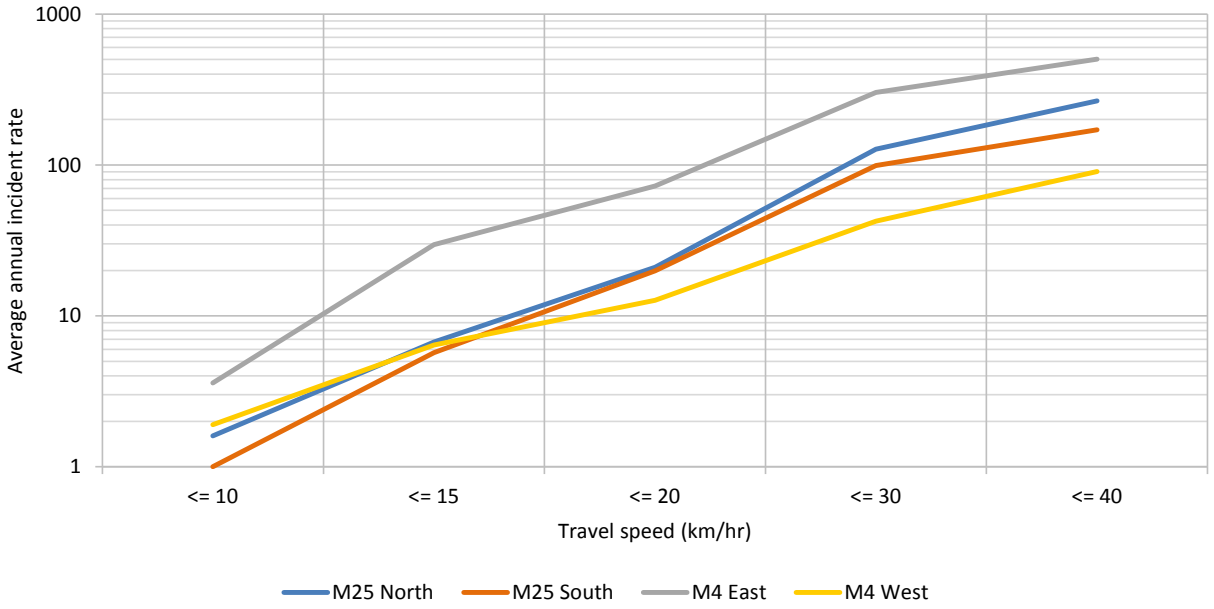



**Figure 3-2: Annual disruptive incident rate - travel towards Heathrow**



3.1.6 The following key conclusions can be drawn from the historic journey time data analysis:

- The occurrence of minor to moderate incidents is extremely frequent, with up to 500 per year on the M4 east. This is most likely due to congestion issues and reflects the very high volumes of traffic carried by the M4 and M25;
- Incident frequency very quickly drops off with increasing severity, with very severe incidents (speed <= 10 km/hr) occurring between 1 and 6 times per year, dependent on location; and
- Travel along the M4 east of Heathrow is the least reliable by a substantial margin. This is reflective of the roads relatively low capacity, with only 2 mainline lanes in each direction, exacerbating the impact of events which generate additional demand or incidents resulting in lane closure.

**Incident impact assessment – highway assignment modelling**

3.1.7 Due to the considerable time required to run and analyse highway assignment model scenarios across all time periods (AM peak, Inter-peak and PM peak), incident impact analysis was limited to the following two locations: **M4 junction 1 to 2**; and **M25 junction 11 to 12**. These two sections of highway were identified as the most highly congested locations, carrying more than 500 airport-related trips under forecast 2030 conditions.

3.1.8 To assess the impact of an incident at each of these locations, the highway assignment models, developed as part of the post-consultation surface access work were used. To simulate the effect of an incident, new scenario runs were completed with the removal of a single lane at each identified location in the direction of travel towards Heathrow.

3.1.9 Figure 3-3 to Figure 3-6 present the AM peak hour flow difference between incident and non-incident model runs for both all traffic and Heathrow-bound traffic only. A full set of figures covering all time periods (AM peak, Inter-peak and PM peak) are included in Appendix C.

**Figure 3-3: M4 incident, AM, flow difference for travel to Heathrow only**

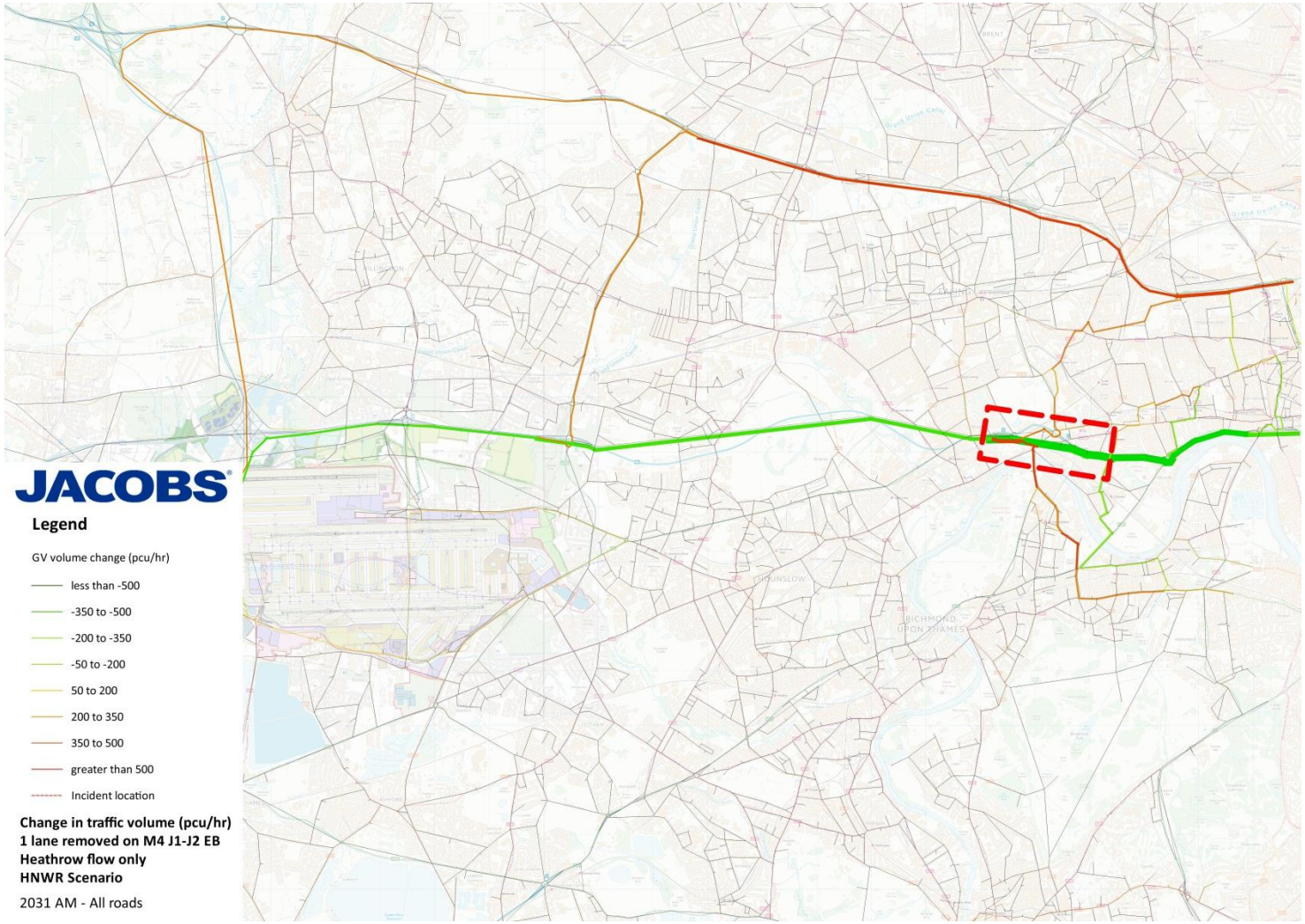


**Figure 3-4: M4 incident, AM, flow difference all vehicles**

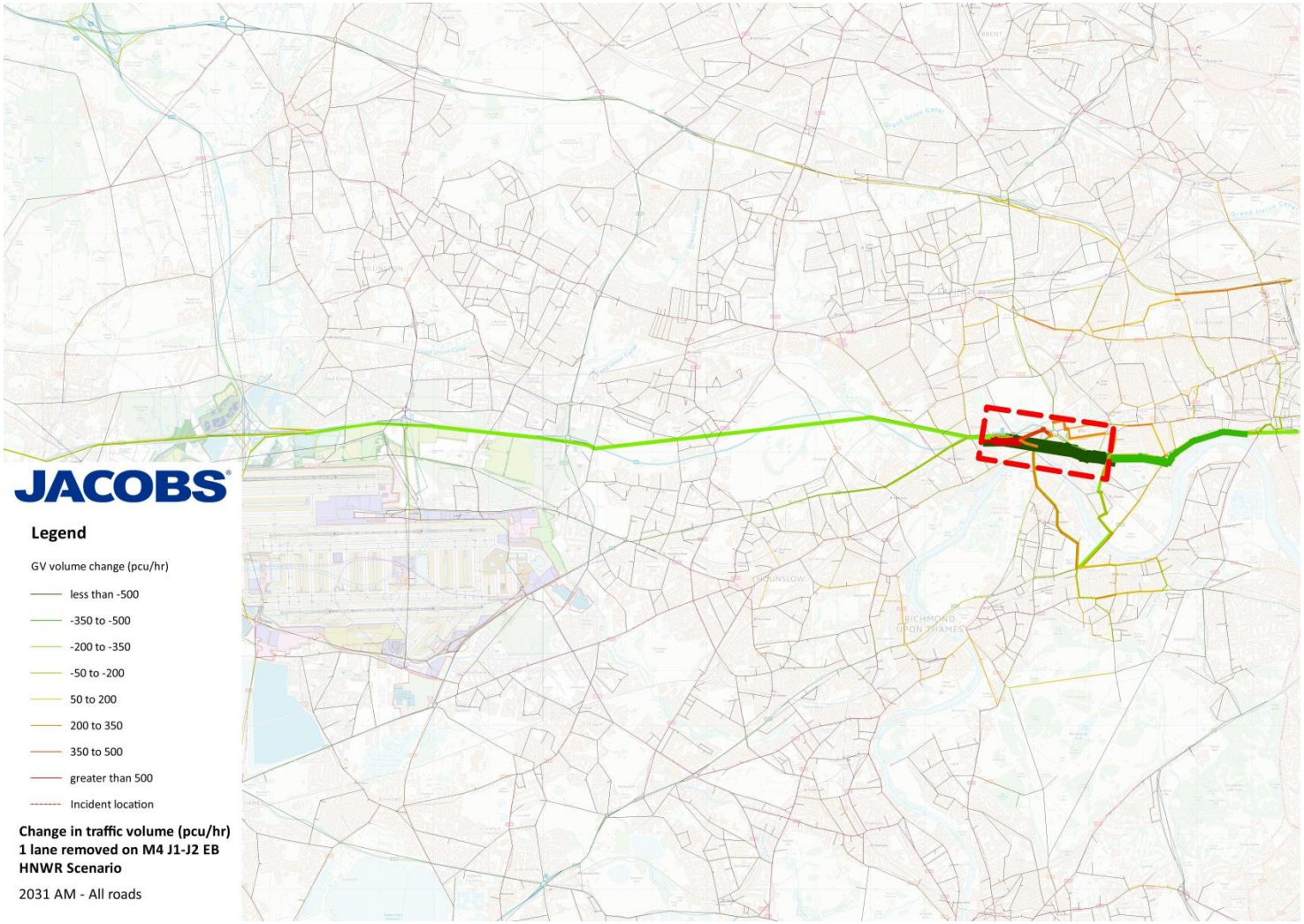


**Figure 3-5: M25 incident, AM, flow difference for travel to Heathrow only**

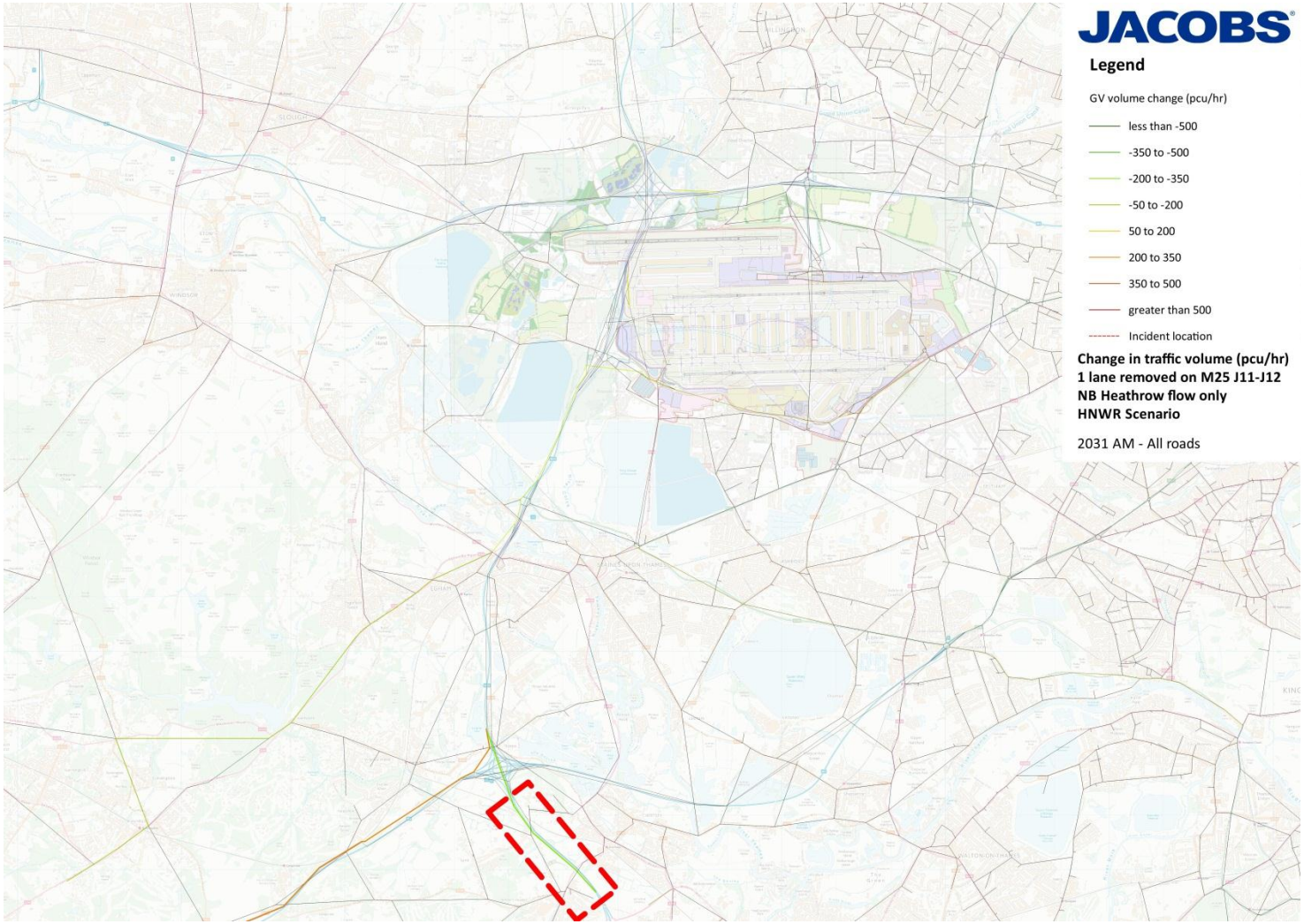
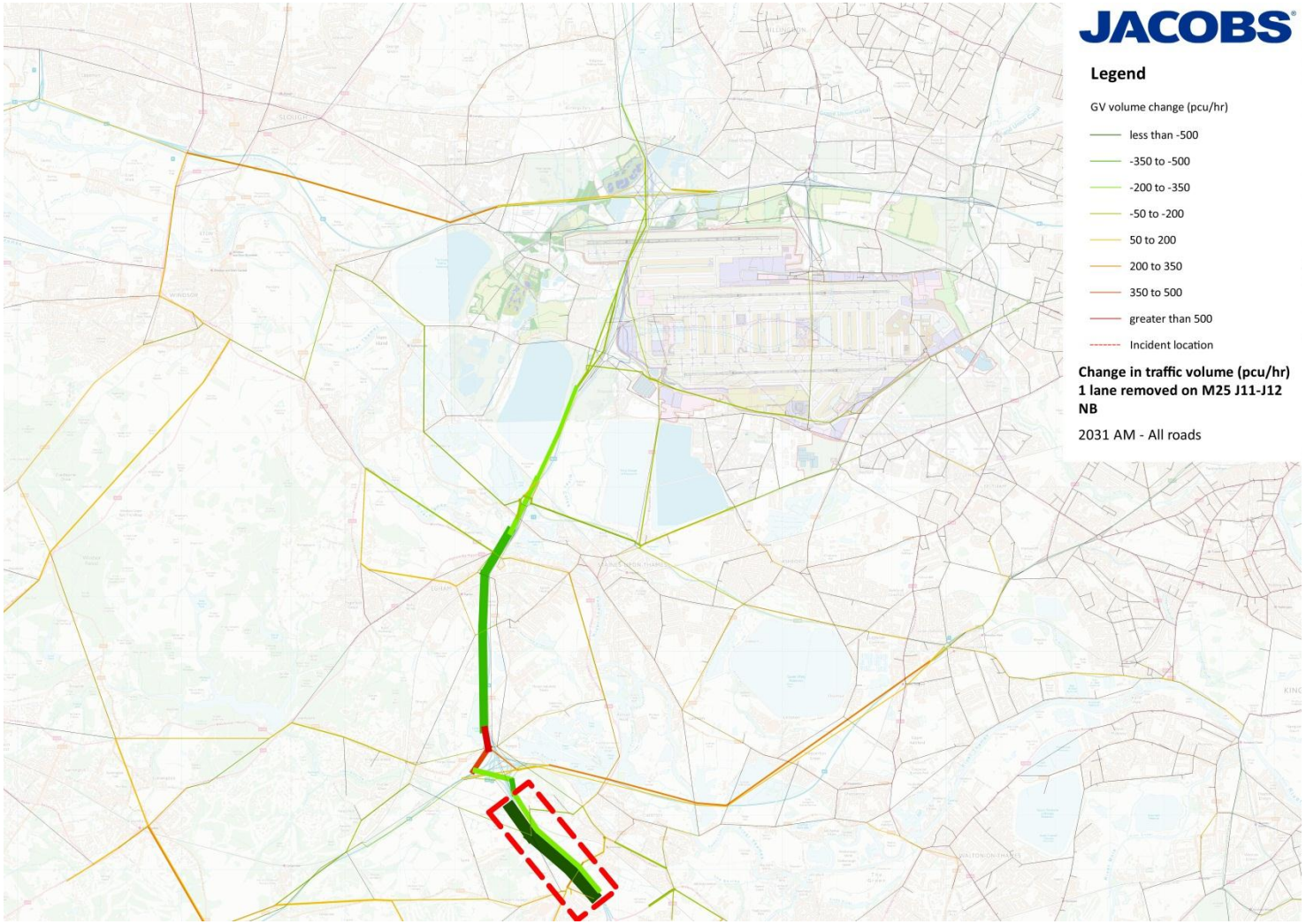


**Figure 3-6: M25 incident, AM, flow difference all vehicles**



3.1.10 Table 3-3 and Table 3-4 present travel speed and queued flow impact results from the M4 and M25 incident models.

**Table 3-3: Incident analysis - travel speed impact**

| | Scenario | |
|---|---|---|
| **Time period** | **Normal conditions** | **Incident** |
| **Travel speed to Heathrow via M4 (km/hr) (Incident on M4 J1 to J2)** | | |
| **AM** | 46.73 | 29.79 (-36%) |
| **IP** | 57.28 | 44.83 (-22%) |
| **PM** | 53.39 | 30.14 (-43%) |
| **Travel speed to Heathrow via M25 (km/hr) (Incident on M25 J11 to J12)** | | |
| **AM** | 51.08 | 39.93 (-22%) |
| **IP** | 60.57 | 52.58 (-13%) |
| **PM** | 55.72 | 47.64 (-14%) |

**Table 3-4: Incident analysis - change in queued flow**

| | Scenario | |
|---|---|---|
| **Time period** | **Normal conditions** | **Incident** |
| **Incident on M4 J1 to J2** | | |
| **AM** | 2.24% | 3.28% (+1.04) |
| **IP** | 0.42% | 0.66% (+0.24) |
| **PM** | 3.19% | 3.28% (+0.09) |
| **Incident on M25 J11 to J12** | | |
| **AM** | 2.24% | 3.32% (+1.08) |
| **IP** | 0.42% | 0.58% (+0.16) |
| **PM** | 3.19% | 3.99% (+0.80) |

3.1.11 The following key conclusions can be drawn from the incident highway assignment modelling:

- A lane closure incident on the M4 east of Heathrow would result in a significant re-routing of traffic travelling to Heathrow airport. This shift would be primarily to the M40 and A312/M25;
- The travel speed impact of an M4 incident is substantial (a reduction of up to 43%). However, the increase in queued flow (vehicles not able to reach their destination within the modelled period) for trips towards Heathrow is relatively modest, indicating the availability of suitable alternative travel routes;
- A lane closure incident on the M25 south of Heathrow would not result in significant re-routing of airport-bound traffic. This is likely due to a combination of the high capacity of M25 reducing the relative impact of closing a single lane, non-airport traffic re-routing and freeing up capacity and the lack of a good alternative route allowing airport traffic to avoid the incident; and
- Travel speed impact of an M25 incident is modest and queued flow impact is similarly modest.

3.1.12 It should be noted that the traffic re-routing results presented relate to the traffic assignment process reaching an iterative equilibrium, so that every user has minimised their own travel time. This implies knowledge of the likely travel conditions ahead of time, which may not be plausible in the immediate aftermath of an incident occurring. Existing variable message signage on the strategic road network is able to provide some travel condition information in response to an incident although the degree to which traffic effectively re-routes in response is likely to be less than the level predicted by the highway assignment model.

**Highway network resilience qualitative review**

3.1.13 To assess the overall resilience of the highway network, travel routes from an urban centre located in four different directions from the airport were evaluated – the four urban centres were identified as follows:

- *North*: Watford;
- *East*: London;
- *South*: Guildford;
- *West*: Reading.

3.1.14 This assessment considers the Heathrow road network in its present state only and does not take into account infrastructure improvements proposed as part of the Heathrow North West Runway (HNWR) Scheme. This approach was adopted because the assessment was high-level in nature, considering capacity only in terms of mainline lane counts and considering travel distances of 24 kilometres or greater. The improvements associated with runway capacity expansion are confined to the area immediately surrounding Heathrow and will not meaningfully impact the outcome of such an assessment.

3.1.15 Use of the highway assignment model developed as part of the post-consultation work to assist with this evaluation was initially considered. This would have allowed the impact of infrastructure improvements and additional traffic demand to be taken into account. However, the model does not have sufficient road network detail to the south and west of Heathrow airport to comparatively evaluate travel from all directions and as such, was deemed not suitable.

3.1.16 Table 3-5 presents a summary of travel routes to Heathrow airport from each direction. Alternative travel routes were identified on the following basis:

- Travel must be primarily along the trunk road network (Motorways and dual carriageway A roads);
- Travel distance must not be more than 100% longer than the primary route; and
- The route must be largely independent of the primary identified route.

3.1.17 Based on the Heathrow travel routes summary information, a qualitative MCA analysis of highway network resilience was undertaken. Performance against the criteria was graded from good to poor (refer Appendix B for grading measures) and assigned a corresponding score (poor +0, moderate +1, good +2), with resilience graded based on the total score as follows:

- Poor: 0 to 2;
- Moderate: 3 to 5;
- Good: 6 to 8.

**Table 3-5: Heathrow Airport travel route summary**

| Route | Capacity[3] | Distance | Travel Time[4] |
|---|---|---|---|
| ***North*: travel from Watford** | | | |
| **Primary:** Hempstead Road, M25 J20 to J15, M4/M4 Spur | 4 lanes | 36 km | 30 – 45 min |
| **Alternative #1:** Stephenson Way, M1 J1 5 to 1, A406, A40, A312, M4/M4 Spur | 2 lanes | 45 km (+25%) | 45 - 90 min (+50% – 100%) |
| ***East*: travel from London** | | | |
| **Primary:** A4, M4/M4 Spur | 2 lanes | 25 km | 30 – 75 min |
| **Alternative #1**: A40, A312, M4/M4 Spur | 2 lanes | 31 km (+24%) | 40 – 110 min (+33% - 68%) |
| **Alternative #2:** A4, M4 J1 to J2, A4, A30, Southern Perimeter road | 2 lanes | 24 km (-4%) | 40 – 100 min (+33% - 33%) |
| **Alternative #3:** A4, A316, A312, A30, Southern Perimeter road | 1 lane | 27 km (+8%) | 45 – 110 min (+50% - 68%) |
| ***South*: travel from Guildford** | | | |
| **Primary:** Stoke Road, A3, M4 J10 to J14, Southern Perimeter Road | 3 lanes | 39 km | 30 – 60 min |
| **Alternative #1:** Stoke Road, A3, A244, A307, A309, A308, School Road/Cockhouse Lane | 1 lane | 42 km (+8%) | 50 – 75 min (+60% - 25%) |
| ***West*: travel from Reading** | | | |
| **Primary:** A329(M), M4 J10 to M4 Spur | 2 lanes | 44 km | 35 – 60 min |
| **Alternative #1:** A329(M), M3 J3 to J2, M25 J12 to J14, Southern Perimeter Road | 2 lanes | 51 km (+16%) | 50 – 90 min (+43% - 50%) |

3.1.18 Table 3-6 presents the results of the highway resilience analysis completed for Heathrow. Based on the adopted assessment criteria, highway network resilience was graded as moderate for all directions except London, where resilience was graded as good. Given the comparatively larger passenger catchment covered by travel from London, overall resilience of the Heathrow highway network was considered to be **good to moderate**.

**Table 3-6: Heathrow highway network resilience MCA analysis**

| Primary route capacity | Availability of alternative routes | Alternative route capacity[5] | Travel time penalty[6] | Resilience grade |
|---|---|---|---|---|
| ***North*: travel from Watford** | | | | |
| Good (+2) | Poor (+0) | Moderate (+1) | Moderate (+1) | **Moderate (4)** |
| ***East*: travel from London** | | | | |
| Moderate (+1) | Good (+2) | Moderate (+1) | Good (+2) | **Good (6)** |
| ***South*: travel from Guildford** | | | | |
| Good (+2) | Poor (+0) | Poor (+0) | Good (+2) | **Moderate (4)** |
| ***West*: travel from Reading** | | | | |
| Moderate (+1) | Poor (+0) | Moderate (+1) | Good (+2) | **Moderate (4)** |

[3] Minimum number of mainline travel lanes for a non-insignificant proportion of journey
[4] Travel time as reported by Google Maps for a typical Wednesday, departing at 5:00pm
[5] Highest capacity alternative route
[6] Fastest alternative travel route

## 3.2 Heathrow Northern Runway Extension

**Incident impact assessment – journey time analysis**

3.2.1 All journey time analysis undertaken as part of this study was conducted based on historic data recorded between 2004 and 2014. As such, the analysis for both proposed Heathrow expansion options is identical. Section 3.1 provides details of the analysis.

**Incident impact assessment – highway assignment modelling**

3.2.2 Due to the considerable time required to run and analyse highway assignment model scenarios across all time periods (AM peak, Inter-peak and PM peak), incident impact analysis was limited to two critical locations, identified as the sections of highway carrying more than 500 airport related trips per hour: **M4 junction 1 to 2**; and **M25 junction 11 to 12**. These two sections of highway were identified as the most highly congested locations carrying more than 500 airport-related trips under forecast 2030 conditions. To assess the impact of an incident at each of these locations, the highway assignment models, developed as part of the post-consultation surface access work were used. To simulate the effect of an incident, new scenario runs were completed with the removal of a single lane at each identified location in the direction of travel towards Heathrow.

3.2.3 Figure 3-7 to Figure 3-10 present the AM peak hour flow difference between incident and non-incident model runs for both all traffic and Heathrow-bound traffic only. A full set of figures covering all time periods (AM peak, Inter-peak and PM peak) are included in Appendix D. Table 3-7 and Table 3-8 present travel speed and queued flow impact results from the M4 and M25 incident models.

**Table 3-7: Incident analysis - travel speed impact**

| | Scenario | |
|---|---|---|
| **Time period** | **Normal conditions** | **Incident** |
| **Travel speed to Heathrow via M4 (km/hr)** | | |
| **AM** | 40.32 | 28.14 (-30%) |
| **IP** | 52.96 | 42.96 (-19%) |
| **PM** | 49.75 | 30.12 (-39%) |
| **Travel speed to Heathrow via M25 (km/hr)** | | |
| **AM** | 36.86 | 33.38 (-9%) |
| **IP** | 45.44 | 41.98 (-8%) |
| **PM** | 38.41 | 34.98 (-9%) |

**Table 3-8: Incident analysis - change in queued flow**

| | Scenario | |
|---|---|---|
| **Time period** | **Normal conditions** | **Incident** |
| **Incident on M4 J1 to J2** | | |
| **AM** | 2.90% | 3.86% (+0.96) |
| **IP** | 0.46% | 0.75% (+0.29) |
| **PM** | 3.17% | 3.36% (+0.18) |
| **Incident on M25 J11 to J12** | | |
| **AM** | 2.90% | 3.50% (+0.60) |
| **IP** | 0.46% | 0.62% (+0.17) |
| **PM** | 3.17% | 3.84% (+0.67) |

**Figure 3-7: M4 incident, AM, flow difference for travel to Heathrow only**

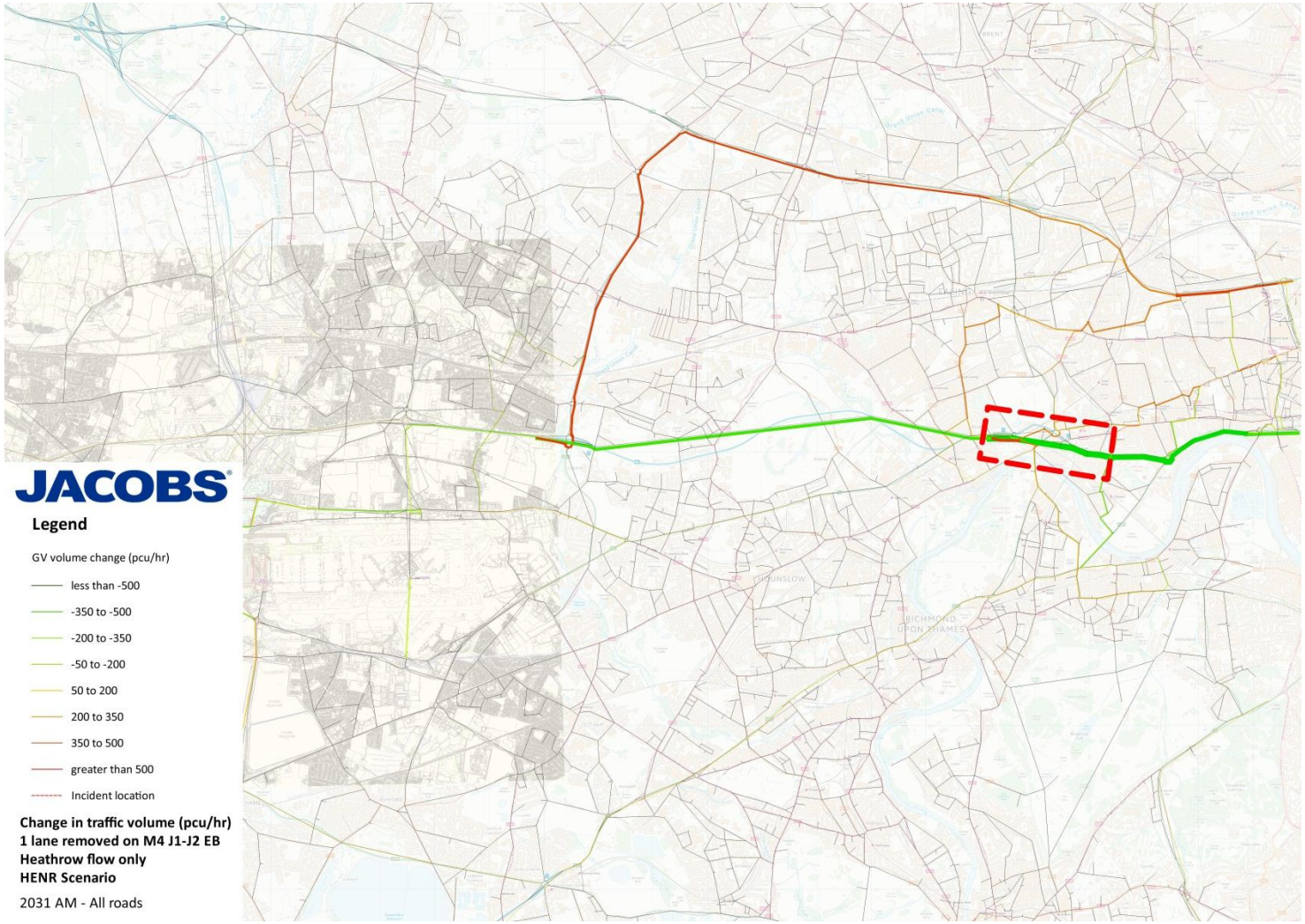


**Figure 3-8: M4 incident, AM, flow difference all vehicles**

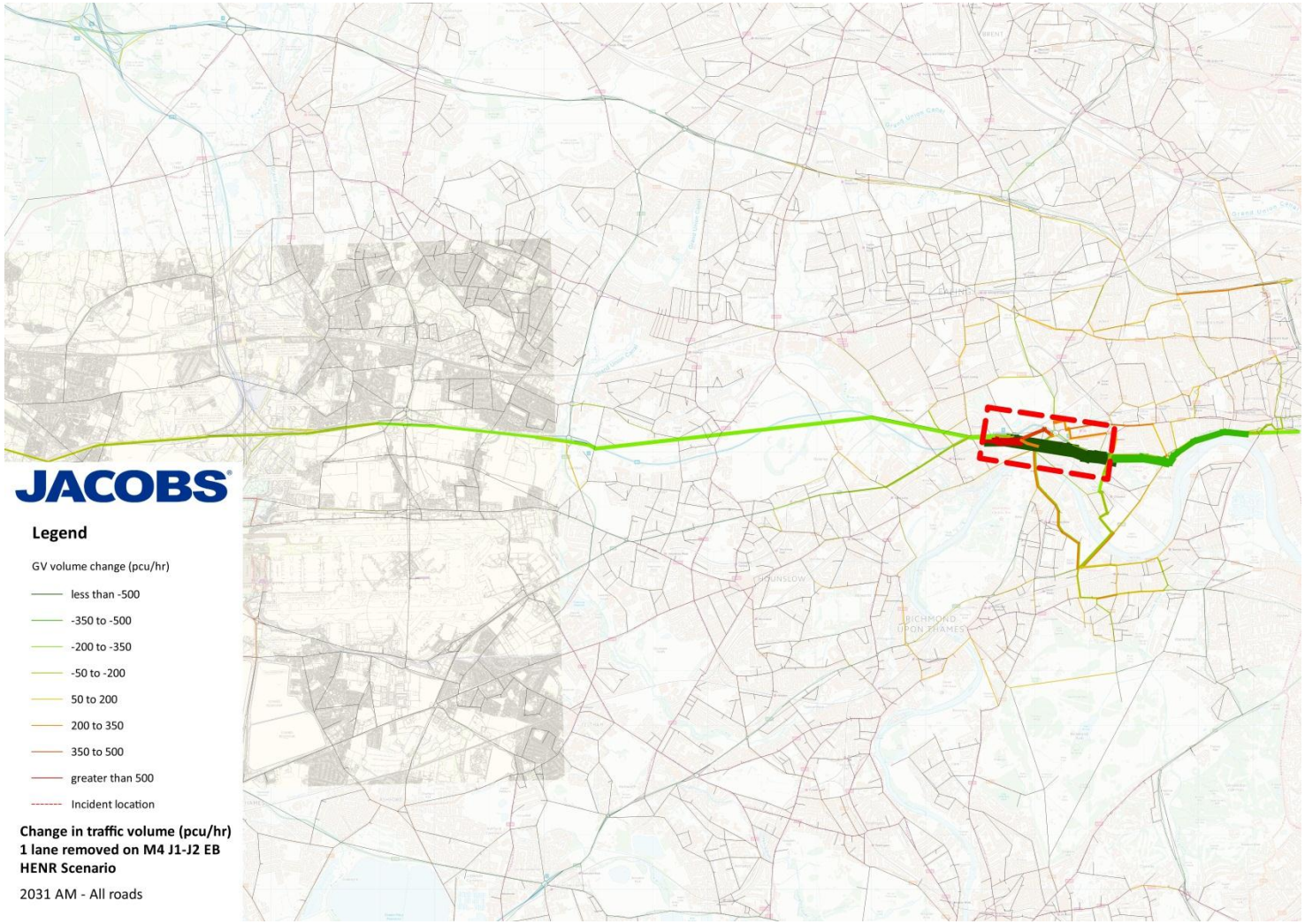


**Figure 3-9: M25 incident, AM, flow difference for travel to Heathrow only**

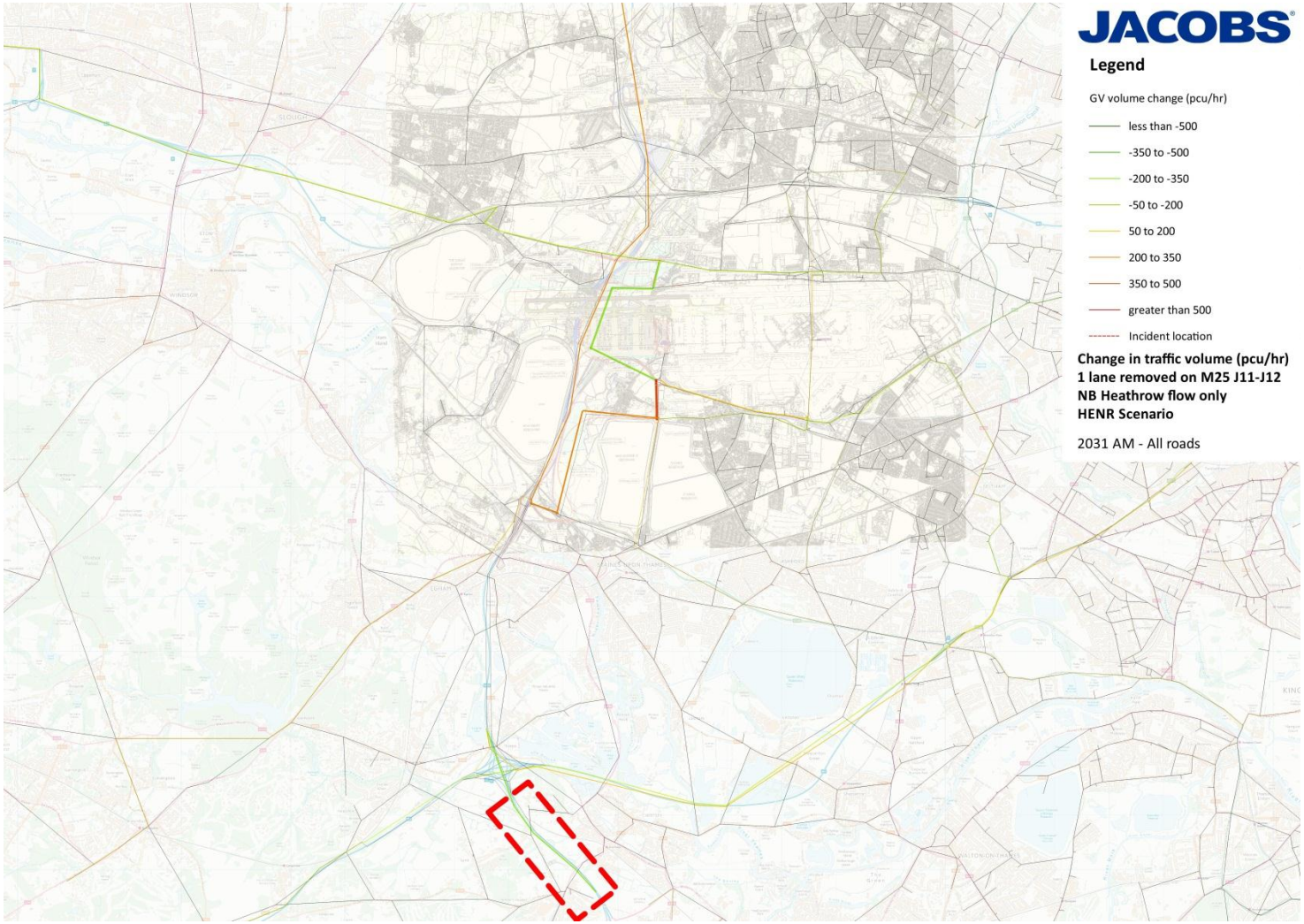
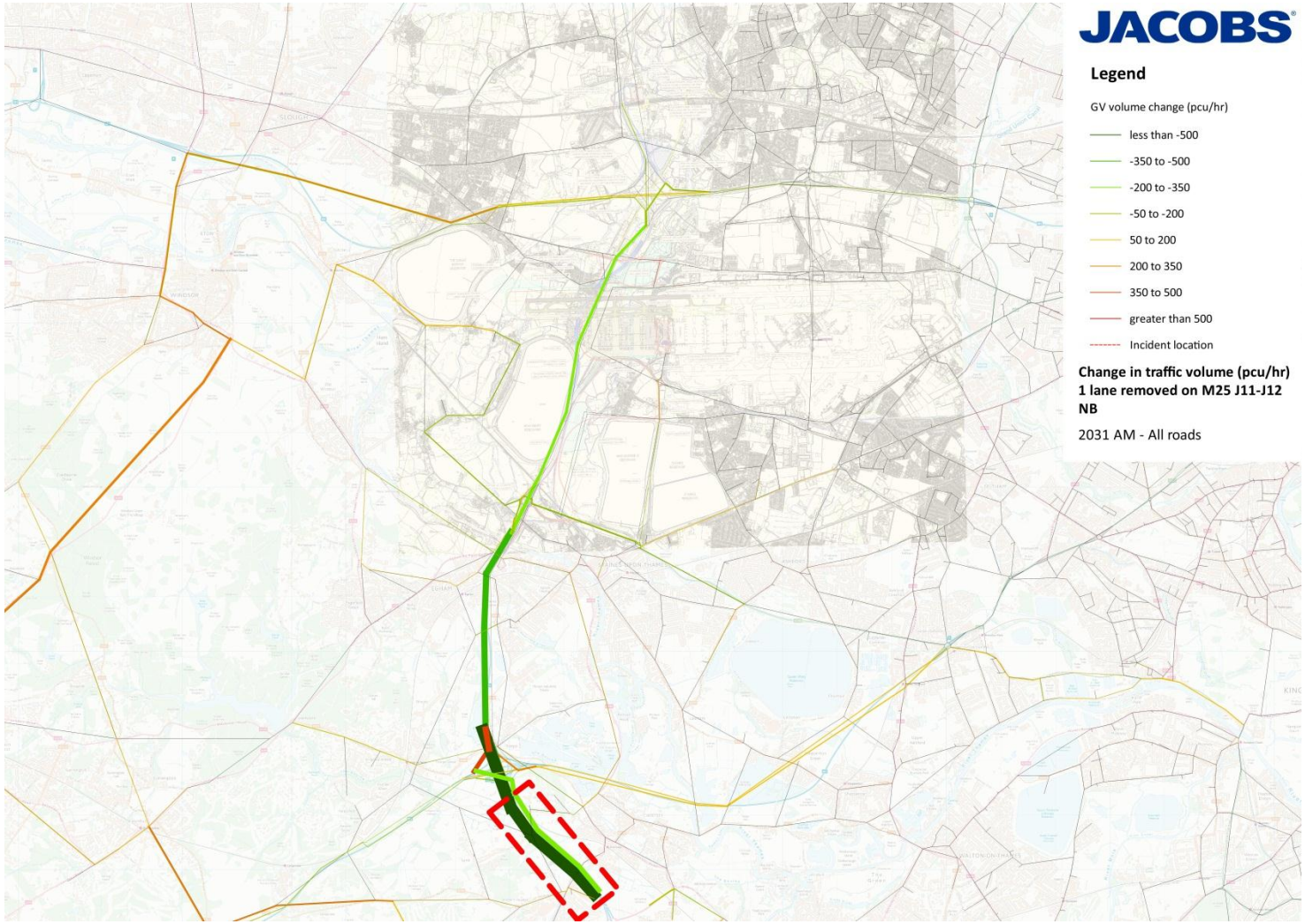


**Figure 3-10: M25 incident, AM, flow difference all vehicles**



3.2.4 The following key conclusions can be drawn from the incident highway assignment modelling:

- A lane closure incident on the M4 east of Heathrow would result in a significant re-routing of traffic travelling to Heathrow airport. This shift would be primarily to the M40 and A312/M25;
- The travel speed impact of an M4 incident is substantial (reduction up to 43%). However, the increase in queued flow (vehicles not able to reach their destination within the modelled period) for trips towards Heathrow is relatively modest, indicating the availability of suitable alternative travel routes;
- A lane closure incident on the M25 south of Heathrow results in traffic from the west re-routing from the M4/A4 to an alternative route via M25 Junction 13. This is likely due to a reduction in traffic volume on the M25 downstream of the incident freeing up capacity at the junction. However, this re-routing is largely occurring outside of the model's detailed simulation area, and as such, may not be an accurate representation of likely travel behaviour; and
- Travel speed impact of an M25 incident is modest while queued flow impact is similarly modest.

3.2.5 It should be noted that the traffic re-routing results presented relate to the traffic assignment process reaching an iterative equilibrium, so that every user has minimised their own travel time. This implies knowledge of the likely travel conditions ahead of time, which may not be plausible in the immediate aftermath of an incident occurring. Existing variable message signage on the strategic road network is able to provide some travel condition information in response to an incident although the degree to which traffic effectively re-routes in response is likely to be less than the level predicted by the highway assignment model.

**Highway network resilience qualitative review**

3.2.6 The Heathrow Northern Runway Extension (HNRE) scheme qualitative resilience review is identical to that of the HNWR scheme referenced in section 3.1.

## 3.3 Gatwick Second Runway

3.3.1 Gatwick Airport is well connected to the strategic motorway network via direct access to the M23 from the spur at Junction 9, providing access towards London, the M25 and the south coast. Local access is provided via the A23 linking the airport with Crawley and other nearby towns.

**Incident impact assessment – journey time analysis**

3.3.2 To assess the likelihood of a disruptive incident occurring on the strategic road network leading to and from Gatwick Airport, analysis of historic travel time data was undertaken to identify the rate at which disruptions currently occur, using journey time data from the Highways Agency (HA) online journey time database[7].

3.3.3 Disruptions were identified on the basis of average hourly travel speed, assuming a significant reduction in speed as indication of an incident – it should be noted that the data did not include any information on the reasons for delays occurring. Incidents were categorised by severity according to observed average travel speed, as follows:

- Very minor: travel speed <= 40km/hr;
- Minor: travel speed <= 30 km/hr;
- Moderate: travel speed <= 20 km/hr;
- Severe: travel speed <= 15 km/hr;

[7] https://jtdb.hatris.co.uk

- Very severe: travel speed <= 10 km/hr.

3.3.4 The occurrence incidents were identified based on absolute travel speed rather than a relative reduction from posted speed because, when outside of free flow conditions, highway speed flow relationships are not dependent to a significant extent on posted speed.

3.3.5 Journey times were obtained from the database on an hourly average basis for six years between 2005 and 2010 (10 years of historic data was not available due to technical issues with the database) at the following locations:

- M23 north (J1 to J9);
- M23 south (J9 to J111);
- M25 east (J3 to J7);
- M4 west (J12 to J7).

3.3.6 Table 3-9, Table 3-10, Figure 3-11 and Figure 3-12 present the results of the journey time data analysis, showing the annual occurrence rate for each incident category.

**Table 3-9: Annual disruptive incident rate - travel towards Gatwick**

| | Location | | | |
|---|---|---|---|---|
| **Incident category** | **M23 north** | **M23 south** | **M25 east** | **M25 west** |
| **Very severe** | 0.2 | 1.0 | 1.8 | 0.5 |
| **Severe** | 0.8 | 1.5 | 7.8 | 7.5 |
| **Moderate** | 1.8 | 3.3 | 18.7 | 21.8 |
| **Minor** | 5.3 | 7.7 | 61.5 | 60.5 |
| **Very Minor** | 9.3 | 15.5 | 123.2 | 137.2 |

**Table 3-10: Annual disruptive incident rate - travel from Gatwick**

| | Location | | | |
|---|---|---|---|---|
| **Incident category** | **M23 north** | **M23 south** | **M25 east** | **M25 west** |
| **Very severe** | 0.2 | 0.8 | 1.0 | 0.8 |
| **Severe** | 0.8 | 1.7 | 5.8 | 5.3 |
| **Moderate** | 2.0 | 3.2 | 18.8 | 13.2 |
| **Minor** | 5.2 | 6.5 | 42.0 | 37.5 |
| **Very Minor** | 13.2 | 10.5 | 72.2 | 95.2 |

**Figure 3-11: Annual disruptive incident rate - travel towards Gatwick**

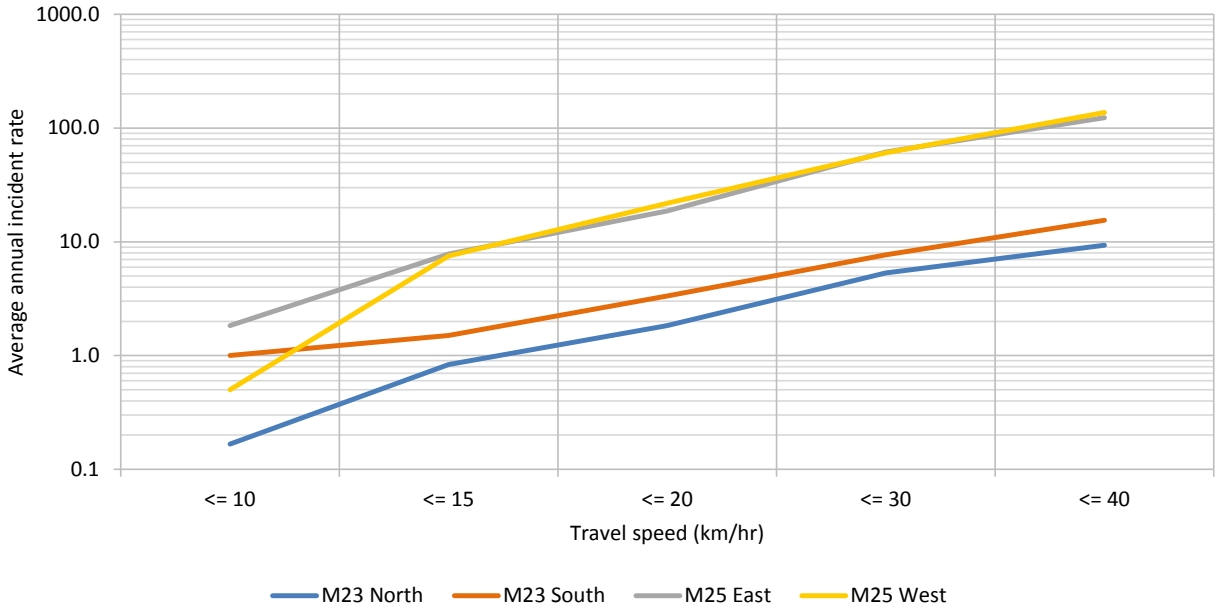
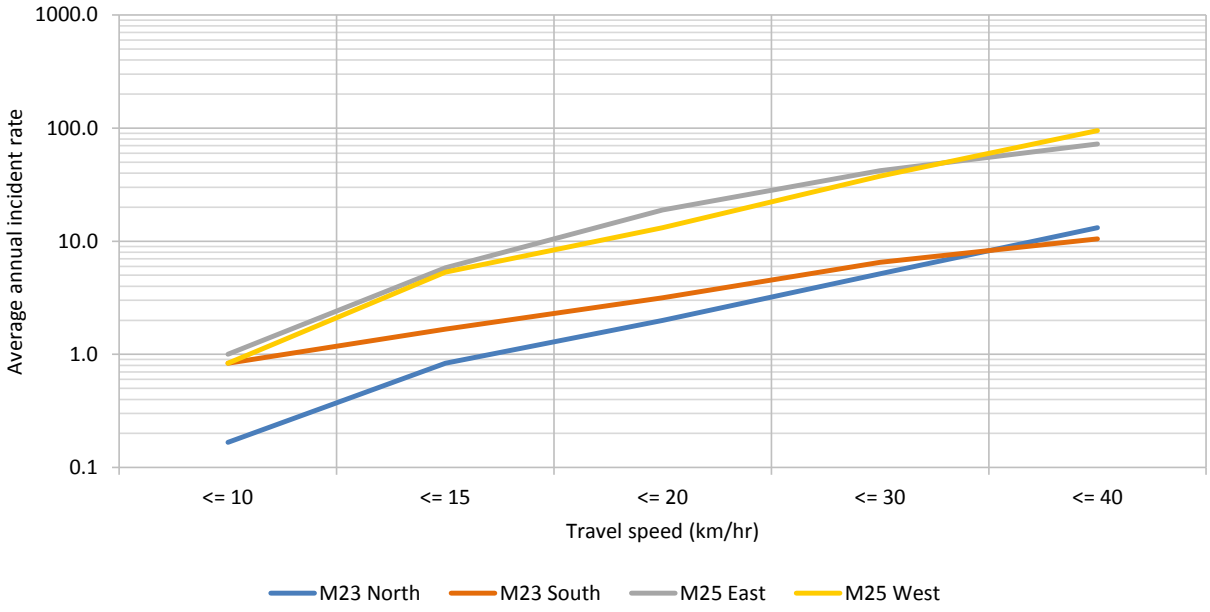



**Figure 3-12: Annual disruptive incident rate - travel towards Gatwick**




3.3.7 The following key conclusions can be drawn from the historic journey time data analysis:

- Minor to moderate incidents frequently occur on the M25, with to up 130 per year on the M25 east. This is most likely due to congestion issues and reflects the very high volumes of traffic carried by the M25;
- Incident frequency very quickly drops off with increasing severity, with very severe incidents (speed <= 10 km/hr) occurring between 0.2 and 1.8 times per year, dependent on location; and
- Travel on the M23 is substantially more reliable than the M25, with all but very severe incidents occurring significantly less frequently. This is most likely due to the comparatively lower level of

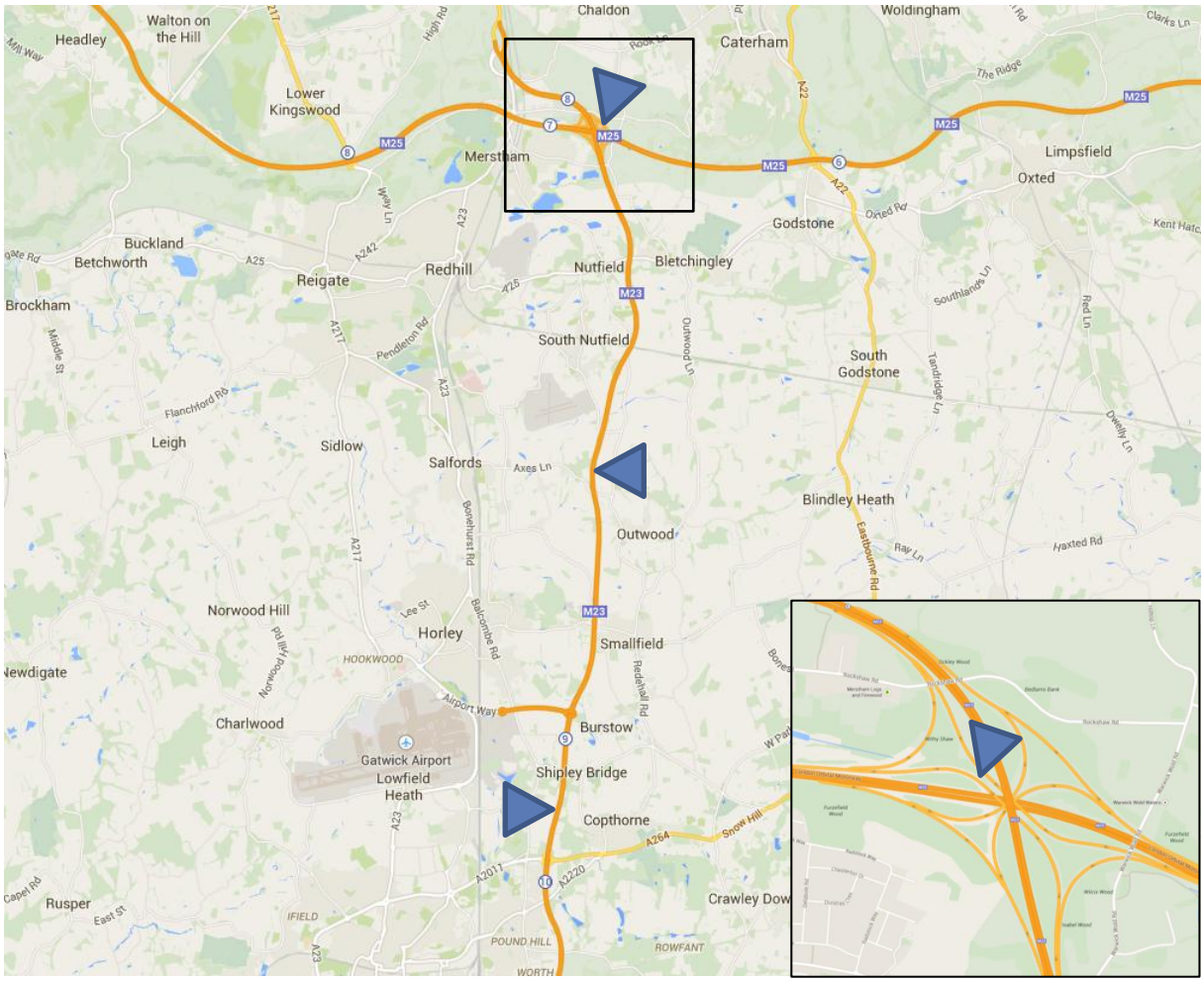
existing congestion on the M23 and the fact that very severe incidents are most likely caused by events forcing lane closure, rather than congestion.

**Incident impact assessment – highway assignment modelling**

3.3.8 Incident impact analysis was considered at three key locations on the strategic network close to Gatwick as follows – these are illustrated on the map in Figure 3-13:

- On the M25 eastbound off ramp heading south east to the M23 southbound;
- On the M23 southbound, north of Junction 9, and
- On the M23 northbound, south of Junction 9.

**Figure 3-13: Gatwick incident location sites**




3.3.9 Incident impacts were assessed using the Gatwick Airport dynamic model developed as part of the post-consultation surface access study.

3.3.10 For the M25 off-slip test, an incident was simulated by removing a single lane (reducing capacity from 2 lanes to 1). For both M23 tests, 2 lanes were removed to achieve a significant capacity decrease as the assessed road links around Gatwick are less congested than those around Heathrow. A single lane closure on the M23 therefore has very little impact on performance.

3.3.11 Figure 3-14 to Figure 3-18 present the AM peak hour flow difference between incident and non-incident model runs for both all traffic and Gatwick-bound traffic only. A full set of figures covering the remaining time periods (Inter-peak and PM peak) is included in Appendix E.

**Figure 3-14: M25 to M23 slip incident, AM flow difference**

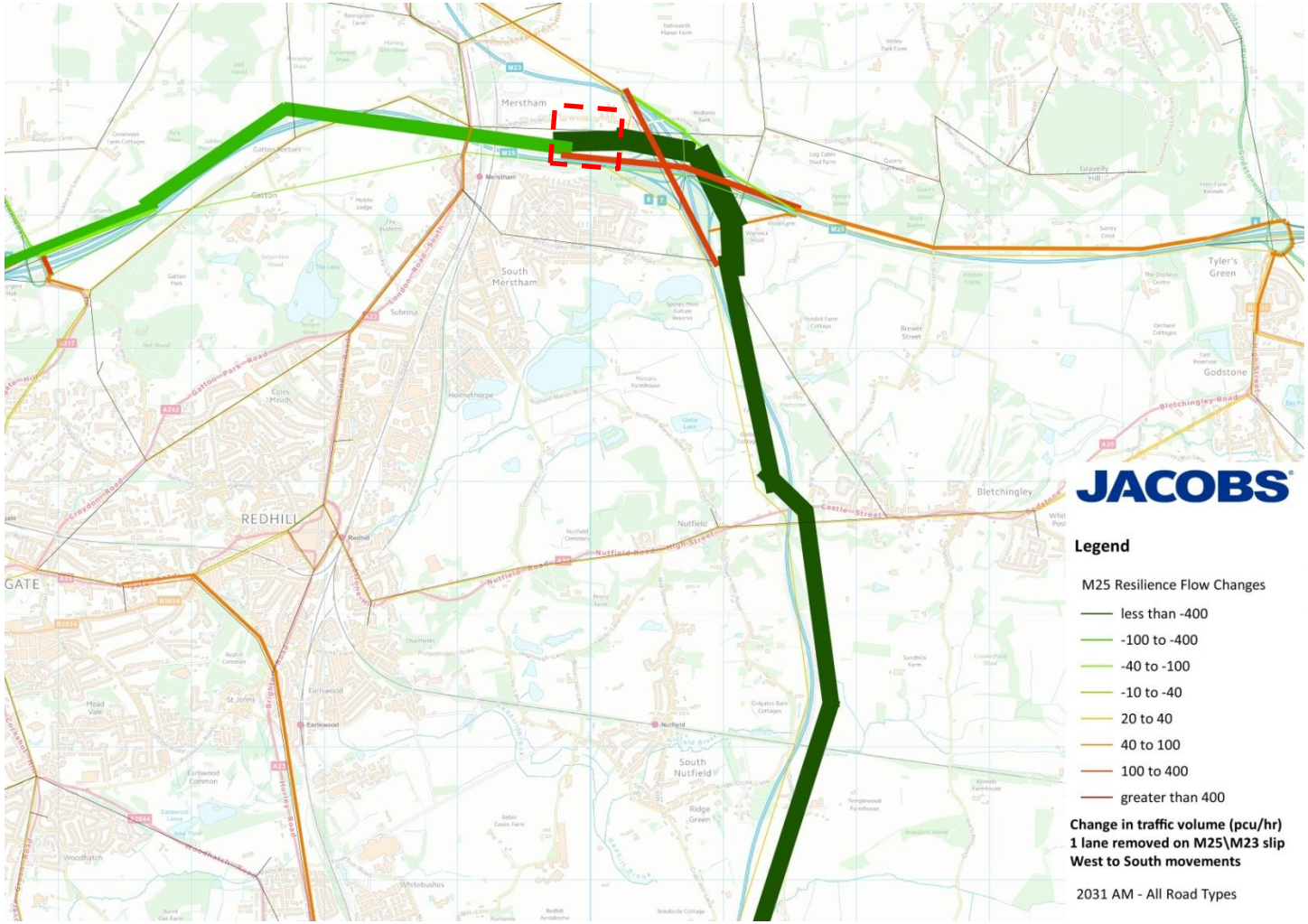


**Figure 3-15: M25 to M23 slip incident, AM flow difference to Gatwick**

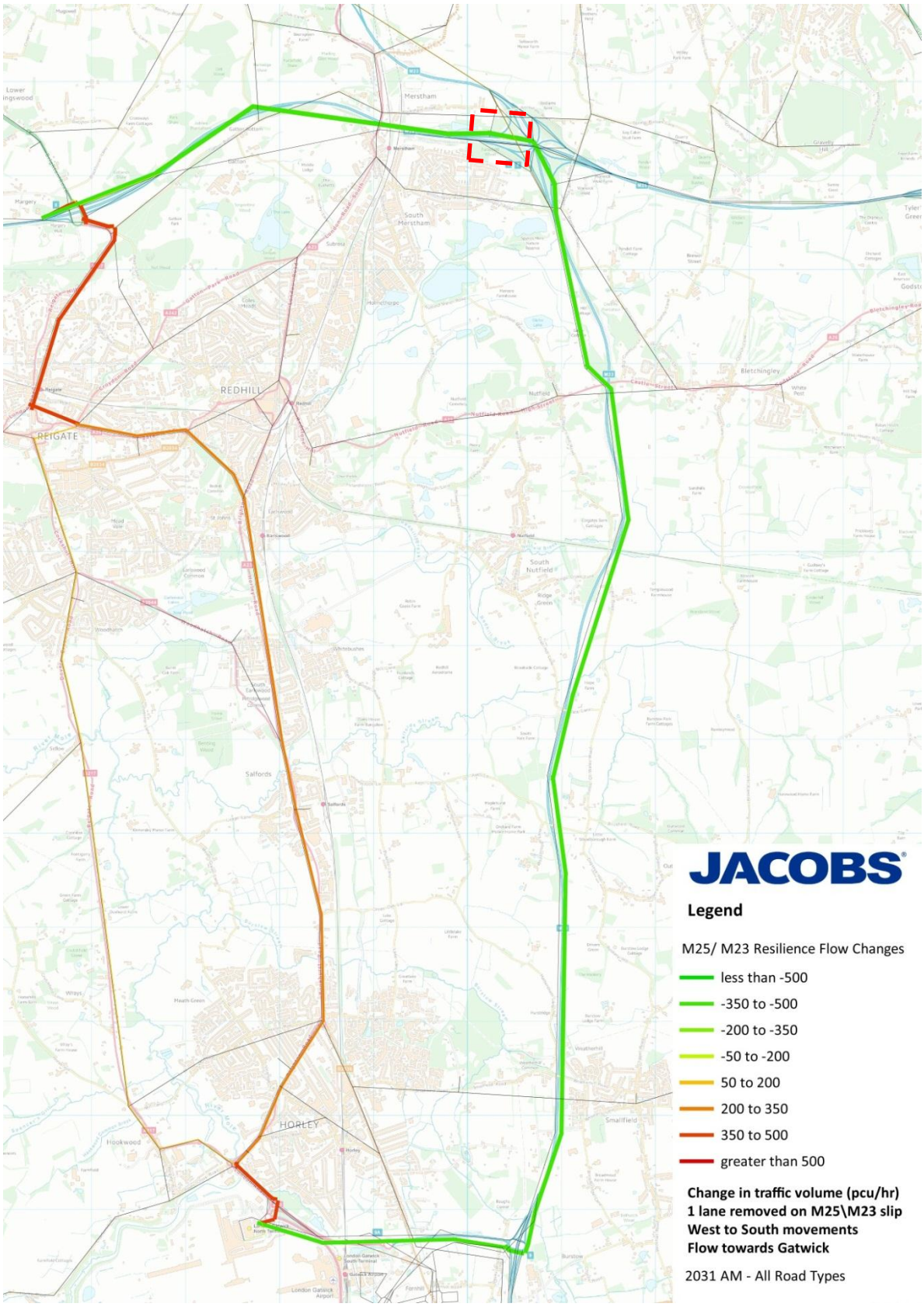


**Figure 3-16: M23 southbound incident, AM flow difference**

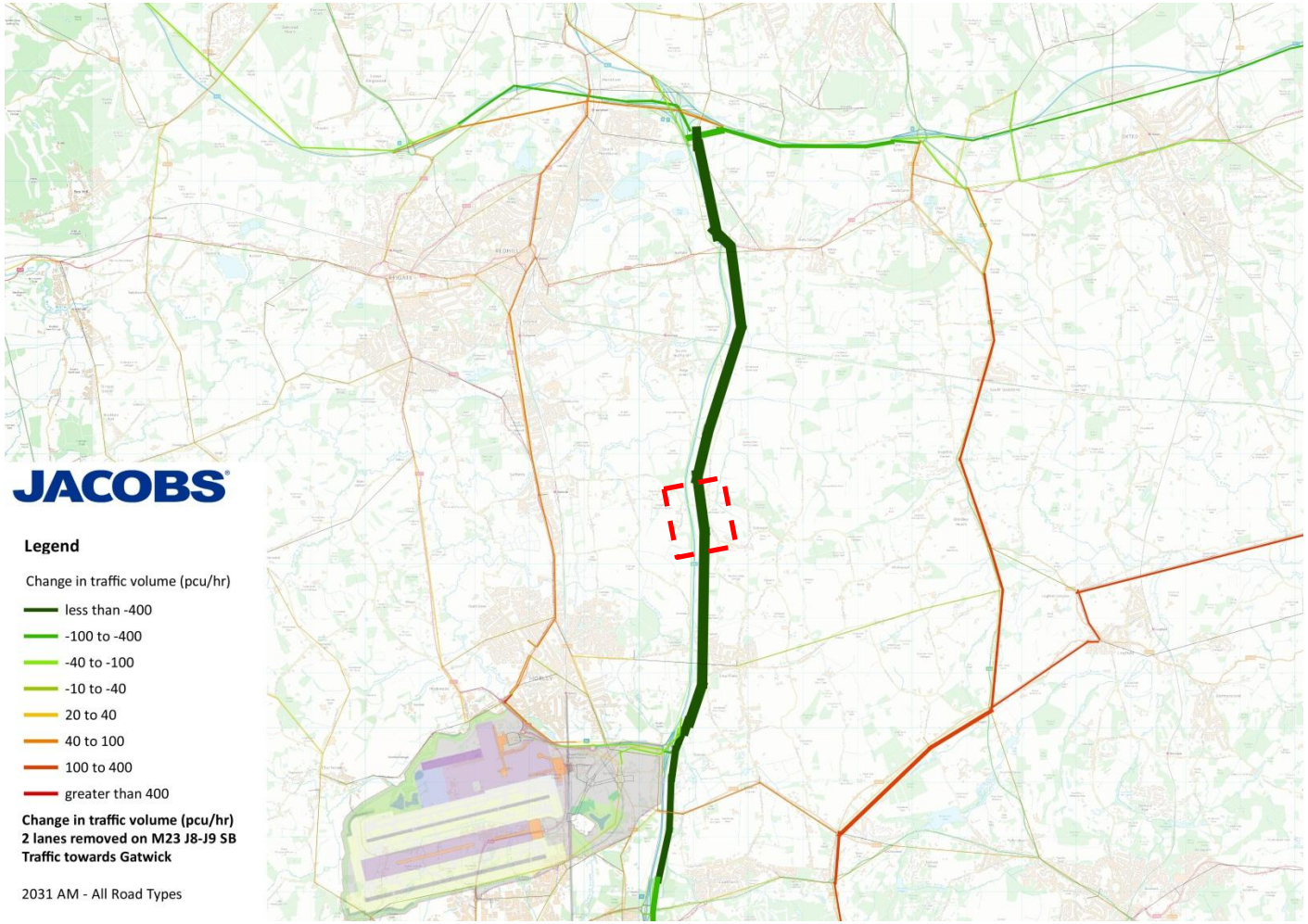


**Figure 3-17: M23 southbound incident, AM flow difference to Gatwick**

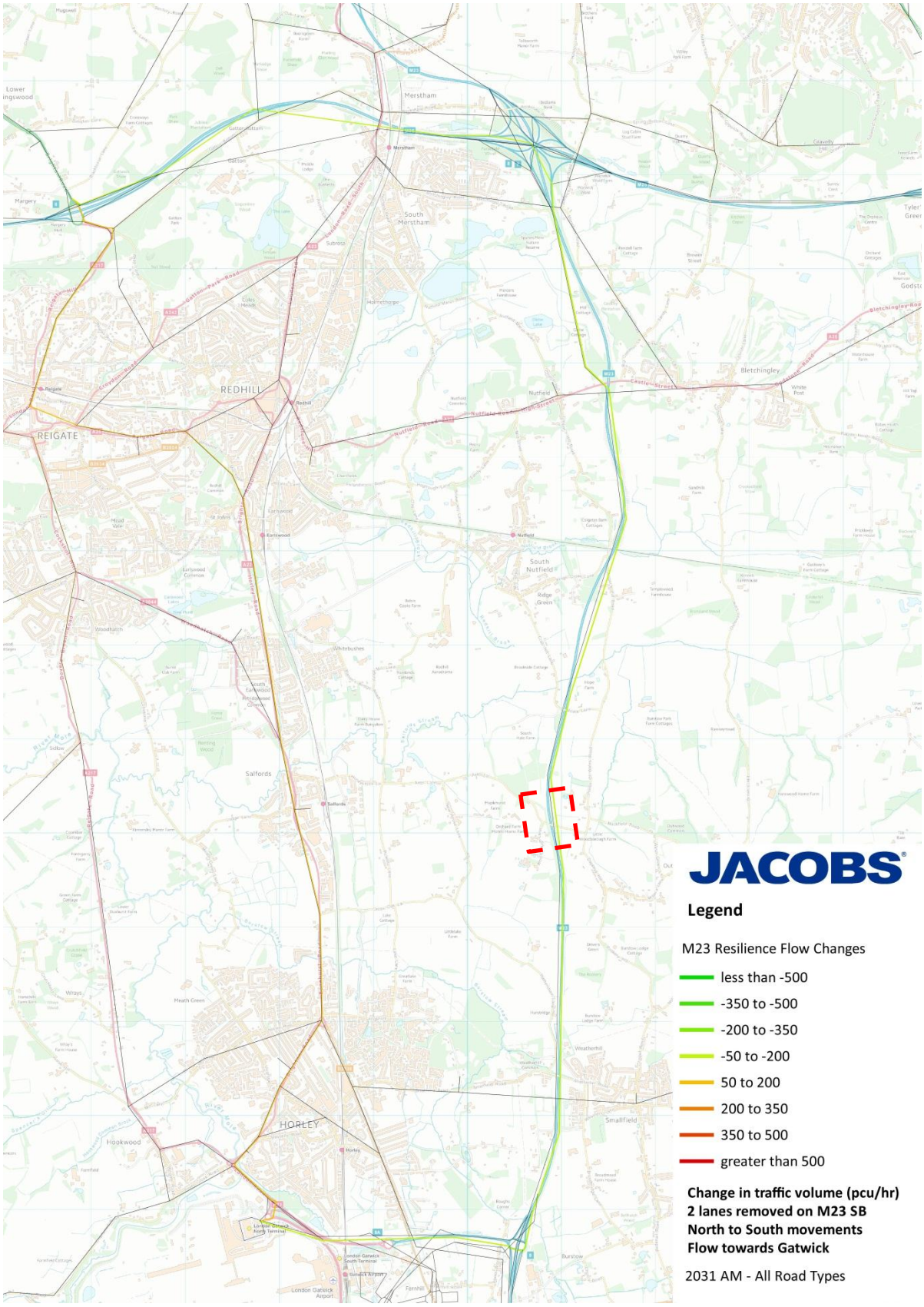
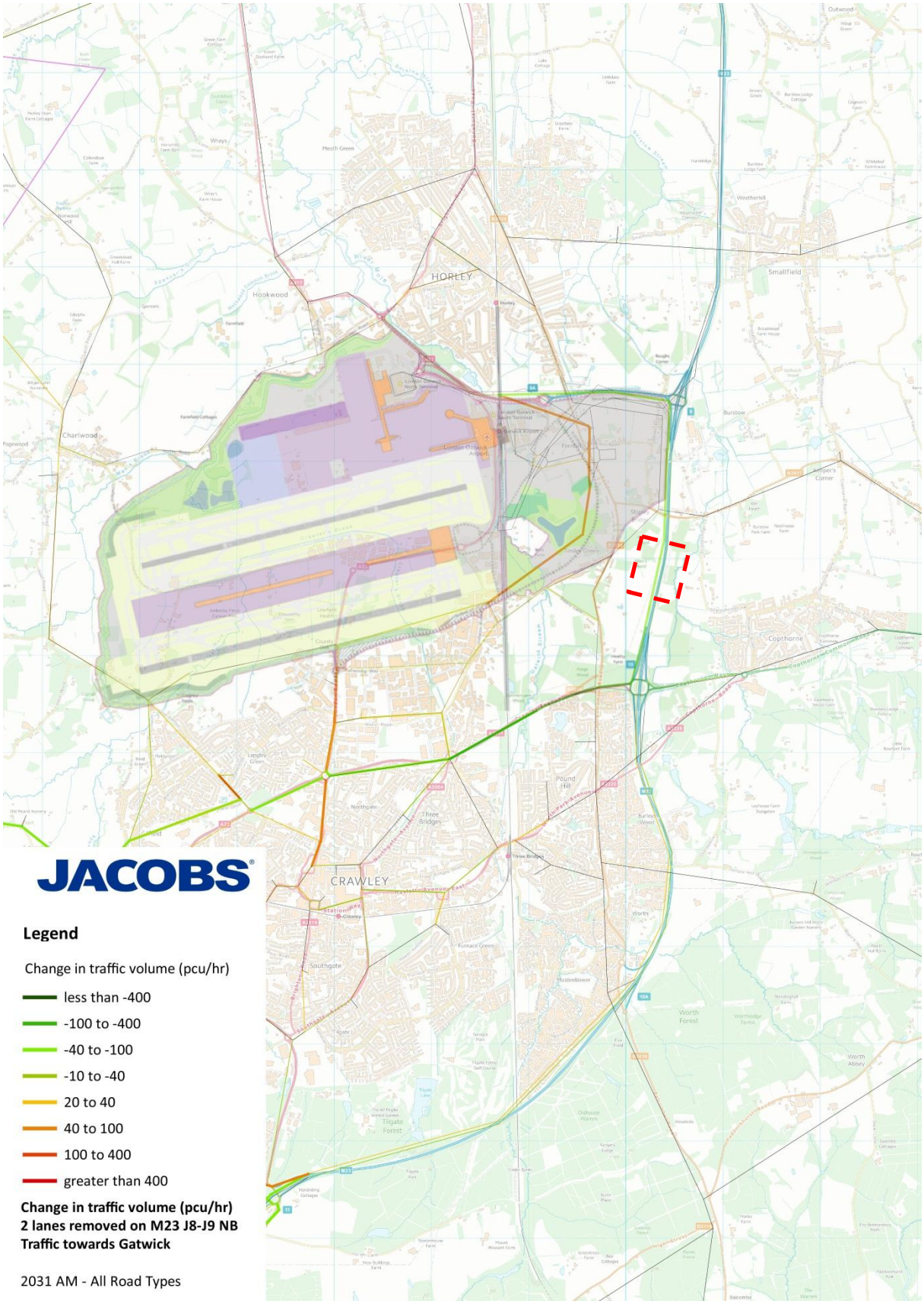


**Figure 3-18: M23 northbound incident, AM flow difference**



3.3.12 Table 3-11 and Table 3-12 present travel speed and queued flow impact results from the M25 and M23 incident models.

**Table 3-11: Incident analysis – travel speed impact**

| | Scenario | |
|---|---|---|
| **Time period** | **Normal conditions** | **Incident** |
| **Travel speed to Gatwick (km/hr) incident on M25 off slip** | | |
| AM | 78.29 | 63.56 (-19%) |
| IP | 85.09 | 81.04 (-5%) |
| PM | 77.89 | 74.32 (-4%) |
| **Travel speed to Gatwick (km/hr) incident on M23 southbound, north of Junction 9** | | |
| AM | 78.29 | 66.79 (-15%) |
| IP | 85.09 | 71.58 (-16%) |
| PM | 77.89 | 65.90 (-15%) |
| **Travel speed to Gatwick (km/hr) incident on M23 northbound, south of Junction 9** | | |
| AM | 79.75 | 77.64 (-3%) |
| IP | 95.85 | 93.90 (-2%) |
| PM | 97.15 | 94.61 (-3%) |

**Table 3-12: Incident analysis - change in queued flow**

| | Scenario | |
|---|---|---|
| **Time period** | **Normal conditions** | **Incident** |
| **Incident on eastbound M25 off slip to M23 southbound** | | |
| AM | 2.36% | 3.16% (0.80) |
| IP | 0.27% | 0.37% (0.11) |
| PM | 2.95% | 3.39% (0.43) |
| **Incident on M23 southbound, north of Junction 9** | | |
| AM | 2.25% | 2.36% (0.11) |
| IP | 0.27% | 0.45% (0.19) |
| PM | 2.95% | 2.91% (0.02) |
| **Incident on M23 northbound, south of Junction 9** | | |
| AM | 2.36% | 2.40% (0.03) |
| IP | 0.27% | 0.27% (0.00) |
| PM | 2.95% | 2.96% (0.01) |

3.3.13 The following conclusions can be drawn from the incident highway modelling:

- A lane closure on the eastbound M25 off slip towards the M23 would result in a re-routing of some traffic travelling to Gatwick Airport. Traffic would primarily divert via Junction 8 of the M25 and then travel via the A23 towards the airport.
- The travel speed impact of such an incident is substantial (-19%) however the increase in queued flow is modest, indicating the availability of alternative routes.
- An incident southbound on the M23 between Junction 8 and 9 results in a similar pattern of diversion. A proportion of southbound traffic on the A23 from inside London switches to the A23 at the Hooley interchange. Some traffic from the M25 west leaves the motorway at Junction 8 to access the airport via the A23. A proportion of traffic from the M25 east travelling towards the

south coast leaves the motorway at Junctions 5 or 6 and diverts via alternative routes including the A21 and A26.

- Both the travel speed impact of such an incident and increase in queued flow are modest, indicating the availability of alternative routes.
- An incident northbound on the M23 between Junction 10 and 9 results in traffic re-routing via the A23 through Crawley. Again, the travel speed impact of such an incident and the increase in queued flow are modest, indicating the availability of alternative routes.

3.3.14 As noted previously, the traffic re-routing results presented relate to the traffic assignment process reaching an iterative equilibrium, so that every user has minimised their own travel time. This implies knowledge of the likely travel conditions ahead of time, which may not be plausible in the immediate aftermath of an incident occurring. Existing variable message signage on the strategic road network is able to provide some travel condition information in response to an incident although the degree to which traffic effectively re-routes in response is likely to be less than the level predicted by the highway assignment model.

**Highway network resilience qualitative review**

3.3.15 To assess the overall resilience of the highway network, travel routes from an urban centre located in four different directions from the airport were evaluated – the four urban centres selected were as follows:

- *North*: London;
- *East*: Thurrock;
- *South*: Brighton;
- *West*: Reading.

3.3.16 This assessment considers the Gatwick road network in its present state only and does not take into account infrastructure improvements proposed as part of the Gatwick Second Runway Scheme. This approach was adopted because the assessment is high-level in nature, considering capacity only in terms of mainline lane counts and considering travel distances of 24 kilometres or greater. The road improvements proposed to support a Second Runway are confined to the area immediately surrounding Gatwick and will not meaningfully impact the outcome of such an assessment.

3.3.17 Use of the highway assignment model developed as part of the post-consultation work was initially considered to assist with this evaluation. This would have allowed the impact of infrastructure improvements and additional traffic demand to be taken into account. However, the model does not have sufficient road network detail away from Gatwick Airport to comparatively evaluate travel from all directions and as such, was deemed not suitable.

3.3.18 Table 3-13 presents a summary of travel routes to Gatwick from each direction. The presented alternative travel routes were identified on the following basis:

- Travel must be primarily along the trunk road network (Motorways and dual carriageway A roads);
- Travel distance must not be more than 100% longer than the primary route; and
- The route must be largely independent of the primary route identified.

**Table 3-13: Gatwick Airport travel route summary**

| Route | Capacity[8] | Distance | Travel Time[9] |
|---|---|---|---|
| ***North*: travel from London** | | | |
| **Primary:** A23, M23 J1 to 9, M23 Spur | 1 | 44.6 | 60 – 120 min |
| **Alternative #1:** A23, A22, A264, M23 J10 to J9, M23 Spur | 1 lane | 63 km (+40%) | 85 - 150 min (+42% – 25%) |
| **Alternative #2:** A24, A264, m23 J11 to J9, M23 Spur | 1 lane | 81 km (+78%) | 110 – 160 min (+83% – 33%) |
| ***East*: travel from Thurrock** | | | |
| **Primary:** A282, M25 J1 to J7, M23 J8 to J9, M23 Spur | 3 lanes | 65 km | 45 – 60 min |
| **Alternative #1**: A282, A2, A23, A264, M23 J10 to J9, M23 Spur | 1 lane | 93 km (+43%) | 120 – 150 min (+166% - 150%) |
| ***South*: travel from Brighton** | | | |
| **Primary:** A23, M23 J11 to J9, M23 Spur | 3 lanes | 43 km | 35 – 45 min |
| **Alternative #1:** A27, A,26, A22, A264, M23 J10 to J9, M23 Spur | 1 lane | 65 km (+51%) | 70 – 100 min (+100% - 122%) |
| **Alternative #2:** A27, A283, A24, A264, M23 J11 to J9, M23 Spur | 1 lane | 81 km (+88%) | 65 – 85 min (+86% - 89%) |
| ***West*: travel from Reading** | | | |
| **Primary:** A329(M), M4 J10 to M25 J15, M25 J15 to | 3 lanes | 102 km | 65 – 120 min |

3.3.19 Based on the Gatwick travel routes summary information, a qualitative MCA analysis of highway network resilience was undertaken. Performance against the criteria was graded from good to poor (refer Appendix B for grading measures) and assigned a corresponding score (poor +0, moderate +1, good +2), with resilience graded based on the total score as follows:

- Poor: 0 to 2;
- Moderate: 3 to 5;
- Good: 6 to 8.

3.3.20 Table 3-14 presents the results of the highway resilience analysis completed for Gatwick. Based on the adopted assessment criteria, highway network resilience for travel to Gatwick Airport is shown to be **moderate to poor**.

[8] Minimum number of mainline travel lanes for a non-insignificant proportion of journey
[9] Travel time as reported by Google Maps for a typical Wednesday, departing at 5:00pm

**Table 3-14: Gatwick highway network resilience MCA analysis**

| Primary route capacity | Availability of alternative routes | Alternative route capacity[10] | Travel time penalty[11] | Resilience grade |
|---|---|---|---|---|
| ***North*: travel from London** | | | | |
| Poor (+0) | Moderate (+1) | Poor (+0) | Good (+2) | **Moderate (3)** |
| ***East*: travel from Thurrock** | | | | |
| Good (+2) | Poor (+0) | Poor (+0) | Poor (+0) | **Poor (2)** |
| ***South*: travel from Brighton** | | | | |
| Good (+2) | Moderate (+1) | Poor (+0) | Moderate (+1) | **Moderate (4)** |
| ***West*: travel from Reading** | | | | |
| Good (+2) | N/A (+0) | N/A (+0) | N/A (+0) | **Poor (2)** |

[10] Highest capacity alternative route
[11] Fastest alternative travel route

# 4. Rail resilience analysis

## 4.1 Network Rail overview (2010/11 to 2014/15)

4.1.1 The starting point for the rail resilience analysis was to review network-wide issues for the time period 2010/1 to 2014/5 to provide context for the discussion of individual routes and services provided later in this chapter. As indicated in the chapter on methodology earlier in this report, the basis of the review of rail resilience was data provided by NR for this 5-year period.

4.1.2 A summary of the main issues affecting the network over this 5-year period are as follows:

- 2010/11: NR responsibility delay minutes increased by 9% over the previous year – the main contributor to the increase was the severe weather experienced during November and December 2010;
- 2011/12: the Public Performance Measure (PPM) rose to 91.6% at the year-end, which was an improvement of 0.7% from the previous year – NR minutes delay also decreased by 6% although train mileage increased by 4% – the improvements in performance were attributed to less severe weather than anticipated and investment in autumn mitigations;
- 2012/13: during 2012, operational performance in England and Wales was badly affected by adverse weather – in December, large sections of the network suffered severe flooding and weather-related delays were therefore 142% worse than in 2011/12;
- 2013/14: weather-related events were once again the main cause of delay with flooding and gales causing widespread disruption while in December snow and ice affected reliability – PPM, at 90%, was 2.5% behind the regulatory target;
- At the commencement of Control Period 5 (CP5) in 2014/15, NR performance was less than the final regulatory CP4 performance trajectory and plans were put in place to bring performance to target level during 2016 – the Office of Rail Regulations Quarter (ORR) 1 and 2 reports for NR describe the plans as achieving their milestones but not improving performance and NR is reviewing the plans – one area identified is the level of reactionary delay when an incident occurs, which may indicate a more congested network.

## 4.2 Heathrow Airport

**Western region overview**

4.2.1 During 2010/11 the main reason for delays was weather-related events during the winter period. In 2012/13 severe weather caused problems, particularly with embankments at coastal locations, for example in Devon and Cornwall. The revised timetable in operation at Reading during its re-modelling also affected performance.

4.2.2 Similar to the national situation in 2013/14 the main cause of delay was weather-related with rising groundwater in the Thames Valley causing flooding problems. At Maidenhead a single flooding incident caused 55,000 minutes of delay. The weather also caused significant disruption to FGW services across the entire operating network. Overall NR performance was worse than planned at 279,000 minutes over target. Progress however with the Reading redevelopment resulted in a reduction in reactionary delays during the latter part of the year.

### Heathrow Connect

4.2.3 Table 4-1 provides summary performance statistics for Heathrow Connect services over the 5-year period. The table indicates that across the period, the CaSL statistic was at 25 per 1,000 services, indicating the number of scheduled services that were either fully or partially cancelled or arrived at their destination over 30 minutes late when compared with the timetabled arrival time. Of this, approximately 3 per 1,000 were related to NEPs, for example the Crossrail works programme.

4.2.4 In terms of total minutes of delay per 1,000 trains, the total for Heathrow Connect was 356 minutes, of which 20 were related to NEPs and a further 12 were logged with an unknown cause. Minutes delay does not include services falling into the CaSL category and therefore represents an independent performance indicator, although in some cases the underlying causes for both may be similar.

**Table 4-1: Heathrow Connect services**

| | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Total |
|---|---|---|---|---|---|---|
| **CaSL per 1,000 trains** | | | | | | |
| NEP | 0 | 0 | 9 | 3 | 6 | 3 |
| Non NEP | 15 | 18 | 21 | 21 | 46 | 22 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **15** | **19** | **30** | **25** | **53** | **25** |
| **Total mins delay per 1,000 trains** | | | | | | |
| NEP | 3 | 7 | 16 | 50 | 51 | 20 |
| Non NEP | 231 | 304 | 368 | 382 | 477 | 324 |
| Unknown | 8 | 12 | 15 | 14 | 19 | 12 |
| **Total** | **241** | **324** | **399** | **445** | **547** | **356** |

4.2.5 The top 5 delays affecting Heathrow Connect services over the reference period were:

- technical fleet delays (10,013 mins);
- train crew causes (4,208);
- point failures (3,340);
- train operations (3,094);
- track circuit failures (3,062).

4.2.6 Across the period, some 57% of delay minutes on services could be attributed to NR, with the remainder related to delays caused by TOCs.

4.2.7 During 2014/15 there was an increase in CaSL, which was likely to be partly caused by the Christmas engineering overrun that affected Paddington. A comparison of the Heathrow Connect figures with the HEX and FGW figures, described later in this section, indicates the impact of the priority given to HEX services over other services on the GWML when disruption occurs.

### Heathrow Express

4.2.8 Table 4-2 summarises performance on HEX over the same 5-year period. The table indicates that the CaSL statistic for HEX was 13 services per 1,000, which is significantly lower than the equivalent figure for Heathrow Connect. However, the table also indicates that total minutes delay for HEX was 681 per 1,000 trains, suggesting that HEX is more frequently subject to smaller duration delays while Heathrow Connect is subject to more CaSL.

**Table 4-2: Heathrow Express services**

| | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Total |
|---|---|---|---|---|---|---|
| **CaSL per 1,000 trains** | | | | | | |
| NEP | 0 | 0 | 7 | 1 | 1 | 2 |
| Non NEP | 12 | 8 | 11 | 11 | 16 | 11 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **12** | **8** | **17** | **12** | **17** | **13** |
| **Total mins delay per 1,000 trains** | | | | | | |
| NEP | 8 | 22 | 61 | 68 | 53 | 42 |
| Non NEP | 555 | 574 | 630 | 634 | 746 | 624 |
| Unknown | 13 | 10 | 14 | 16 | 25 | 15 |
| **Total** | **576** | **606** | **706** | **717** | **823** | **681** |

4.2.9 The top 5 delays affecting HEX over the reference period were:

- technical fleet delays (33,648 mins);
- point failures (15,278);
- track circuit failures (13,017);
- external fatalities and trespass (11,135);
- severe weather beyond the capability of the infrastructure (4,632).

**FGW (GWML)**

4.2.10 Table 4-3 summarises performance on FGW routes between Reading and Paddington over the 5-year time period. The table indicates that in terms of CaSL, performance on FGW services was worse than both Heathrow Connect and HEX, with 41 services per 1,000 impacted. Similarly, total minutes delay is at 3,766 per 1,000 services, substantially higher than HEX or Heathrow Connect, indicating that FGW services not subject to CaSL were on average late by almost 4 minutes across the time period assessed.

**Table 4-3: First Great Western**

| | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Total |
|---|---|---|---|---|---|---|
| **CaSL per 1,000 trains** | | | | | | |
| NEP | 2 | 3 | 6 | 4 | 7 | 4 |
| Non NEP | 36 | 28 | 39 | 42 | 41 | 37 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **38** | **31** | **45** | **46** | **48** | **41** |
| **Total mins delay per 1,000 trains** | | | | | | |
| NEP | 137 | 184 | 217 | 253 | 301 | 216 |
| Non NEP | 3,229 | 3,065 | 3,548 | 3,776 | 3,557 | 3,431 |
| Unknown | 102 | 101 | 106 | 123 | 164 | 119 |
| **Total** | **3,469** | **3,351** | **3,871** | **4,152** | **4,022** | **3,766** |

4.2.11 The top five delays affecting FGW services over the reference period were as follows:

- technical fleet delays (665,079 mins);
- external fatalities and trespass (225,022);

- severe weather beyond the capability of the infrastructure (224,265);
- track circuit failures (203,940);
- points failures (200,262).

4.2.12 The table indicates that NEPs affected the performance of FGW services that operated in the Thames Valley to a degree – some 10% of CaSL and 6% of total minutes delay was attributed to these projects over the time period assessed. It is worth noting that the figures in the table related to NEPs indicate the disruption that is directly attributable to those programmes, for example disruption specifically identified as being related to the over-running of engineering works.

4.2.13 However, other delays not categorised as related to NEPs may actually be indirectly caused by project works. An example of this would be a long-running engineering project that results in temporary reduced capacity on a line or at stations, which results in higher than usual levels of reactionary delay associated with unrelated incidents such as train or signal failures. It is not possible to determine definitively the extent to which NEPs indirectly impact on delays and CaSL from the way that such incidents are recorded.

4.2.14 The CaSL and minutes delay spike evident in 2014/5 is assumed to have been influenced by a Christmas engineering overrun.

**South West Trains**

4.2.15 During 2010/11 the main source of delays was weather-related events during the winter period. In 2012/13 the route experienced poor asset reliability and severe weather. Broken rails also caused an increase in temporary speed restrictions. In 2013/14 NR performance was worse than planned with the main reason being weather-related, in particular the effect of storms that caused trees to be blown on to the running lines.

4.2.16 Table 4-4 summarises performance on all South West Trains services over the 5-year time period. In terms of CaSL, the total figure across the period was 22 services per 1,000, which is similar to Heathrow Connect and lower than FGW but higher than HEX. Total minutes delay per 1,000 services was recorded at 1,084, which was significantly higher than both Heathrow Connect and HEX but substantially lower than FGW. The table also indicates that very little of the delay or CaSL on South West Trains was attributed directly to NEPs.

**Table 4-4: South West Trains services**

| | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Total |
|---|---|---|---|---|---|---|
| **CaSL per 1,000 trains** | | | | | | |
| NEP | 0 | 0 | 0 | 1 | 0 | 0 |
| Non NEP | 15 | 18 | 22 | 25 | 27 | 21 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **15** | **18** | **22** | **26** | **28** | **22** |
| **Total mins delay per 1,000 trains** | | | | | | |
| NEP | 7 | 10 | 5 | 23 | 9 | 11 |
| Non NEP | 885 | 1,013 | 1,139 | 1,050 | 1,077 | 1,032 |
| Unknown | 22 | 27 | 4 | 42 | 118 | 41 |
| **Total** | **914** | **1,050** | **1,148** | **1,115** | **1,204** | **1,084** |

4.2.17 The top five delays affecting South West Train services over the reference period were:

- external fatalities and trespass (79,923 mins);

- train operator external causes (79,841);
- technical fleet delays (71,569);
- train crew causes (62,603);
- track faults including broken rails (57,461).

**Piccadilly Line**

4.2.18 With the information available it was not possible to identify the reasons for delays or cancellations on the Piccadilly Line, as the data was provided by LU rather than NR. The service however appeared to be reliable as indicated in Table 4-5. Over the five year period, average excess journey time reduced by 25% although there was a spike evident in 2014/5. The % of scheduled kms operated over the same period increased from 95.7% to 96.9%.

**Table 4-5: Piccadilly Line**

| | 2010/2011 | 2011/2012 | 2012/2013 | 2013/2014 | 2014/2015 |
|---|---|---|---|---|---|
| % of kms operated | 95.7% | 96.4% | 97.9% | 97.2% | 96.9% |
| Excess time (mins)[12] | 3.06 | 2.57 | 2.14 | 2.04 | 2.31 |

## 4.3 Gatwick Airport

**Sussex (Southern)**

4.3.1 During 2010/11 the main source of delay was weather-related events during the winter period. In 2012/13 the route suffered from flooding and high winds. Heavy rain and snow contributed to a high number of asset failures.

4.3.2 NR performance was worse than planned in 2013/2014. The main causes of delay that affected Southern services were fatalities, adverse weather, possession overruns and the Brighton Mainline being close to capacity, which incurred significant sub-threshold delays (of less than 3 minutes). NR also stated in their 2014 annual return that the delivery of the main tranche of the Thameslink Programme has reduced the scope for delivering major improvements in performance.

4.3.3 Table 4-6 summarises performance on Southern services over the 5-year period. The CaSL statistic for this period was 39 services per 1,000, which was higher than HEX, Heathrow Connect and South West Trains services but marginally lower than FGW. In terms of total minutes delay, a total of 1,873 per 1,000 services were recorded, which was significantly lower than FGW but higher than all the other service groups considered in this chapter so far.

4.3.4 Unlike FGW, where NEPs contributed directly to 10% of CaSL and 6% of total minutes delay, NEPs (including the Thameslink programme) had very little direct impact on Southern services over the 5-year period, accounting for 2% of both CaSL and total minutes delay. However, as noted earlier, it is not possible to determine definitively the extent to which NEPs indirectly impact on service performance. For example, the Thameslink programme means that there are at present fewer platforms available at London Bridge, which means that in the event of an unrelated incident there is less opportunity to recover the service and reactionary delays are likely to be more extensive.

[12] Average excess train time is made up of combined platform and on-train time, and based on an average journey using the Piccadilly Line

**Table 4-6: Southern services**

| | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Total |
|---|---|---|---|---|---|---|
| **CaSL per 1,000 trains** | | | | | | |
| Thameslink programme | 0 | 0 | 0 | 0 | 1 | 0 |
| Other NEP | 0 | 0 | 1 | 1 | 2 | 1 |
| Non NEP | 31 | 32 | 38 | 45 | 42 | 37 |
| Unknown | 1 | 0 | 0 | 1 | 0 | 1 |
| **Total** | **32** | **32** | **39** | **47** | **45** | **39** |
| **Total mins delay per 1,000 trains** | | | | | | |
| Thameslink programme | 1 | 4 | 8 | 12 | 30 | 11 |
| Other NEP | 17 | 14 | 22 | 38 | 53 | 28 |
| Non NEP | 1,568 | 1,567 | 1,742 | 1,754 | 1,919 | 1,706 |
| Unknown | 141 | 114 | 142 | 144 | 100 | 128 |
| **Total** | **1,727** | **1,699** | **1,913** | **1,948** | **2,102** | **1,873** |

4.3.5 The top five delays affecting Southern train services over the reference period were:

- technical fleet delays (252,997 mins);
- train crew causes (160,664);
- NR signalling operations (141,765);
- external fatalities and trespass (136,215);
- NR unexplained delay (11,388).

**Thameslink**

4.3.6 Table 4-7 summarises the performance of Thameslink services over the 5-year time period. The CaSL statistic was higher on this route than all other NR routes described in this report, at 51 per 1,000 services. However, total minutes delay was lower than recorded on FGW at 2,491 per 1,000 services. As with Southern services, delays and cancellations as a result of NEPs, including the Thameslink programme, had very little direct impact on the totals although an upward trend was evident in 2014/5 and the programme works will have had an indirect impact on service performance to an extent.

4.3.7 The top five delays for Thameslink services over the reference period were:

- technical fleet faults (81,564);
- NR operations- signalling (49,744);
- Train crew issues (48,425);
- fatalities and trespass (34, 552);
- track circuit failures (32,759).

4.3.8 The increase across all performance criteria in 2014/15 is assumed to be caused by the Christmas engineering overrun at Kings Cross and train driver resource issues.

**Table 4-7: Thameslink services**

| | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Total |
|---|---|---|---|---|---|---|
| **CaSL per 1,000 trains** | | | | | | |
| Thameslink programme | 1 | 2 | 1 | 0 | 2 | 1 |
| Other NEP | 0 | 0 | 0 | 1 | 2 | 1 |
| Non NEP | 42 | 44 | 43 | 46 | 70 | 49 |
| Unknown | 0 | 0 | 0 | 1 | 1 | 0 |
| Total | 43 | 47 | 45 | 48 | 73 | 51 |
| **Total mins delay per 1,000 trains** | | | | | | |
| Thameslink programme | 7 | 40 | 32 | 15 | 70 | 33 |
| Other NEP | 22 | 6 | 19 | 59 | 57 | 33 |
| Non NEP | 2,006 | 2,005 | 2,206 | 2,285 | 2,886 | 2,275 |
| Unknown | 111 | 143 | 190 | 161 | 146 | 151 |
| Total | 2,146 | 2,194 | 2,447 | 2,520 | 3,159 | 2,491 |

**FGW (NDL)**

4.3.9 Table 4-8 summarises performance on the NDL over the 5-year time period. The table indicates that on this route, the CaSL statistic was at 33 services per 1,000 while total minutes delay was 1,951 per 1,000 services.

**Table 4-8: North Downs Line**

| | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | Total |
|---|---|---|---|---|---|---|
| **CaSL per 1,000 trains** | | | | | | |
| NEP | 0 | 1 | 0 | 0 | 3 | 1 |
| Non NEP | 33 | 26 | 29 | 43 | 30 | 32 |
| Unknown | 1 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **34** | **27** | **29** | **43** | **34** | **33** |
| **Total mins delay per 1,000 trains** | | | | | | |
| Thameslink programme | 0 | 2 | 1 | 1 | 3 | 1 |
| Other NEP | 23 | 37 | 20 | 31 | 28 | 28 |
| Non NEP | 1,699 | 1,778 | 1,632 | 1,942 | 1,842 | 1,777 |
| Unknown | 126 | 155 | 125 | 177 | 139 | 144 |
| **Total** | **1,848** | **1,972** | **1,777** | **2,151** | **2,012** | **1,951** |

4.3.10 The top five delays for NDL over the reference period were:

- technical fleet delays (34,680);
- train crew causes (18,262);
- track faults including broken rails (12,412);
- NR unexplained (12,285);
- station delays (12,098).

4.3.11 Across the 5-year period, railway projects had a marginal direct impact on the NDL service, although 10% of CaSL was attributed to NEPs this year to date. It has not been possible to review why the CaSL figure has increased so significantly for reasons previously mentioned.

## 4.4 Summary of current performance

4.4.1 Since 2010/11 the UK rail network has suffered times of severe disruption due to adverse weather. This has been reflected in NR's results nationally and at service group level. The main source of delays to services to Heathrow and Gatwick Airports has been NR-related.

4.4.2 However out of the train services analysed, fleet technical failures was the singular main cause of delays/cancellations. Rail projects are also contributing to delays, especially with the CaSL results. The impact of project delays means trains are being cancelled and some services are running over 30 minutes late. In terms of delay directly attributable to NEPs, the greatest impact appears to be in the Thames Valley area although as stated earlier, it is not possible to definitively determine the level of delay and CaSL indirectly related to project works. The Piccadilly Line however appears to be very reliable and offers an alternative route to Heathrow when main line rail services are disrupted.

4.4.3 In terms of CaSL, the worst performing service group assessed if direct NEP impacts are excluded was Thameslink, with 49 services per 1,000 affected. FGW (GWML) and Southern services were similar at 37 and 38 respectively, while Heathrow Connect and South West Trains recorded figures of 22 and 31 respectively. The best performing service in this respect was HEX at 11 services per 1,000, reflecting the fact that when disruption occurs on the GWML, HEX is prioritised above other service groups. A summary of CaSL performance by service group over the five year period analysed is provided in Figure 4-1.

4.4.4 In terms of total minutes delay (excluding CaSL) not directly linked to NEPs, FGW (GWML) services were the worst performing at 3,550 minutes per 1,000 services, while on Thameslink services, 2,426 minutes per 1,000 were recorded. As described earlier, this measure reflects delays of less than 30 minutes per service and is therefore a completely separate indicator from CaSL. Southern services were next worst at 1,834 mins per 1,000 trains, while the best performing routes were the two Heathrow services, as summarised in Figure 4-2.

**Figure 4-1: CaSL per 1,000 services by service group and reason for delay (2010/1-2014/5)**

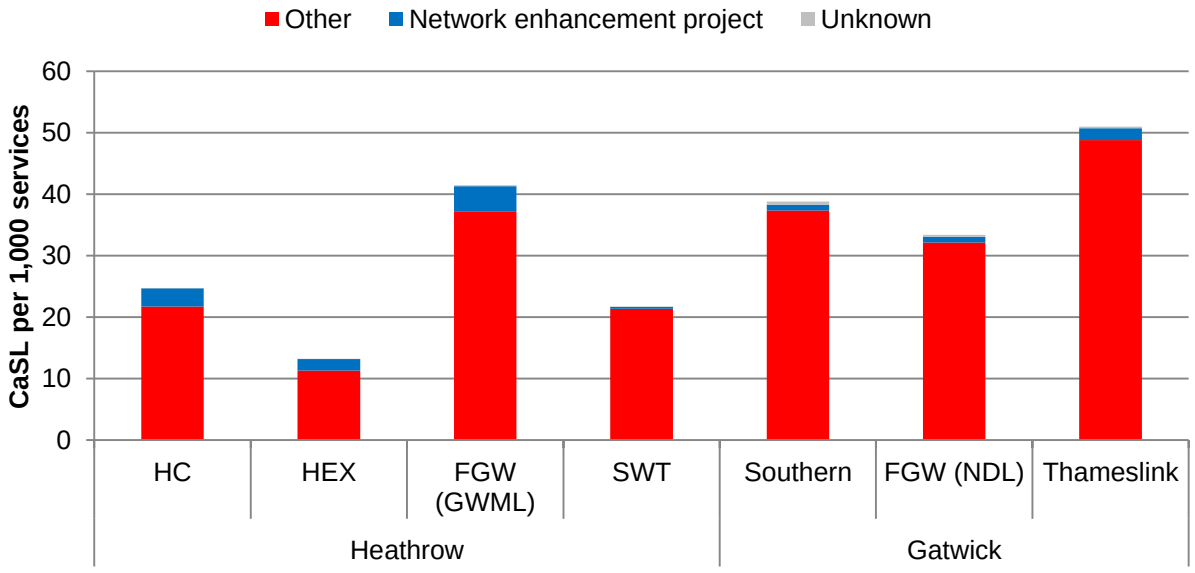
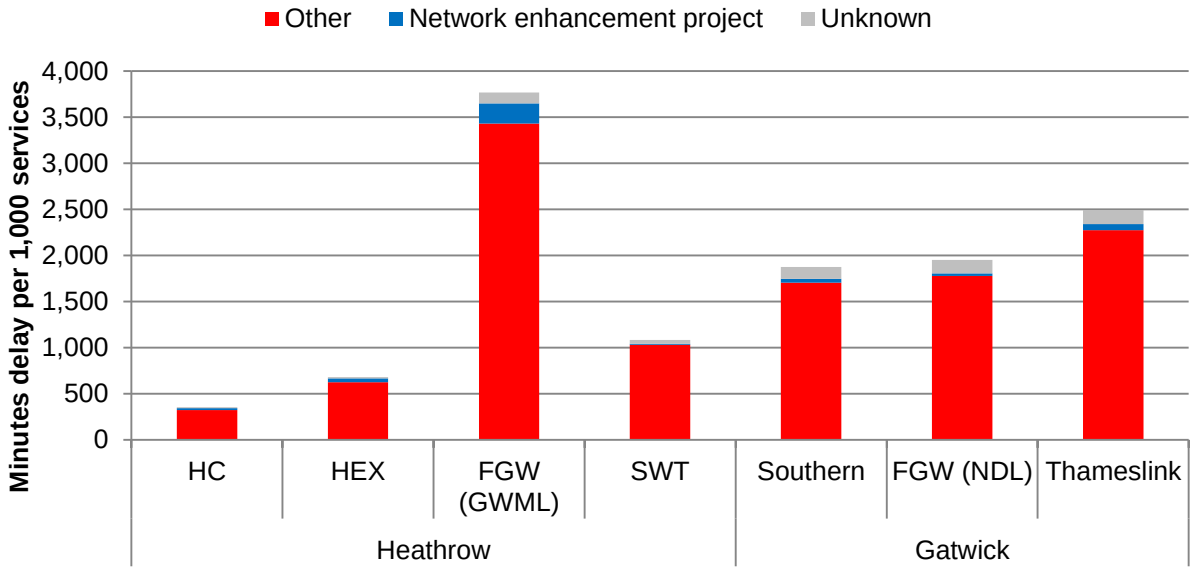


**Figure 4-2: Total minutes delay per 1,000 services (excluding CaSL) by service group and reason for delay (2010/1-2014/5)**




## 4.5 NR contingency plans

4.5.1 By nature it is difficult to predict every scenario that may affect rail services, and contingency plans are consequently produced to provide guidance and operating principles for control staff. It is expected that control staff will also use their professional judgement when making operating and timetabling decisions.

4.5.2 Contingency plans are not a predictor of future performance as they are designed to be reactive to disruptive events. Ensuring plans identify the likely disruptive scenarios and contain realistic operational guidance and principles will however provide a degree of confidence that a disruptive event will be effectively managed.

4.5.3 Jacobs' has reviewed NRs contingency plans for the Western and Sussex regions, and a summary of this review is provided in this section. The plans have been agreed by NR and the relevant TOCs, and are reflective of current service provision.

**Western region**

4.5.4 There are three plans currently in place to cater for different disruptive scenarios, as follows:

- **Plan 1 – full line closure between Paddington and Reading**: this plan involves the re-scheduling of services between Paddington and the west country/Wales to operate to and from Reading, and involves a number of key principles as follows:
  - the cancellation of services wherever alternative routes are available to passengers to free up line capacity;
  - platform clearance at Reading to prevent congestion at the station – for example, it is indicated that consideration should be given to running empty stock to Twyford, Maidenhead or Slough where crews permit;
  - HEX and Heathrow Connect services operating outside the affected area should operate normally wherever possible – the response with regard to airport services will be dependent on where the disruption occurs;

- **Plan 2 – reduced capacity between Paddington and Airport Junction**: the plan accommodates two of the four lines being closed due to an incident, with a maximum of 12 train paths per hour available – the following key details are evident:
  - direct services to Heathrow are reduced to two HEX services per hour with Heathrow Connect services withdrawn;
  - preferred timings for HEX services from Paddington are 10 minutes and 40 minutes past the hour, as these run ahead of stopping services;
- **Plan 2A – reduced capacity between Paddington and Airport Junction**: this plan covers two alternative disruption scenarios to that identified in Plan 2 – capacity reduced by 1 line in the event of normal operation on the remaining lines (i.e. a lower level of disruption than that envisaged by Plan 2), and capacity reduced by 1 line in addition to a planned off-peak engineering possession (which could potentially be more severe than the scenario identified in Plan 2):
  - Under the 'normal operations' plan, if the disruption occurs on the relief lines, it is stipulated that Heathrow Connect should be reduced to an hourly service, or withdrawn completely if a service reduction is not feasible;
  - If the disruption occurs on the main lines, the plan indicates that one HEX service per hour should be withdrawn or selective cancellations should be implemented to clear backlogs – if this approach is not feasible, HEX is to be reduced to a 30-minute frequency – the plan states that consideration should be given to withdrawing Connect services on the relief line to maintain a full HEX service, although it is acknowledged that if journey times are significantly extended due to use of the relief lines, it is better to reduce HEX to a 30-minute frequency;
  - Under the 'planned works' plan, a number of sub-scenarios are presented – the plan notes that a standard 2-track timetable could accommodate 2 or 4 HEX services per hour (depending on the nature of the works) and 1 or 2 Heathrow Connect (depending on HEX);
  - If the maximum capacity in this scenario is 8 trains per hour, the timetable includes 2 HEX services and 1 Heathrow Connect;
  - If 6 trains per hour are possible, 2 HEX services are to be run with Heathrow Connect withdrawn;
  - If 4 trains per hour are possible, all airport services are suspended.

4.5.5 Since the contingency plans described above are agreed between NR and the relevant TOCs, there is no mention of the Piccadilly line although this is obviously an alternative route option for passengers travelling between Heathrow and central London.

**Sussex region**

4.5.6 The Sussex plan is one document describing a service recovery framework and service recovery plans. The plan details a five stage process for managing service disruption, consisting of incident management and containment, service plan declaration, service plan reviews, return to full timetable, and 'hot' debrief (a rapid debrief involving those who dealt with the incident to identify learning and actions that need to be progressed). A set of operating principles has been agreed by all parties. There are eight principles described, including a provision that trains should always serve the airport stations at Gatwick and Luton.

4.5.7 The Service Recovery Plans are split into 14 regions. Some regions are split into a yellow plan (for a partially blocked route) and a red plan (for a serious disruption or fully blocked route). For each line section scenario, the maximum number of train paths has been identified.

4.5.8 Gatwick Airport is identified as part of the Mainline 2 section, and both the red and the yellow plan highlight the proposed service amendments if line capacity is reduced to 14 trains per hour, indicating that 1 Brighton service, 1 Bedford service and 2 Gatwick Express (GEX) services would be withdrawn, leaving GEX with a 30-minute frequency. However, other services running between London and the south coast are shortened but generally maintain a stop at Gatwick, meaning that the airport is not as affected as other stations on the line in the event of an incident.

4.5.9 There is also a red plan if Victoria station is closed, specifying that GEX is to be suspended unless the eastern side of the station is available, when a half-hourly service should operate calling additionally at East Croydon. The plan also includes restricted capacity guidance such as temporary block working and single line working.

## 4.6 Future performance

4.6.1 At the start of each NR CP, regulatory performance targets are agreed with the ORR, and targets for CP6 have not yet been agreed. The best indicator of future network resilience is therefore current performance, which is below current regulatory targets. This is the subject of a NR remedial plan that the ORR is monitoring.

4.6.2 It is known that increasing services and line utilisation can increase the level of reactionary delays. There are a number of major projects that are in development or about to be introduced, which may have an influence on network resilience in the future. Their influence will depend on the ability of NR and TOCs to manage future reliability challenges. These schemes are described below but are not exhaustive:

- Crossrail – will be introduced over several phases and is planned to go into full service during 2019, replacing Heathrow Connect services – a 95% PPM target has been set for the service;
- Western Route Access (WRA) to Heathrow – delivery of this scheme is subject to NR developing a satisfactory business case and agreeing acceptable terms with the Heathrow aviation industry – construction could commence towards the end of CP5 subject to NR agreeing the final business case with the ORR and the DfT, and securing a Development Consent Order (DCO) – WRA will provide passenger services from Reading via Slough to Heathrow and although no timetable has been finalised, four trains an hour to the airport are under consideration – no performance targets have been established;
- Reading Station and line approach enhancements – work commenced in 2010 and is scheduled to be completed in the summer of 2015, and the new layout will increase capacity and facilitate a reduction in reactionary delays as operational flexibility is improved;
- Thameslink programme – the majority of services will operate over the Brighton Mainline with the project scheduled for completion in 2018 – on completion up to 24 trains per hour will run through the core section between St Pancras and Blackfriars at peak times, and new rolling stock will be introduced;
- East West Rail – the objective of this scheme is to link the GWML, Oxford, Bicester, Milton Keynes, Bedford, Cambridge, Ipswich and Norwich – the Western section is currently under development with a number of timetable options proposed, including complementing the new Chiltern Railways Oxford to London Marylebone service via Bicester (due 2016) with an hourly service calling at Didcot Parkway, Oxford, Oxford Parkway, and Bicester Town – an hourly Reading to Milton Keynes service along with an hourly Milton Keynes to London Marylebone service via Aylesbury and High Wycombe is also proposed – the proposed Central and Eastern sections are currently being reviewed to ascertain options, and no performance targets have been set;
- European Rail Traffic Management System (ERTMS) - ERTMS is planned to be introduced on the UK rail network over the next 30 years and will remove some of the constraints of line-side signal block boundaries and establish minimum separation times based on the maximum

permitted speed and braking characteristics of rolling stock – however, line capacity will still be limited by other constraints and the capacity benefits associated with ERTMS may be limited on complex networks that operate close to maximum capacity (although it is difficult at present to quantify benefits prior to full system modelling):

- In the Western region, ERTMS Level 2 with signals is scheduled to be functional in 2017 to support Crossrail services between Paddington and Heathrow (although it is noted that Crossrail could potentially operate with current signalling arrangements) – Level 2 is planned to be functional between Paddington and Bristol by 2019 and signals are to be removed in 2025;
- In terms of the Brighton Main Line, NR is currently reviewing the ERTMS roll-out programme but no implementation dates have yet been fixed.

4.6.3 In addition to the schemes described above, the DfT is sponsoring a study into options for SRA to Heathrow, which is likely to be completed in summer 2015 by NR. A southern rail connection to Waterloo would provide a third segregated rail route between the airport and central London, although it is noted that previous proposals have not progressed as a result of operational issues, in particular related to the high number of level crossings on the route through Richmond and Twickenham and the potential impact on other services.

## 4.7 Issues raised during consultation

**North Downs Line/east-west rail connections to improve rail resilience at Gatwick**

4.7.1 The industry long-term planning process and Wessex route study groups have generated a number of conditional outputs to meet future passenger demand. This includes the Portsmouth Direct Line services to Waterloo and the North Downs line between Reading and Gatwick via Redhill. Under consideration is the introduction of an additional fast service between Reading and Gatwick via Redhill. To allow the additional service, train headways on the route will have to be reduced and line speeds improved.

**Alternative routes London-to-Gatwick routes via Guildford and Tonbridge**

4.7.2 The alternative routes to London do exist but it is questionable that they compare in terms of journey time with alternatives likely to be available at Heathrow in 2030. Sending services via Tonbridge requires reversing trains at Redhill and Tonbridge, and services would also join the line between Bromley South and Victoria, which is currently operating at high capacity levels. Similarly services going via Guildford would need to reverse at Redhill and would reach Victoria via Clapham Junction, which has also limited capacity available. In both cases any delays on the BML are likely to be imported on to both these sections of route. Notwithstanding the capacity and operating issues, journey times are likely to be extended significantly, especially services going via Tonbridge.

4.7.3 There are a number of options in terms of alternative routes to Heathrow depending on the cause of the disruption. The Piccadilly line is an option that appears to be very reliable based on the information supplied by LU with journey times around 30/45 minutes depending on the destination in central London and, if SRA is progressed, this will provide a third segregated rail route into Waterloo with journey times likely to be around 45 minutes. Although not ideal, road transport is also feasible and has been used in the past either from Paddington or connecting with train services at Hayes and Harlington.

**Uckfield to Lewes line**

4.7.4 In the Chancellor of the Exchequers' 2015 budget statement it was announced that funding of £100,000 will be provided for a feasibility study on the re-opening of the line between Uckfield and

Lewes. Restoring the rail link would provide a direct route from Eastbourne to London via Uckfield, which would potentially release train paths on the BML, although an assessment is required to understand the nature of any benefits that may be derived from delivering this scheme.

# 5. Conclusions

## 5.1 Highways

5.1.1 The assessment of highways resilience at Heathrow and Gatwick described in Chapter 3 of this report was divided into three separate sections of analysis on the availability and viability of alternative routes to the airport from key locations; the frequency with which incidents occur on the network at present; and the impact on travel speed and queued flow of lane closures on key sections of the network serving both airports – the latter was assessed using the dynamic SATURN 2030 model runs developed for the post-consultation work-stream.

5.1.2 The dynamic modelling resulted in the following key conclusions:

- At Heathrow, a single lane closure on the M4 between junctions 1 and 2 results in a maximum 39% reduction in traffic speed to the airport in the PM peak – however, queued flow only increases by up to 0.96%, suggesting that most traffic finds its way to the airport via alternative routes in the specified time period;
- A single lane closure on the M25 between junctions 11 and 12 has a much lower impact on Heathrow traffic speed, of only 9%, again in the PM peak – the comparative increase in queued flow is 0.67%;
- At Gatwick, a double lane closure on the M23 southbound north of junction 9 has a maximum impact of a 15% reduction in travel speed to the airport, in the Inter-peak (although reductions are very similar in the peaks) – the comparative increase in queued flow is only 0.19% - a similar incident south of junction 9 has less impact, with travel speed decreasing by a maximum of 3% and queued flow by 0.03%;
- A single lane closure on the M25 eastbound off-slip to the M23 results in a reduction of 19% in traffic speed and a change in queued flow of 0.8%.

5.1.3 It should be noted that SATURN assignments are based on an equilibrium process where every user is assumed to minimise their own travel time. This implies knowledge of the likely travel conditions ahead of time, which may not be plausible immediately following an incident. As an example, at Gatwick, the distance between Junctions 8 and 9 means that, following an incident, many vehicles are likely to be already committed to the M23 corridor and that queued flows are likely to be underestimated by the model. Nevertheless, the analysis suggests that, in general, lane closures on key sections of the road network serving Gatwick are likely to have less impact on traffic accessing the airport than on key sections of the network serving Heathrow, since the road network around Gatwick is forecast to be considerably less congested than around Heathrow in the 2030 Extended Baseline.

5.1.4 The analysis of the frequency of current incidents on the road network serving both airports also appears to suggest that Gatwick performs better than Heathrow at present, for the following reasons:

- On the M25 west of its junction with the M23, 365 annual incidents categorised as ‘very minor’, ‘minor’ or ‘moderate’ occurred in both directions, the highest out of all four of the Gatwick road links assessed as part of this study – on the M23 south of the airport only 47 incidents occurred while to the north of the airport only 37 incidents occurred;
- The highest number of similar incidents around Heathrow was 1,488 on the M4 east of the airport, higher than the M4 west (297), M25 south (851) and M25 north (589);
- In terms of ‘severe’ and ‘very severe’ incidents, a similar pattern emerged – the worst link around Gatwick was the M25 east of its junction with the M23, where 16 annual incidents occurred in both directions;
- Around Heathrow, the worst link for these categories was also the M4 east of the airport with an annual total of 59.

5.1.5 However, the analysis of alternative route choices to each airport from identified urban centres to the north, south, west and east suggests that Heathrow performs better than Gatwick. For the latter, alternatives to the primary route along the M25 from the west or east performed poorly in terms of journey times and lane capacity. This suggests that in contrast to the modelled lane closures discussed above, full carriageway closures on key sections of the road network serving Gatwick would lead to a more significant impact on vehicles travelling to and from the airport.

5.1.6 The above conclusion is based on a high-level analysis of potential impacts. Route choice analysis helps illustrate that there are multiple alternative routes to Heathrow while Gatwick is accessed from the West North and East primarily by the M23. Nevertheless, incidents are random and the significance of any particular event for each airport is heavily dependent on the airport catchment, the volume of trips travelling along particular routes and the amount of road capacity lost. Consequently, it is acknowledged that a major incident could have a significant impact on access to either airport with widespread resulting highway disruption.

## 5.2 Rail

5.2.1 The key performance indicator for the rail network currently with respect to airport passengers was identified as 'Cancellations & Significant Lateness' (CaSL), since services that were either cancelled or more than 30 minutes late were deemed to be more significant than lower level delays that impact more on regular users of the service such as commuters.

5.2.2 It was also necessary to differentiate between delay caused by Network Enhancement Projects (NEPs) and those caused by other factors, since NEPs by nature are temporary – good examples are the Crossrail and Thameslink work programmes, which have both impacted to some extent on network performance on the Great Western and Brighton Mainlines in recent years.

5.2.3 Based on data provided by NR and LU, the worst performing service group assessed for CaSL if NEP works are excluded was Thameslink, with 49 services per 1,000 affected. FGW and Southern services were similar at 37 and 38 respectively, while Heathrow Connect and South West Trains recorded figures of 22 and 31 respectively. The best performing service in this respect was HEX at 11 services per 1,000.

5.2.4 In terms of total minutes delay not linked to NEPs, FGW services were the worst performing at 3,550 minutes per 1,000 services, while on Thameslink services, 2,426 minutes per 1,000 were recorded. As described earlier, this measure reflects delays of less than 30 minutes per service and is therefore a completely independent indicator from CaSL. Southern services were next worst at 1,834 mins per 1,000 trains, while the best performing routes were the two Heathrow services, HEX and Connect.

5.2.5 In general, since 2010/11 the UK rail network has suffered times of severe disruption due to adverse weather. This has been reflected in NR's results nationally and at route level. The main source of delays to services to Heathrow and Gatwick Airports has been NR-related.

5.2.6 However out of the train services analysed, fleet technical failures was the singular main cause of delays/cancellations. Rail projects are contributing to delays, especially with the CaSL results. The impact of project delays means trains are being cancelled and some services are running over 30 minutes late. In terms of passenger affecting minutes the greatest impact that projects are having is in the Thames Valley area. The Piccadilly Line however appears to be very reliable and offers an alternative route to Heathrow when main line rail services are disrupted.

5.2.7 At the start of each NR CP, regulatory performance targets are agreed with the ORR. Targets for CP6 have not yet been agreed. The best indicator of future network resilience is therefore current performance, which is below current regulatory targets. This is the subject of a NR remedial plan that the ORR is monitoring.

5.2.8 It is known that increasing services and reducing line capacity can increase the level of reactionary delays. There are a number of major projects that are in development or about to be introduced, which may have an influence on network resilience in the future. Their influence will depend on the ability of NR and train operators to manage future reliability challenges.

5.2.9 In terms of the range of future services at both Heathrow and Gatwick, it would appear that the former provides a more resilient offer in terms of viable alternatives. At Gatwick, although the North Downs Line and connections via Tonbridge technically provide alternative routes into London to the Brighton Mainline, the journey times associated with works in the Extended Baseline would likely be very poor in comparison, and an incident south of Earlswood can still cut the airport off from London. In contrast, Heathrow would have 3 alternative routes into London if SRA is delivered, and the journey time differential between the 3 would likely be much closer than the alternatives to the Brighton Mainline for Gatwick.

# Appendix A. Consultation comments relating to resilience

| Comment author | Comment |
|---|---|
| Heathrow Airport Limited | We recommend that the Commission:<br>• undertakes an assessment of surface access resilience for each of the shortlisted options as set out in the appraisal framework and includes this in the assessment of how each option meets Surface Access Objective 2 |
| Gatwick Airport Limited | The Commission should give greater weight to the fact that parts of Heathrow's surface access strategy are not fully defined and carry significant delivery risks. The issues of cost, disruption during construction, and the complexity of delivery should be the subject of much more analysis and assessment |
| Gatwick Airport Limited | In order to ensure a fair comparison, the Commission should subject the Heathrow schemes to the same type of analysis as was undertaken for Gatwick on resilience and local road traffic impacts. |
| Gatwick Airport Limited | The Commission's appraisal does not reflect the significant differences between the schemes and excludes some surface access impacts that are key to how the schemes should be appraised. The Commission should undertake further analysis of the three schemes in terms of their costs, the capacity and resilience of their transport networks, the risks to their delivery as well as disruption during construction. Gatwick is confident that a full appraisal will emphasise still further the significant surface access advantages of the Gatwick proposal and highlight the risks and wider impacts on communities affected by the surface access strategies proposed for the Heathrow schemes. |
| Gatwick Airport Limited | The Commission's focus is on the comparative resilience of surface access to the Gatwick and Heathrow schemes. While we have set out below our view that the Commission's current comparative evaluation between the schemes lacks balance, we believe that the Commission has largely overlooked the key question of how to maximise resilience of the system as a whole. This is important as, by expanding Gatwick, system resilience will be improved overall. |
| Gatwick Airport Limited | The Commission questions the resilience of road and rail access for Gatwick without undertaking a complete analysis and without presenting equivalent data for Heathrow. The Commission should consider the reliability of journey times and the available capacity that these networks offer, noting the concerns that its own consultants raise regarding the future capacity of Crossrail and the Piccadilly Line and congestion on the M25 and M4. The Commission and its consultants should reflect these parameters in the analysis and consult Network Rail and the Highways Agency to corroborate the assumptions and data used for all schemes so they are assessed on a fair and equal basis |
| Gatwick Airport Limited | Roads – The Commission states that Gatwick has a "heavy reliance" on the M23. Again, if resilience is being raised for one runway scheme it should be assessed for all schemes to ensure a fair and balanced assessment. The Commission's appraisal should consider all available |

| Comment author | Comment |
|---|---|
| | capacity and the typical traffic conditions experienced on motorways and parallel alternative routes around each scheme, not solely a simplistic count of the number of motorways available. |
| Gatwick Airport Limited | The Commission does not provide any analysis of the resilience of road and rail networks serving Heathrow. The Commission should present analysis for both the road and rail routes serving each scheme and also reflect the greater resilience of transport networks around London through the dispersal of airport-related demand inherent in the Gatwick proposal, which avoids overheating West London road and rail corridors that are already under strain and will remain congested even with committed improvements. |
| Gatwick Airport Limited | **Issue:** No robust analysis has been presented by the Commission or its consultant on road resilience; only limited anecdotal information is presented. **Impact:** Without thorough analysis the traffic impacts from the airport proposals cannot be assessed objectively and fairly in terms of road resilience. **Recommendation:** It is essential that the Commission complete a robust, reliable and complete assessment of road resilience for each runway scheme noting the current position, future service levels, the main causes of problems and the potential future position. This should be undertaken in conjunction with the Highways Agency. Otherwise there will not be a fair, objective and evidence based analysis of road resilience issues at the time of each runway scheme becoming operational. |
| Gatwick Airport Limited | It is essential that the Commission provides a robust, reliable and complete assessment of rail and road resilience for each runway scheme (not just Gatwick as at present) noting the current position, the main causes of problems and the potential future position. This should be undertaken in conjunction with Network Rail and the Highways Agency. Otherwise there will not be a fair, objective and evidence-based analysis of resilience issues at the time of each runway scheme becoming operational. |
| Network Rail | Brighton Main Line: The Commission should also note the references in the Sussex Route Study to the ongoing performance challenge on the BML and the possible need in CP6 for further investment outwith the current scope of the capacity enhancement programme if current PPM targets are to be met or indeed exceeded. In our view such investment is likely to be needed with or without airport expansion. |
| Network Rail | Brighton Main Line: It is also worth noting that access for maintenance and renewal activity is an ongoing challenge on all of Network Rail's Main Line routes into London. For the BML, information on current access regimes and future plans is available to the Commission if required. |
| Network Rail | Great Western Main Line: The Commission should also note the references in the Western Route Study to the ongoing challenge of providing a resilient and maintainable railway specifically in the Thames Valley area of the GWML and the possible need in CP6 for further investment outwith the current scope of the capacity enhancement programme if current PPM targets are to be met or indeed exceeded. The emerging access strategy for the GWML also needs to be considered alongside the performance and capacity requirements to ensure that the railway can be sufficiently maintained alongside the growing requirements for services. In our view such investment is likely to be needed with or without airport expansion. |
| Network Rail | Route Resilience: We note the Commission's references to resilience issues on the BML and GWML. Network Rail is of the view that, assuming the Commission considers the resilience of the lines in question a significant factor in comparing the feasibility of surface access proposals, further analysis should be conducted involving Network Rail and, where appropriate, the current operators |
| Network Rail | Route Resilience: Between September 2011 and September 2014, an assessment of line closures indicates that the BML experienced 22 incidents which resulted in total line blocks between London and Gatwick Airport which equates to an average of 7 – 8 per year. Of these, approximately 70 per cent were fatalities and in these instances Network Rail aims to re-open the line within 90 minutes. |

| Comment author | Comment |
|---|---|
| | However, 12 of the 22 incidents were on the sections between Stoats Nest Junction and Earlswood or after the route splits to London Bridge and London Victoria. Therefore, at these locations there is an alternative route to London available and a service to London from Gatwick Airport would in most cases have been maintained, though likely with some service disruption. This therefore means that there are only 3 – 4 incidents per year that would result in the total loss of any direct access to London from the airport.<br><br>Gatwick Airport also has alternative routes to London via Guildford or Tonbridge, though these would result in extended journey times, the need to interchange and current service patterns are not currently configured to accommodate large volumes of diverted passengers. |
| Network Rail | Route Resilience: Comparatively, between September 2011 and September 2014 an assessment of line closures indicates that the GWML experienced 21 incidents between London Paddington and Heathrow Airport which resulted in trains not running between London and Heathrow Airport on either the GWML or Heathrow branch. This equates to an average of 7 per year. Of these, approximately 75 per cent were fatalities where Network Rail would aim to re-open the line within 90 minutes.<br><br>Heathrow Airport is also served by the Piccadilly Line which provides an alternative route to the airport in such instances. |
| Network Rail | Current and Future Performance: In Network Rail's view, the day to day performance challenges on the routes in question are as relevant of consideration by the Airports Commission as the issue of route resilience (as defined by the Commission as maintaining a service to the airport in times of disruption). |
| Network Rail | Current and Future Performance: The BML and GWML are both highly utilised mixed-used rail arteries which by the end of CP5 will be operating at near full network capacity. Operating this high level of service brings with it challenges in terms of performance that we are already experiencing today. |
| Network Rail | Current and Future Performance: Historical PPM data for TOCs on the GWML and BML shows that achieving performance targets has been increasingly challenging in recent years. |
| Network Rail | Current and Future Performance: A significant part of the challenge in delivering PPM targets is the increasing number of services running on the network in order to accommodate passenger demand. |
| Network Rail | Current and Future Performance: By the end of CP5 the Thameslink, Crossrail and Intercity Express Programmes will result in further service increases on the BML and GWML. Whilst these programmes will deliver new infrastructure at some locations, challenges will remain going forward in achieving robust levels of performance on the routes in question. |

# Appendix B. Highway resilience assessment criteria

| | Good | Moderate | Bad |
|---|---|---|---|
| **Primary route capacity** | 4 or more lanes | 2 to 3 lanes | 1 lane |
| **Number of alternative routes** | 3 or more | 2 | 1 |
| **Alternative route capacity** | 4 or more lanes | 2 to 3 lanes | 1 lane |
| **Travel time penalty** | 0% to 50% | 50% to 100% | 100% or greater |

# Appendix C. Heathrow North West Runway highway analysis figures

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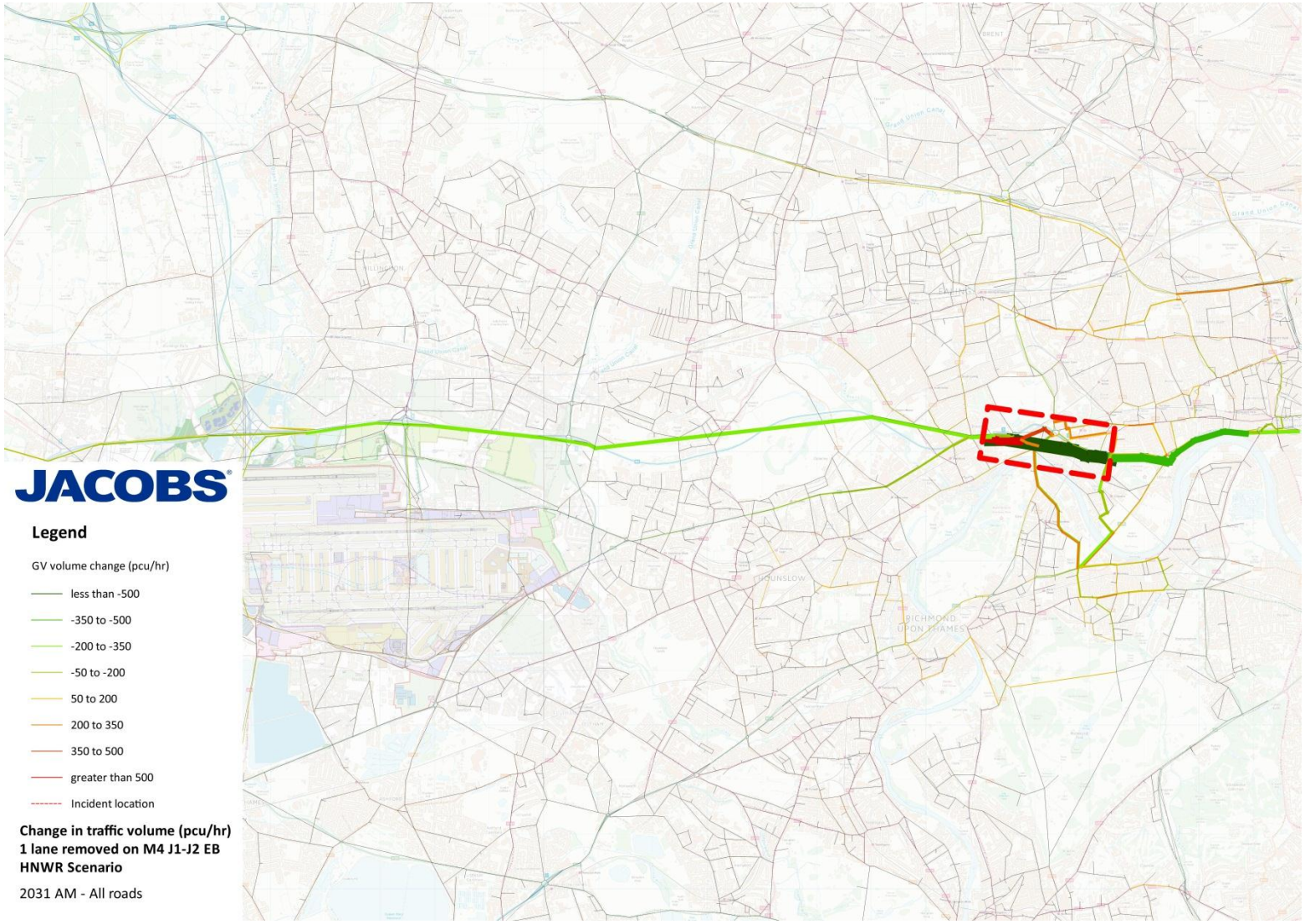

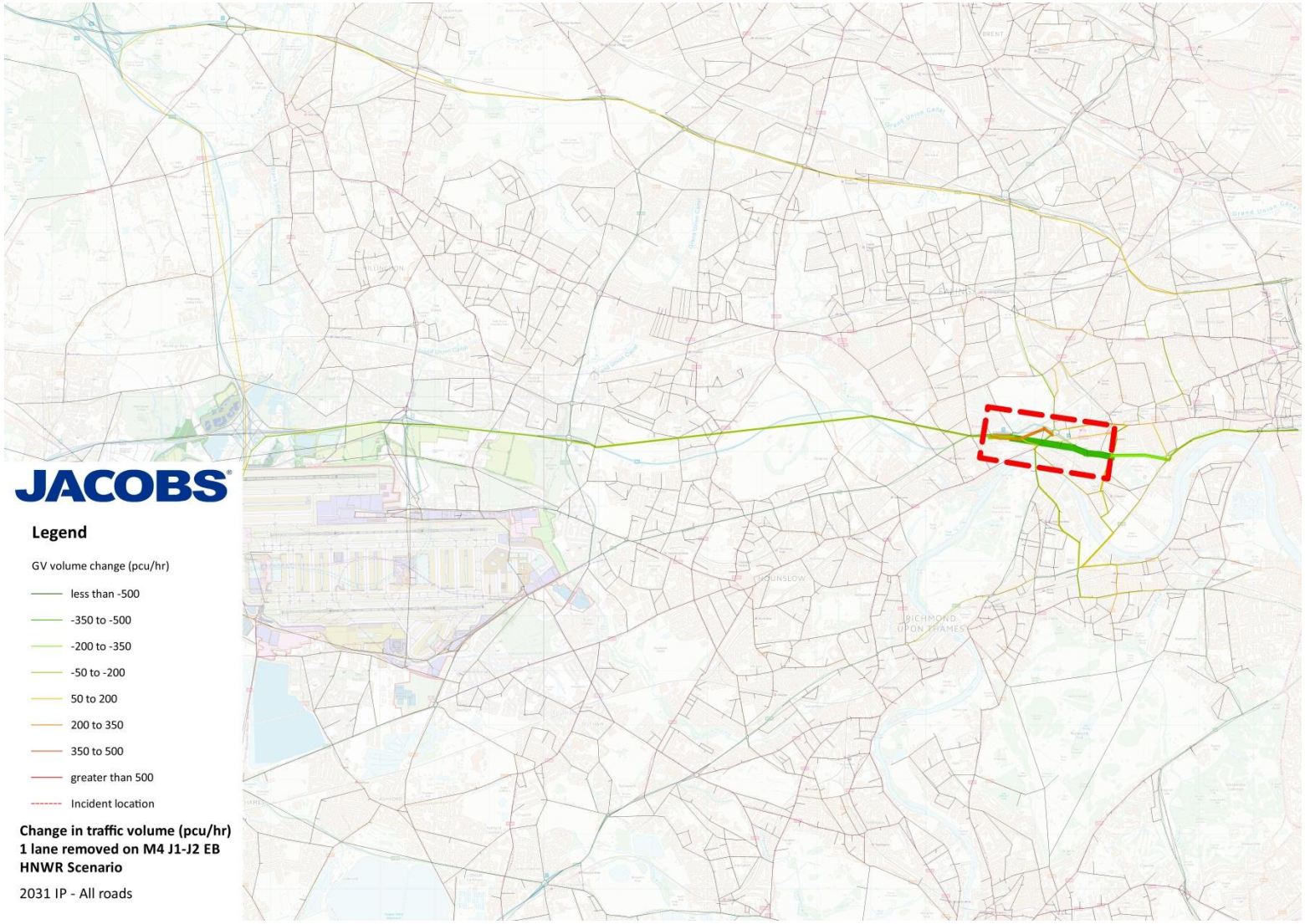

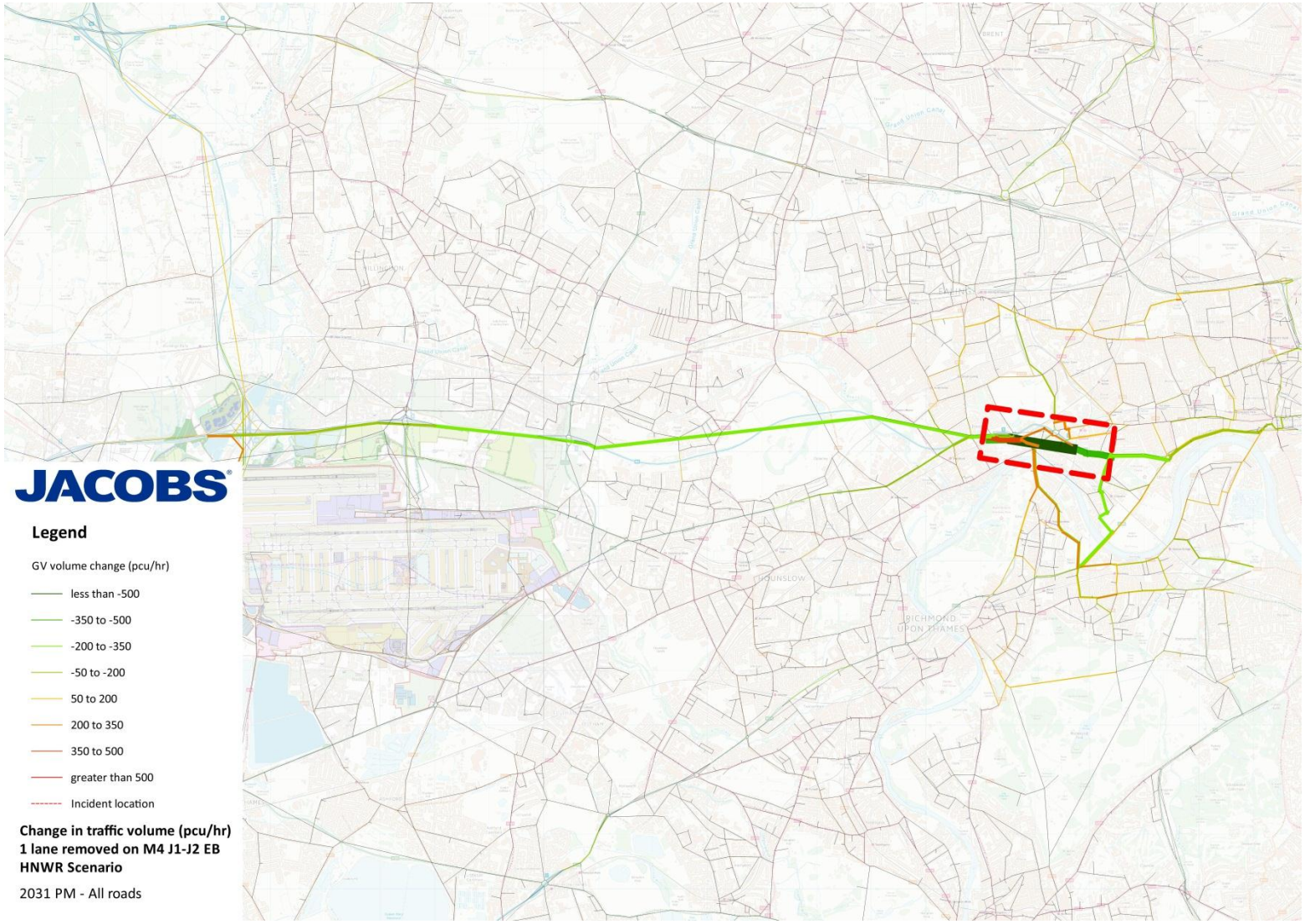

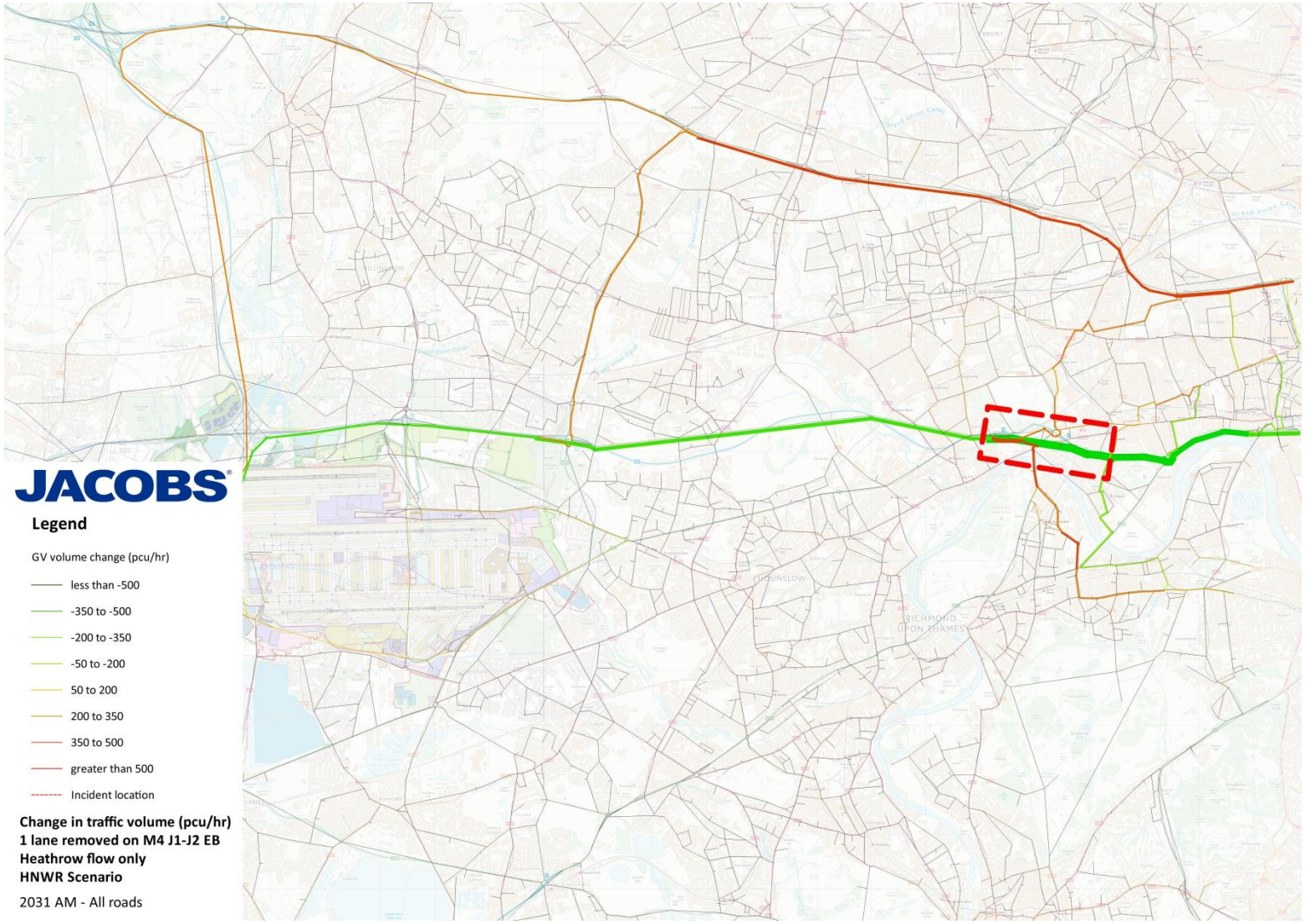

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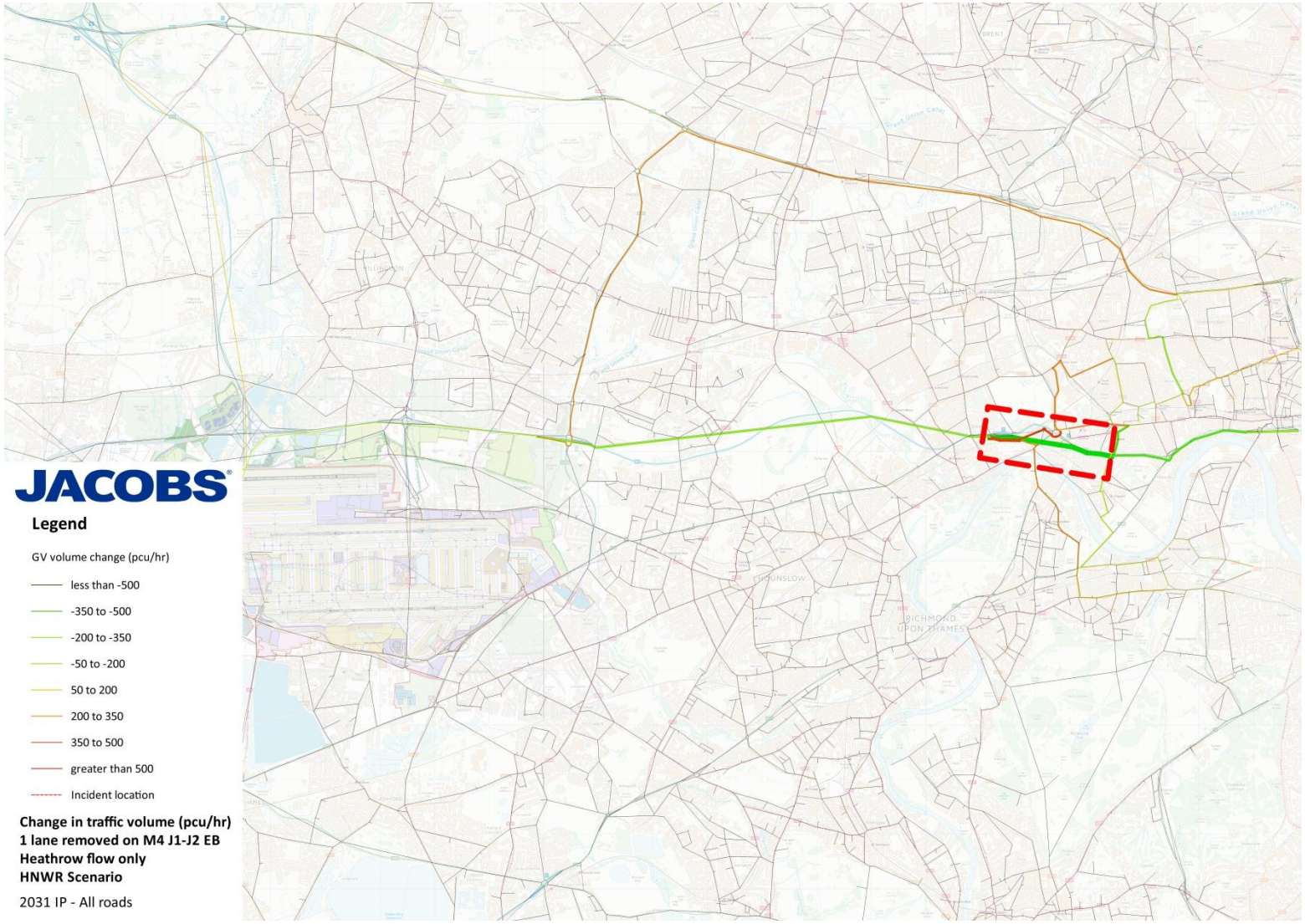

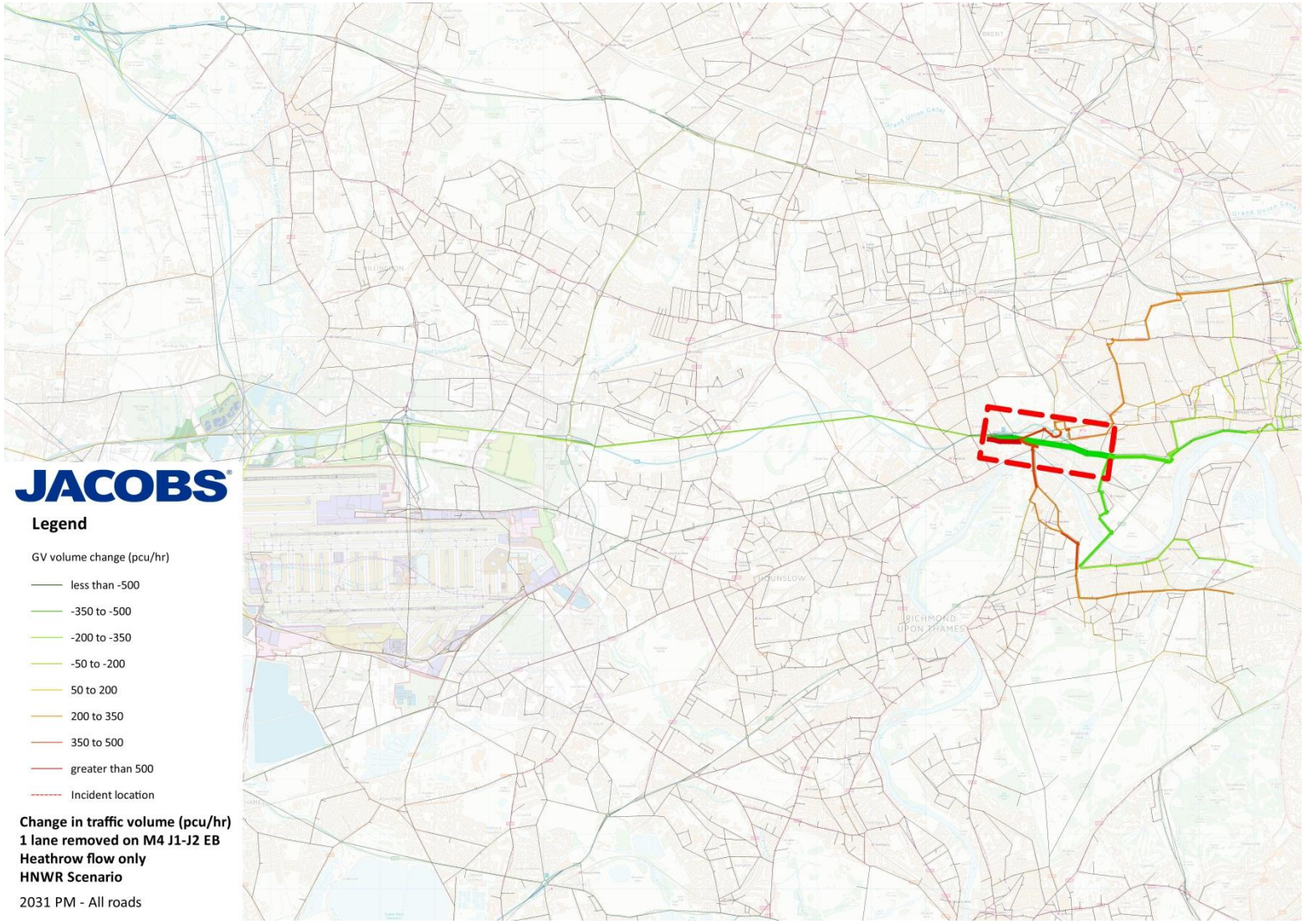

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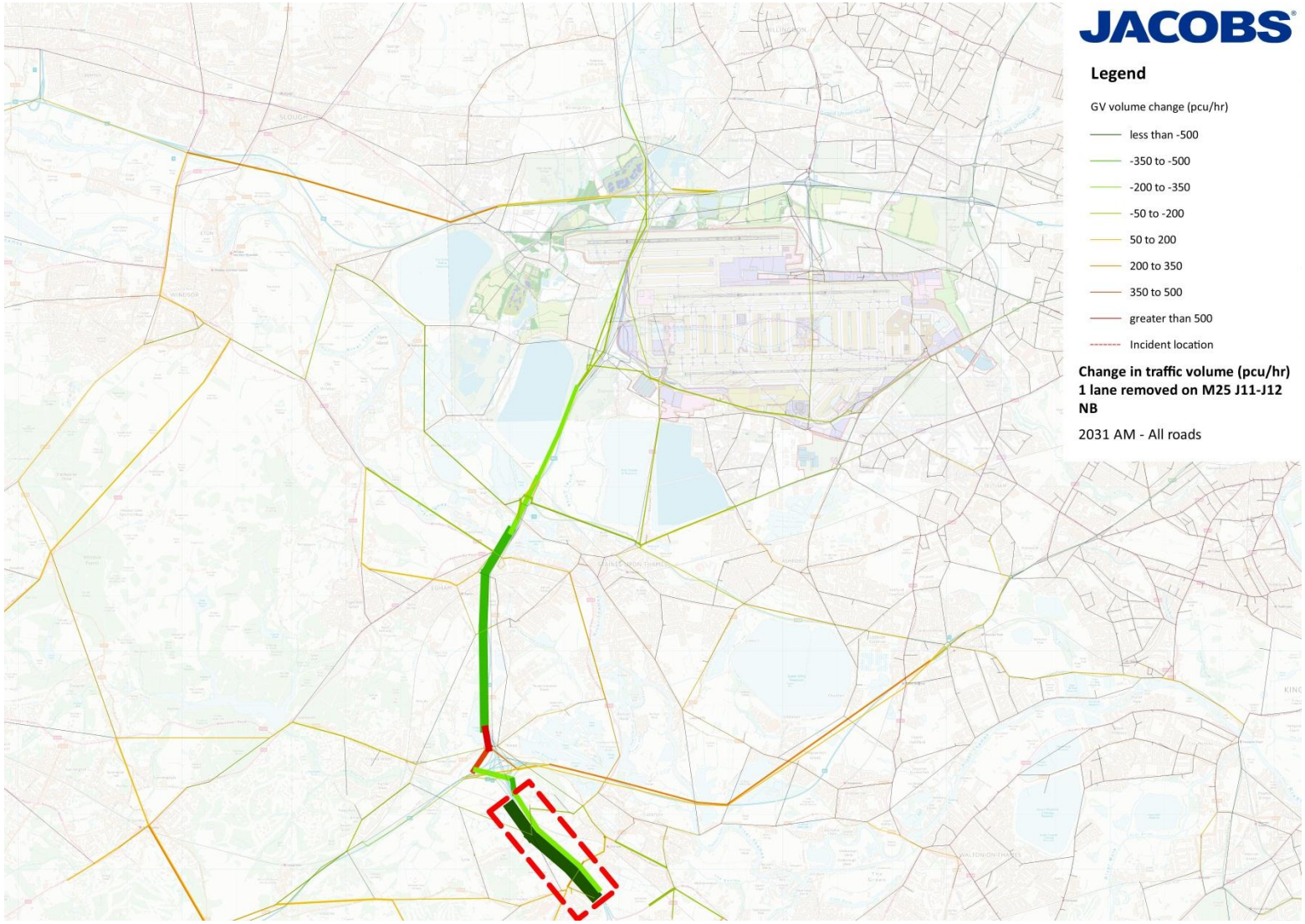

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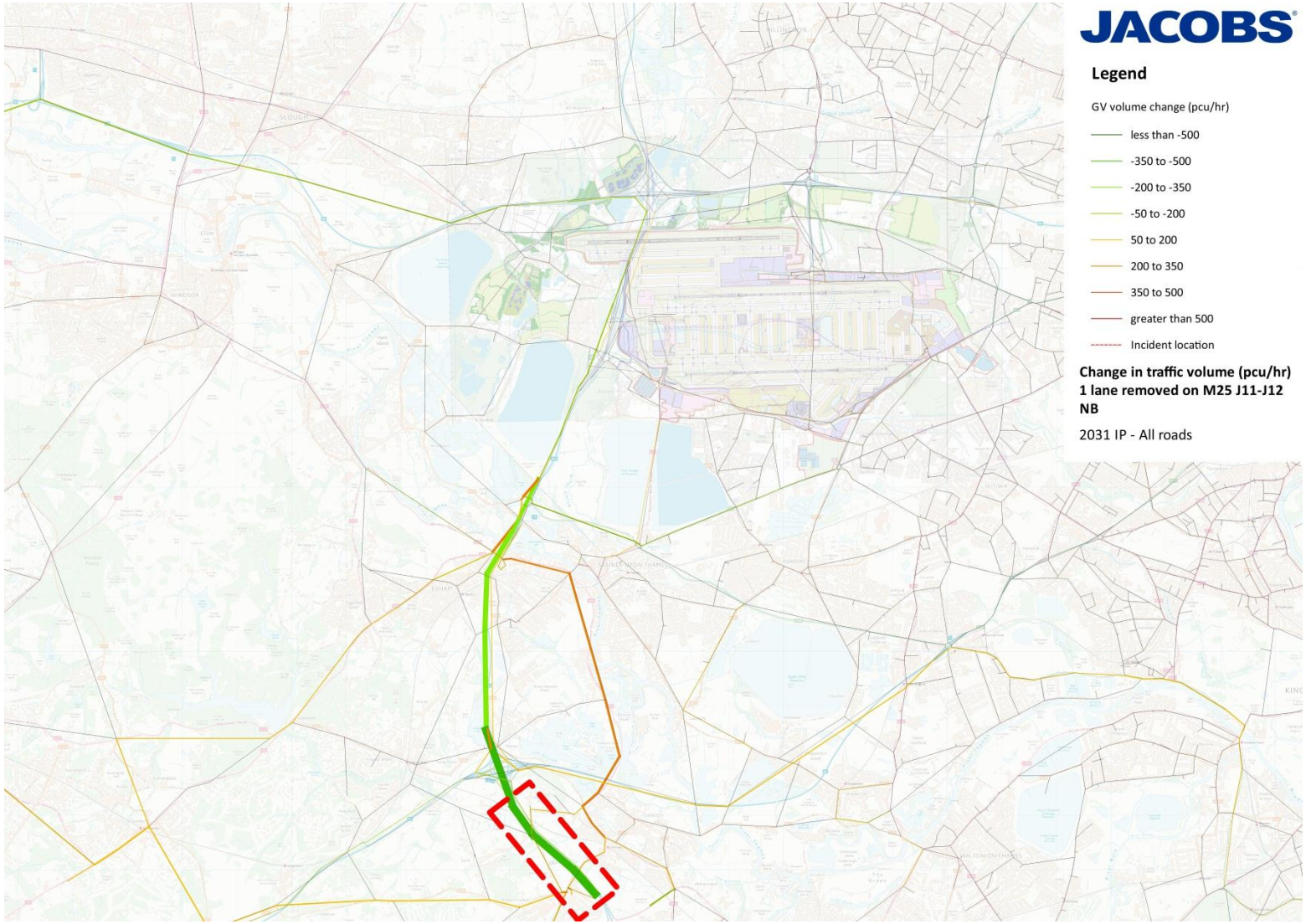

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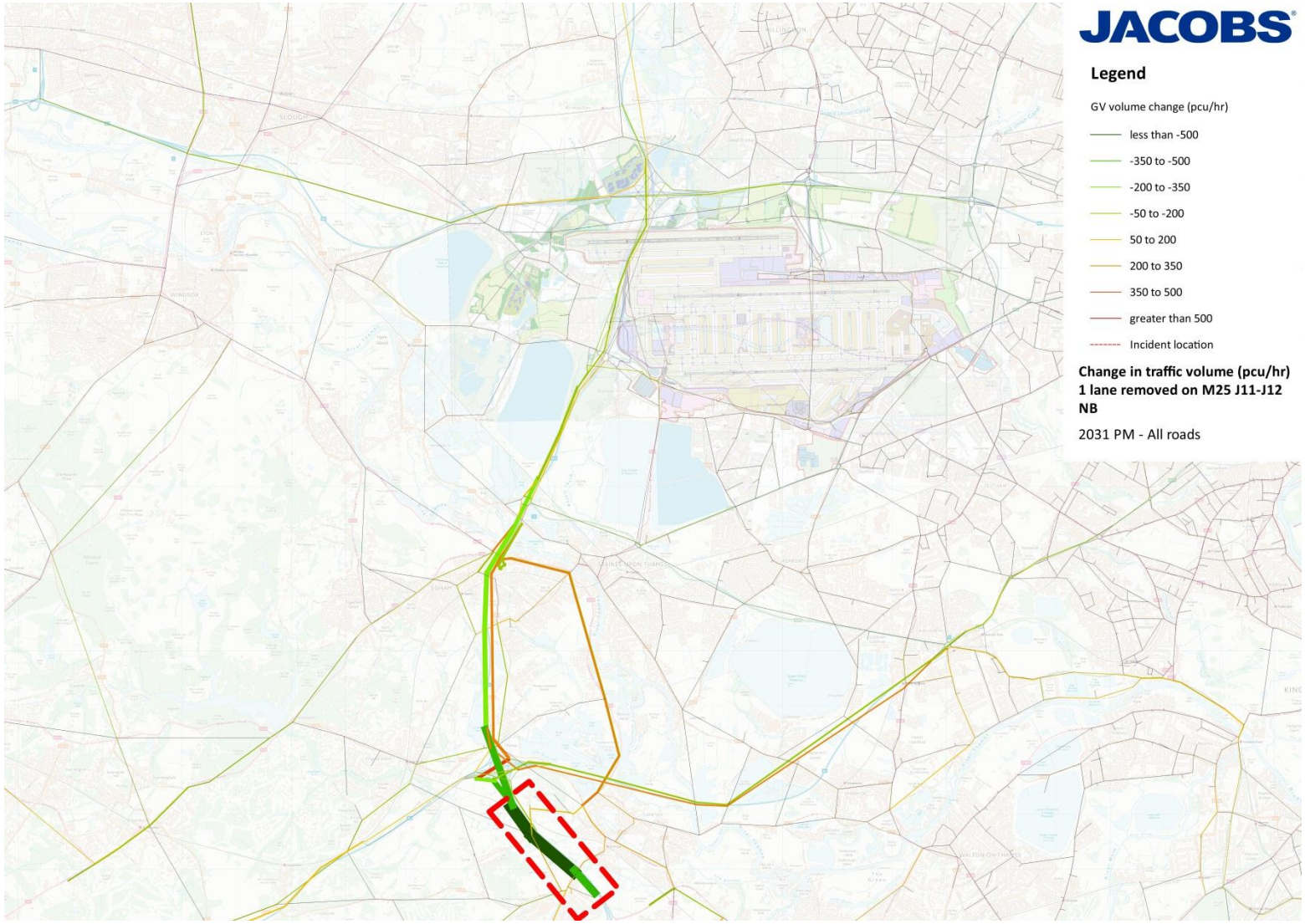

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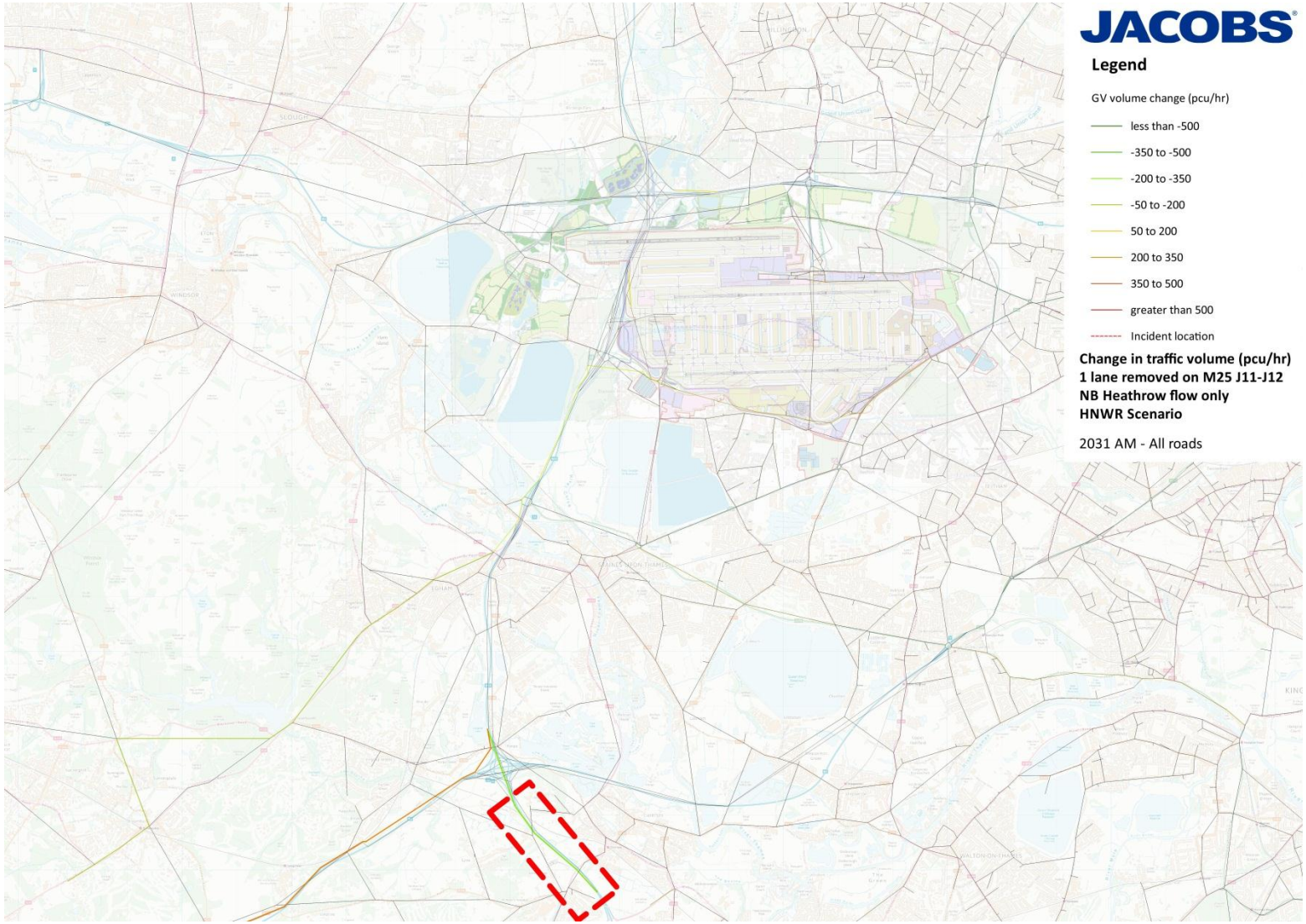

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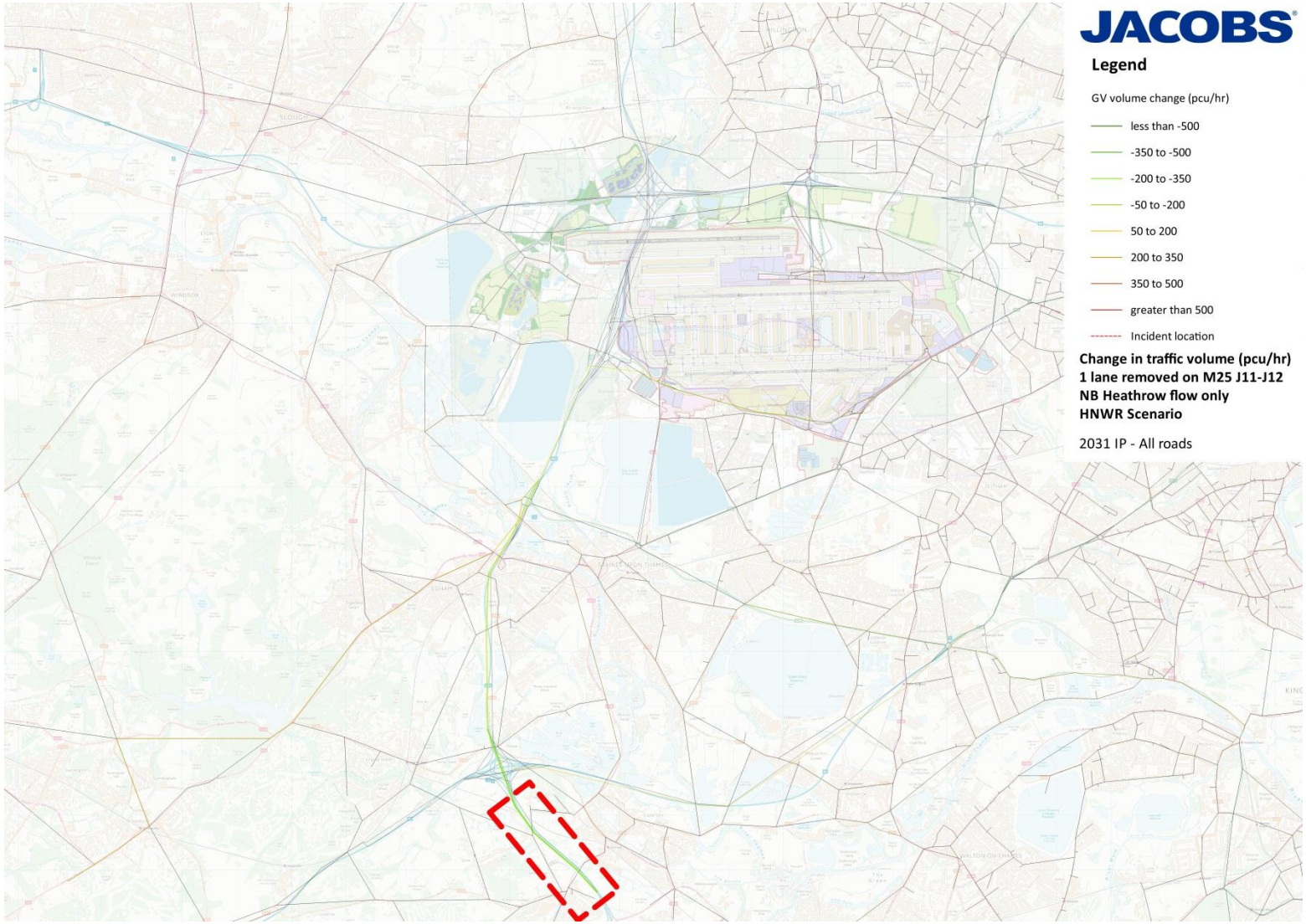

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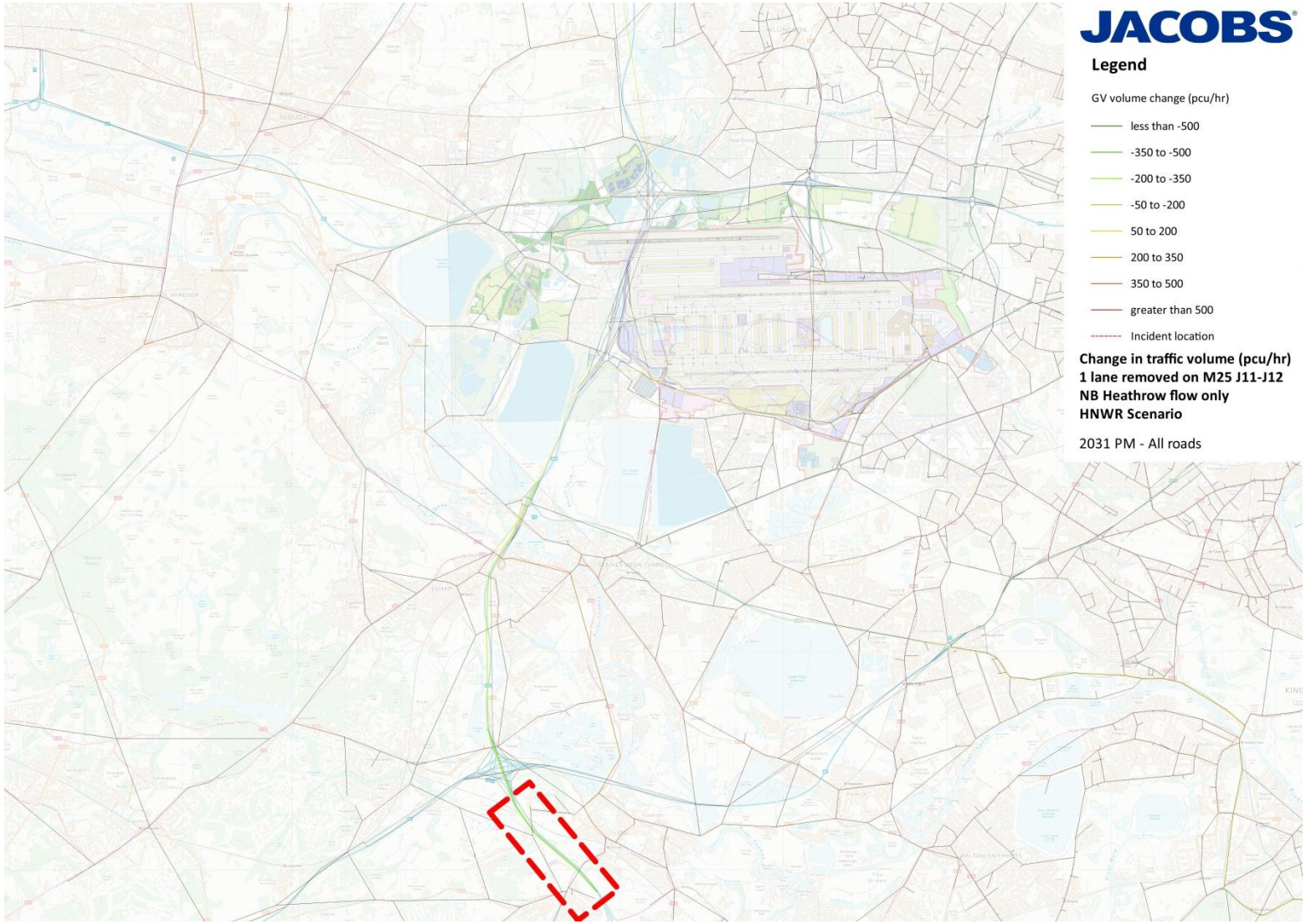
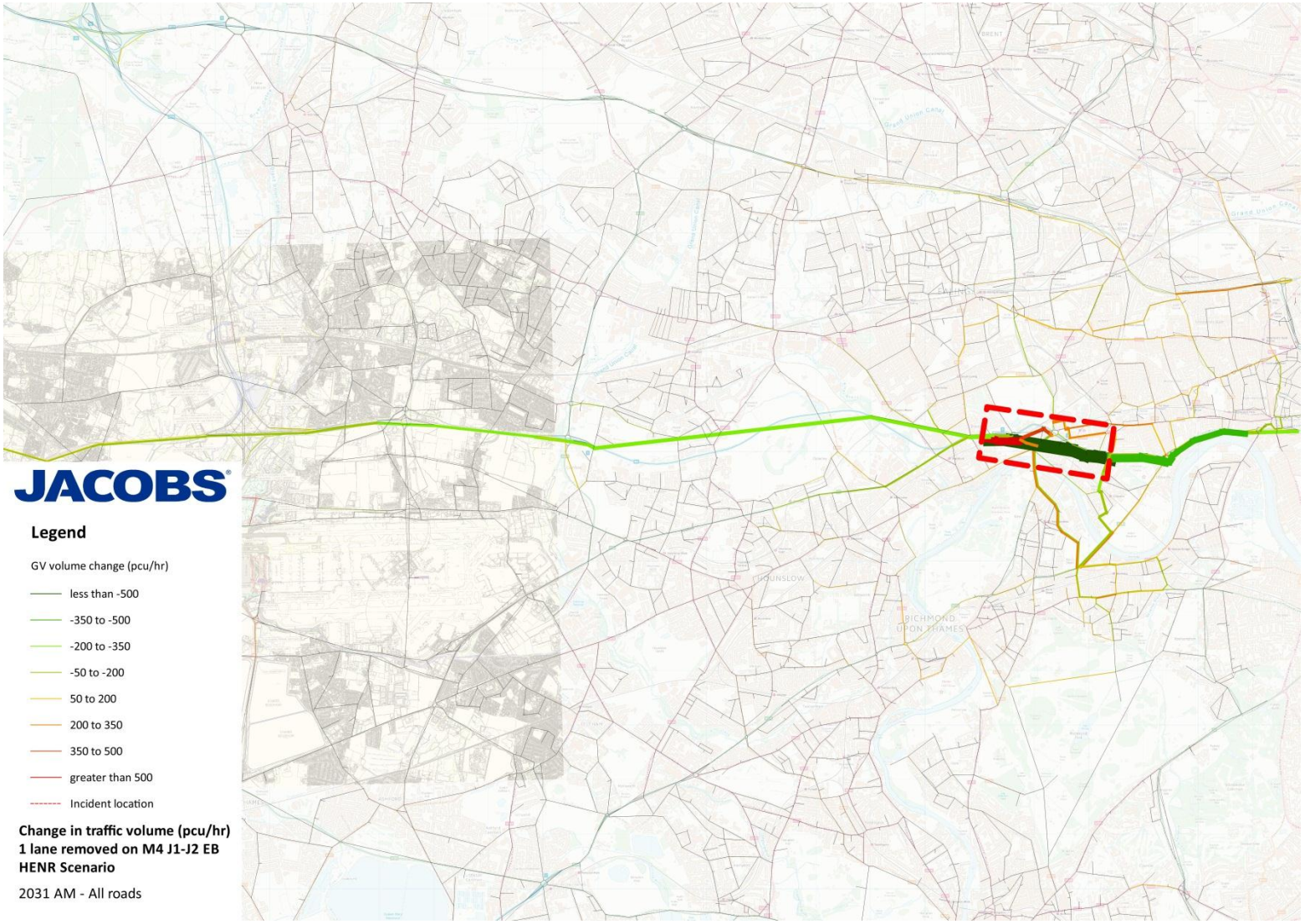
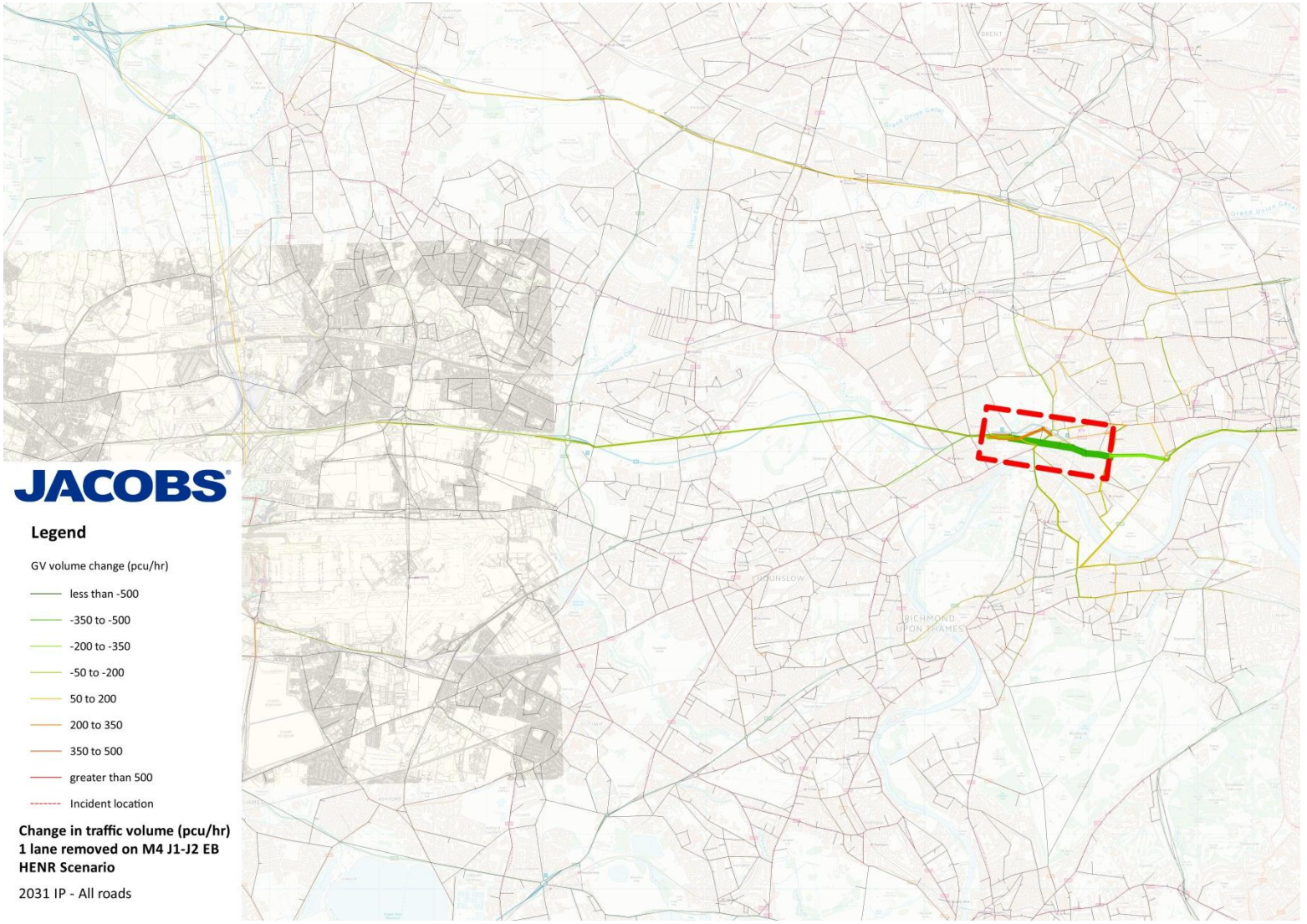
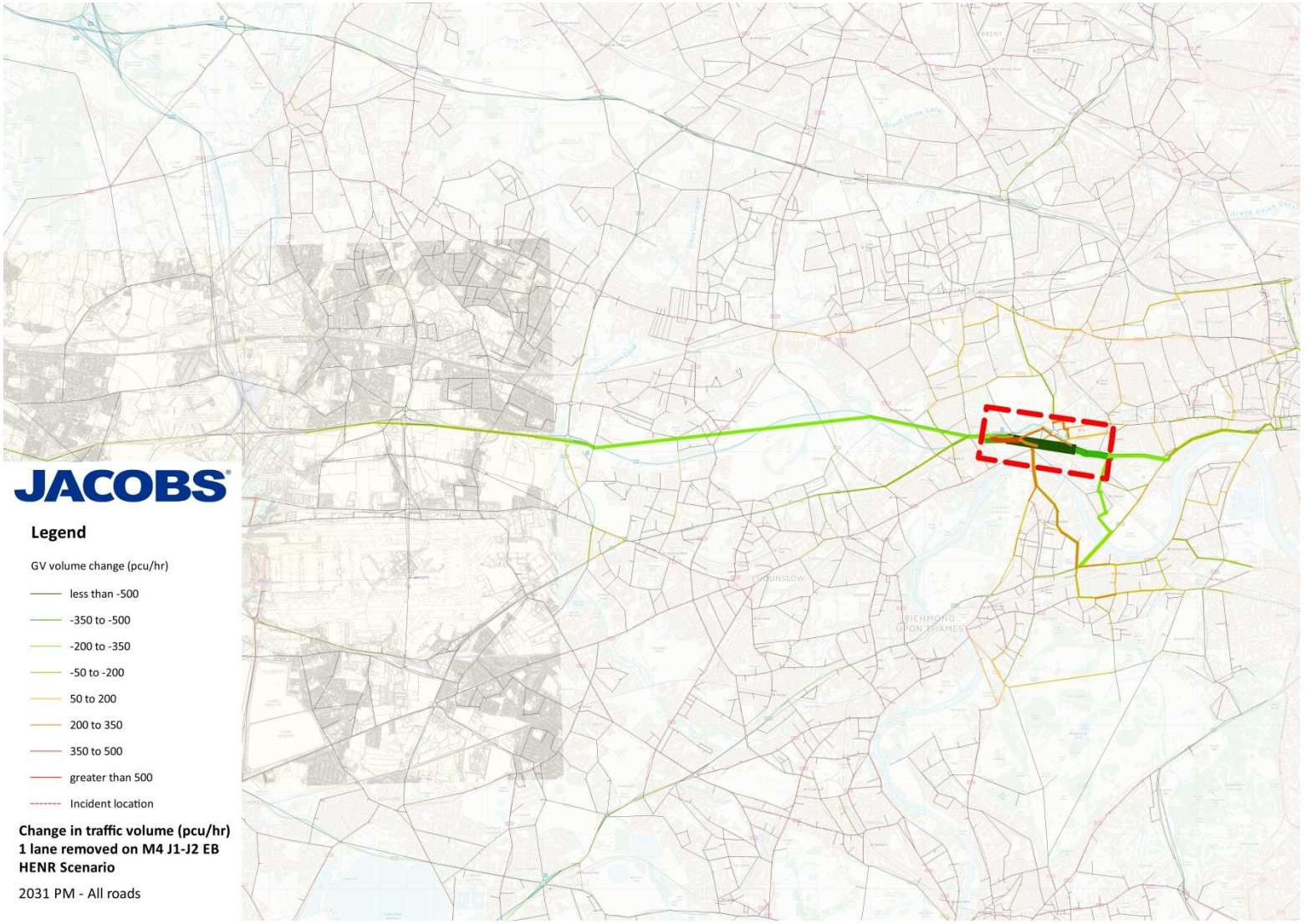


# Appendix D. Heathrow Extended Northern Runway highway analysis figures







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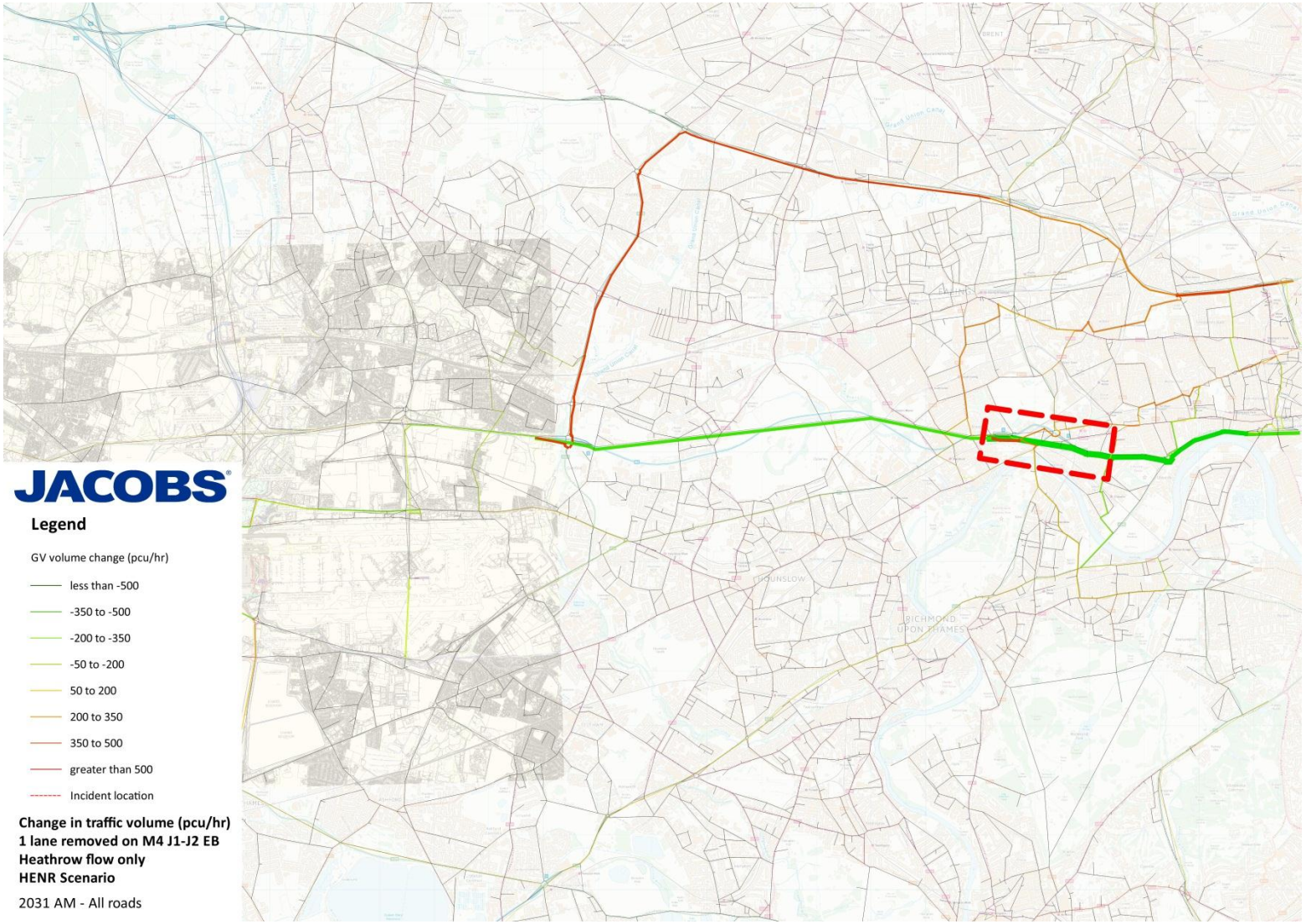

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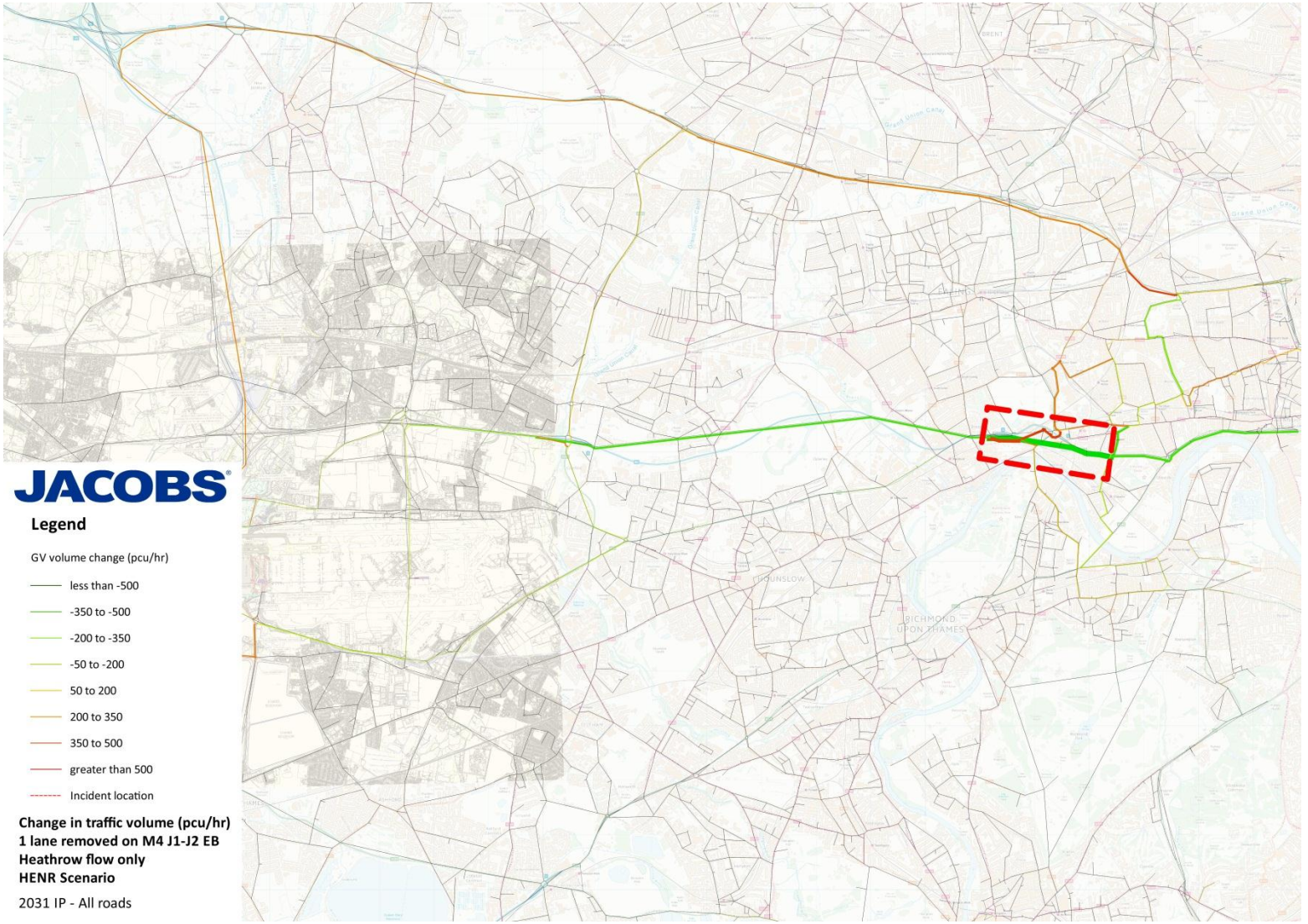

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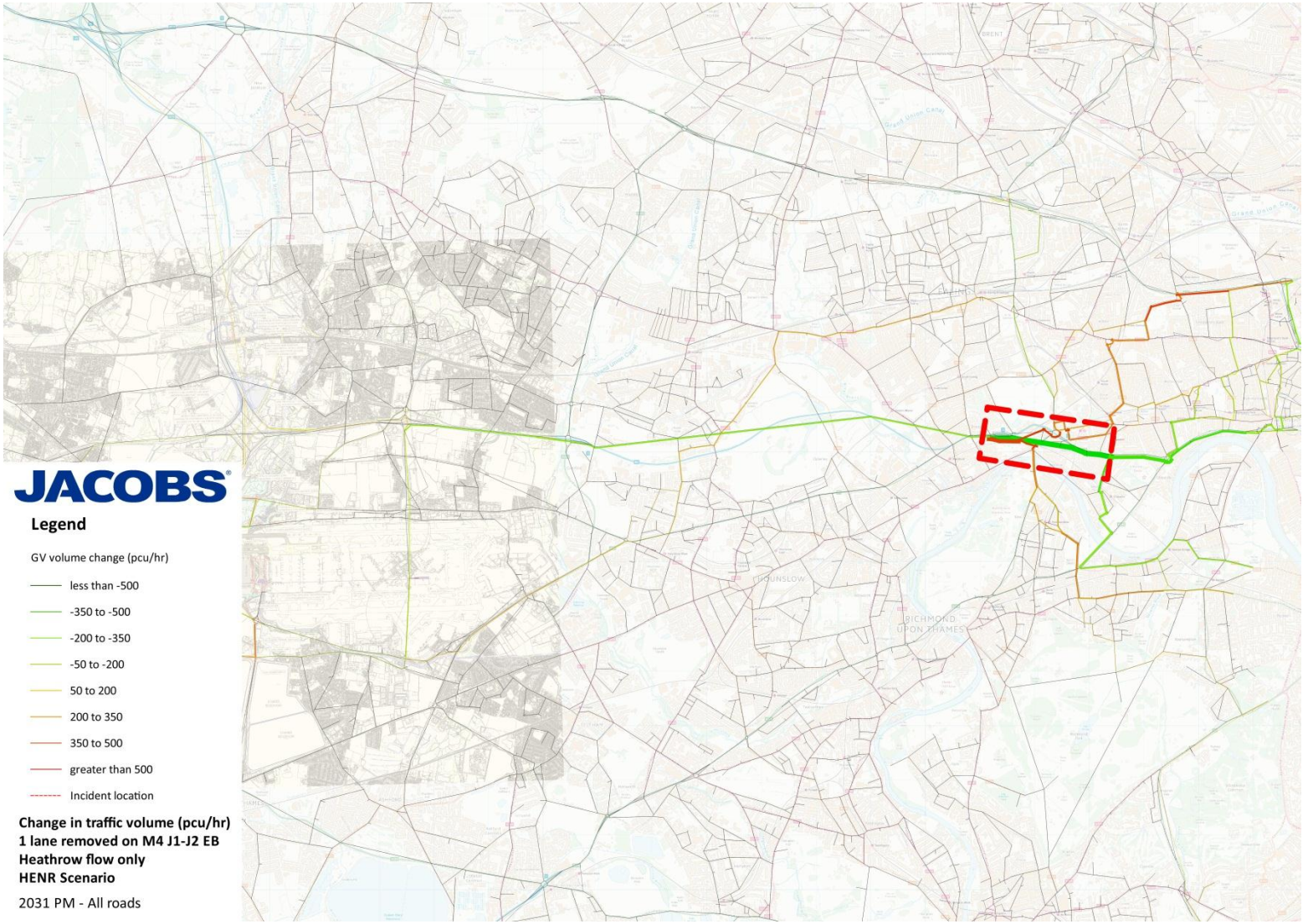

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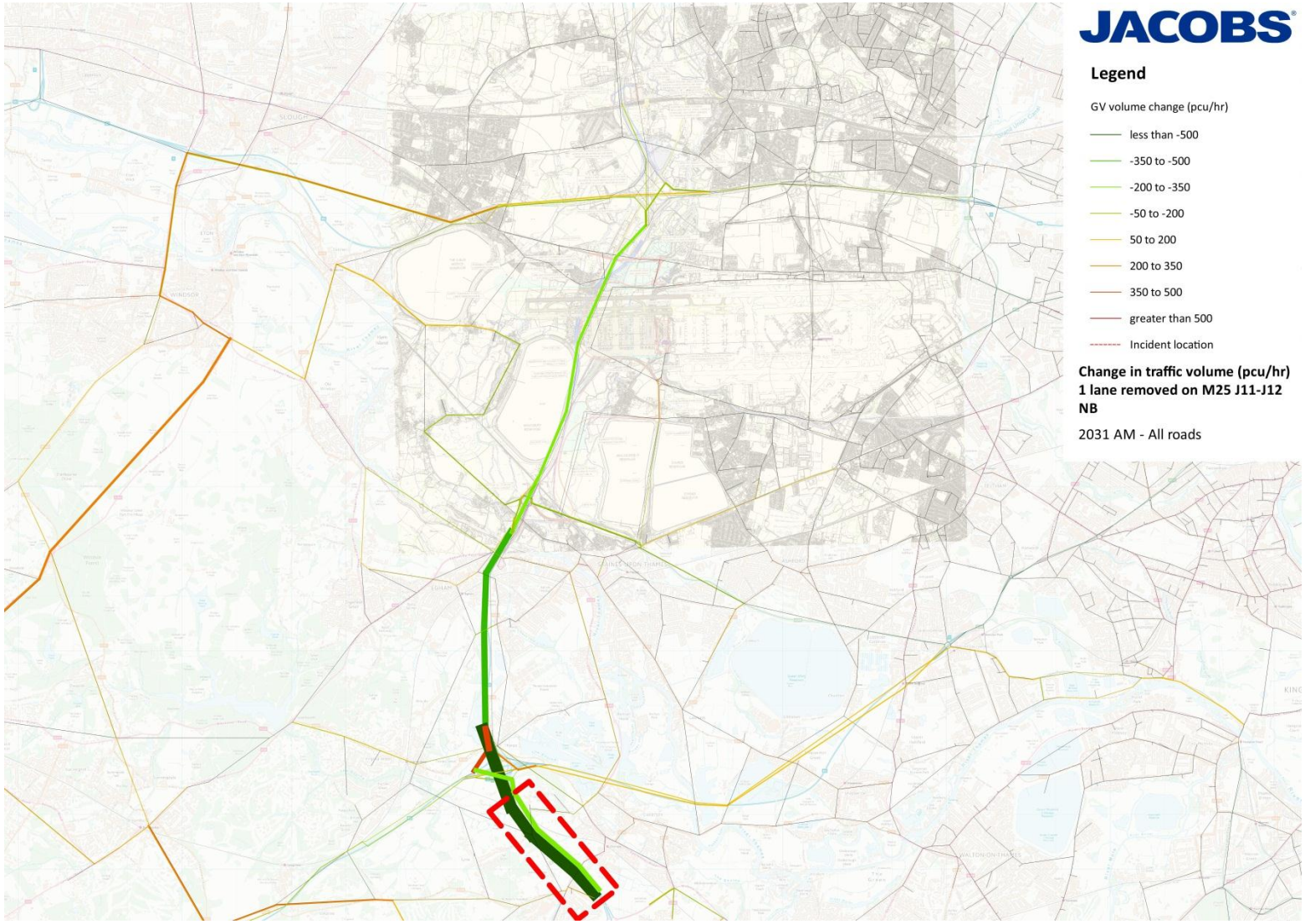

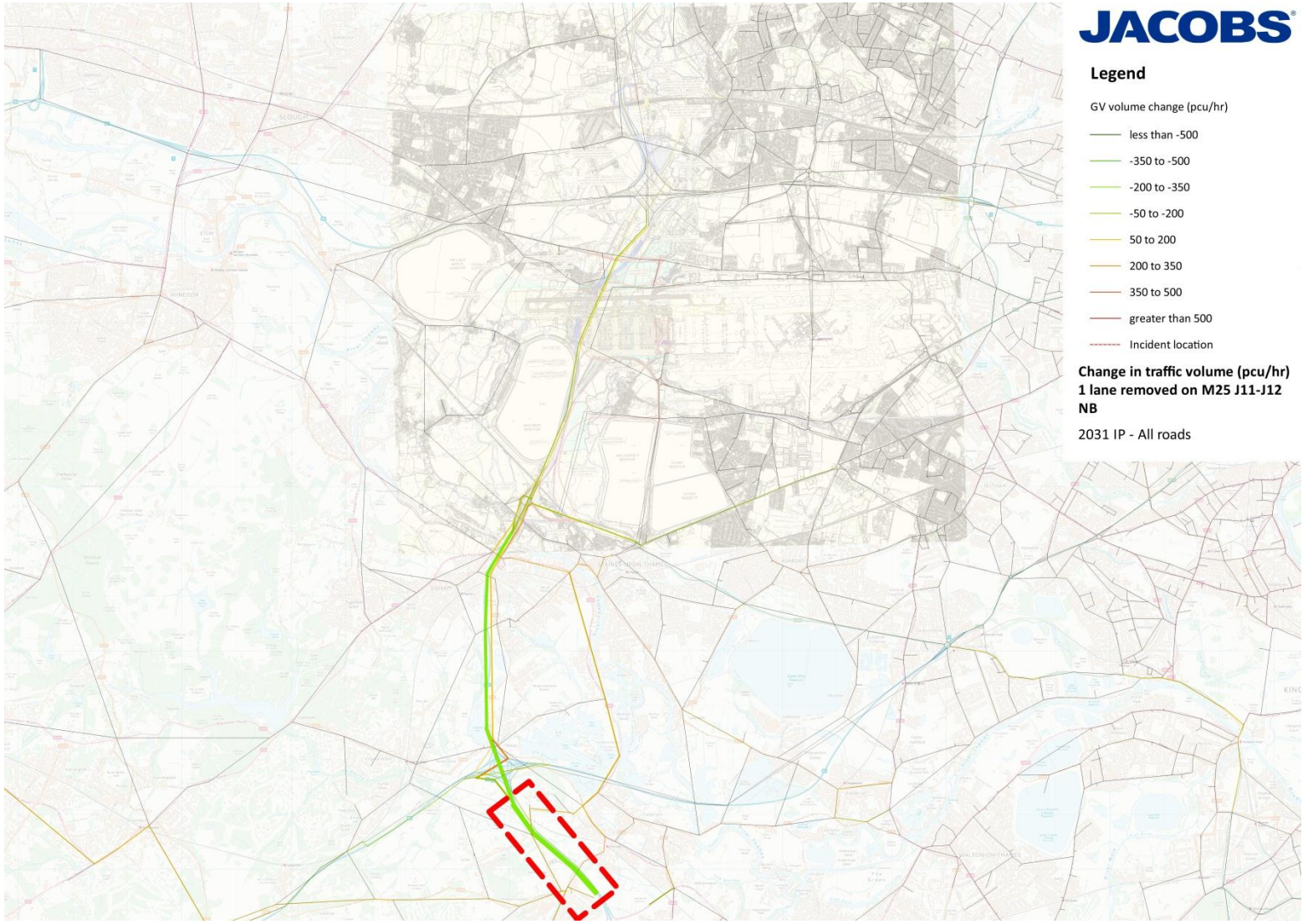

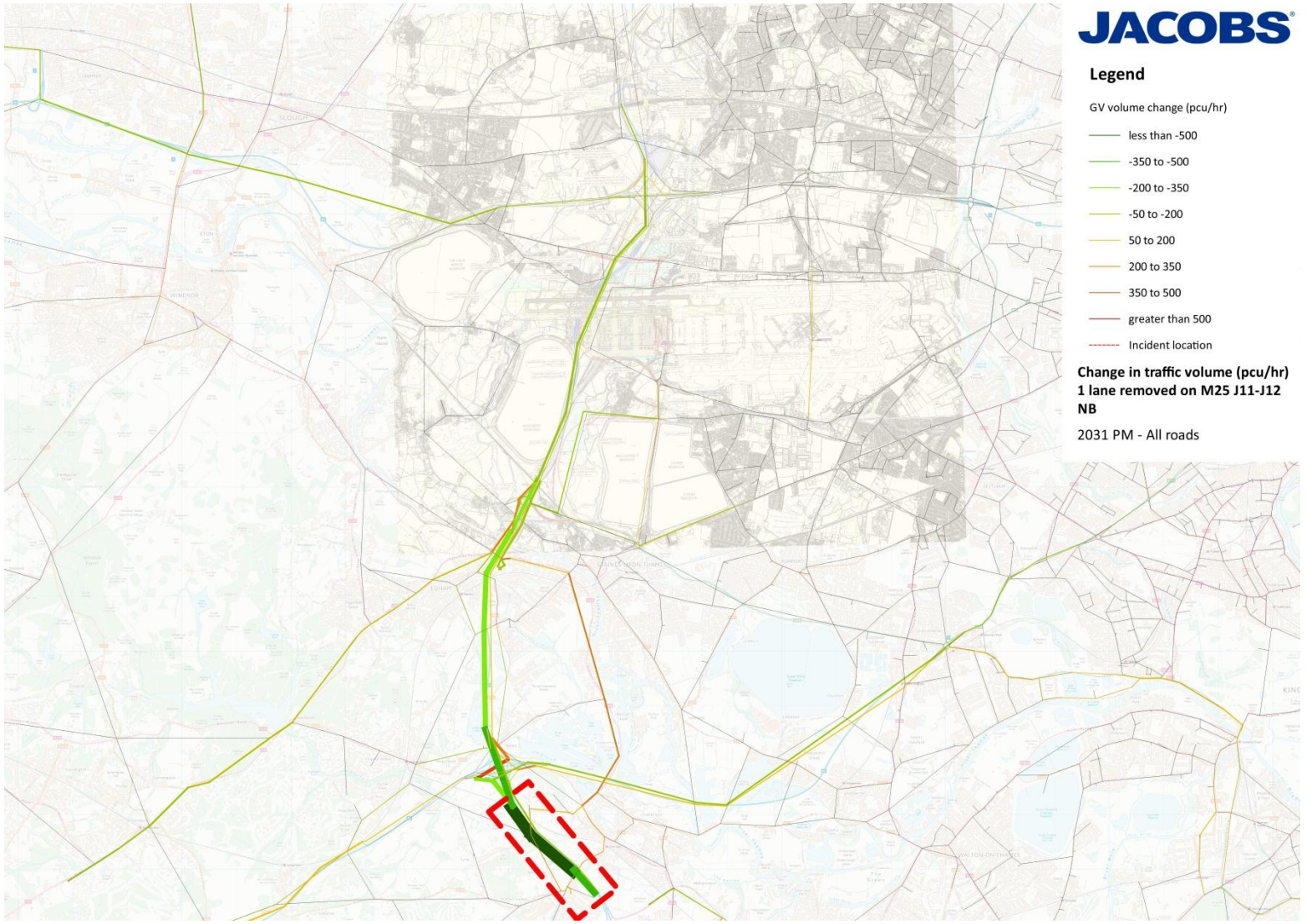

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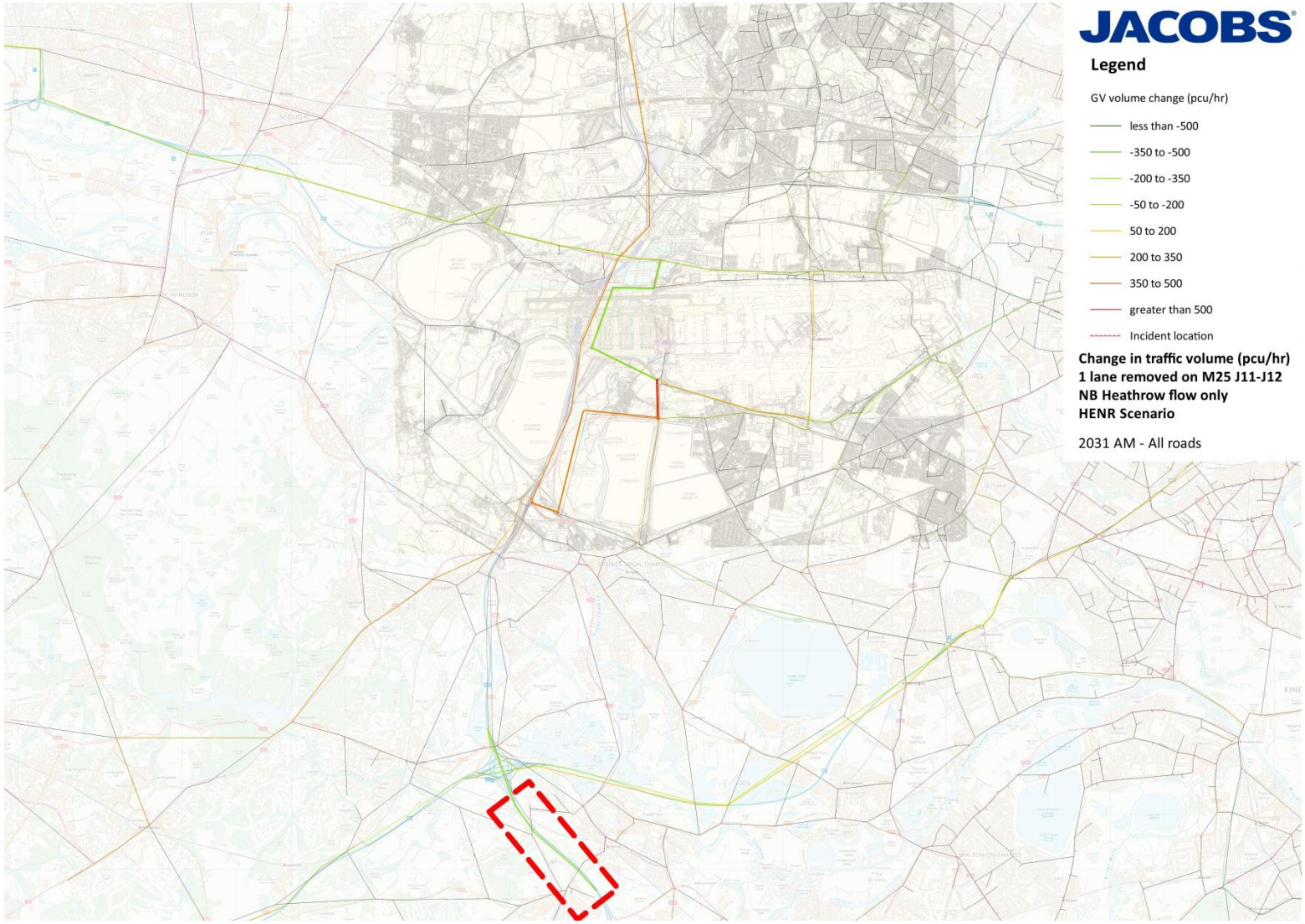

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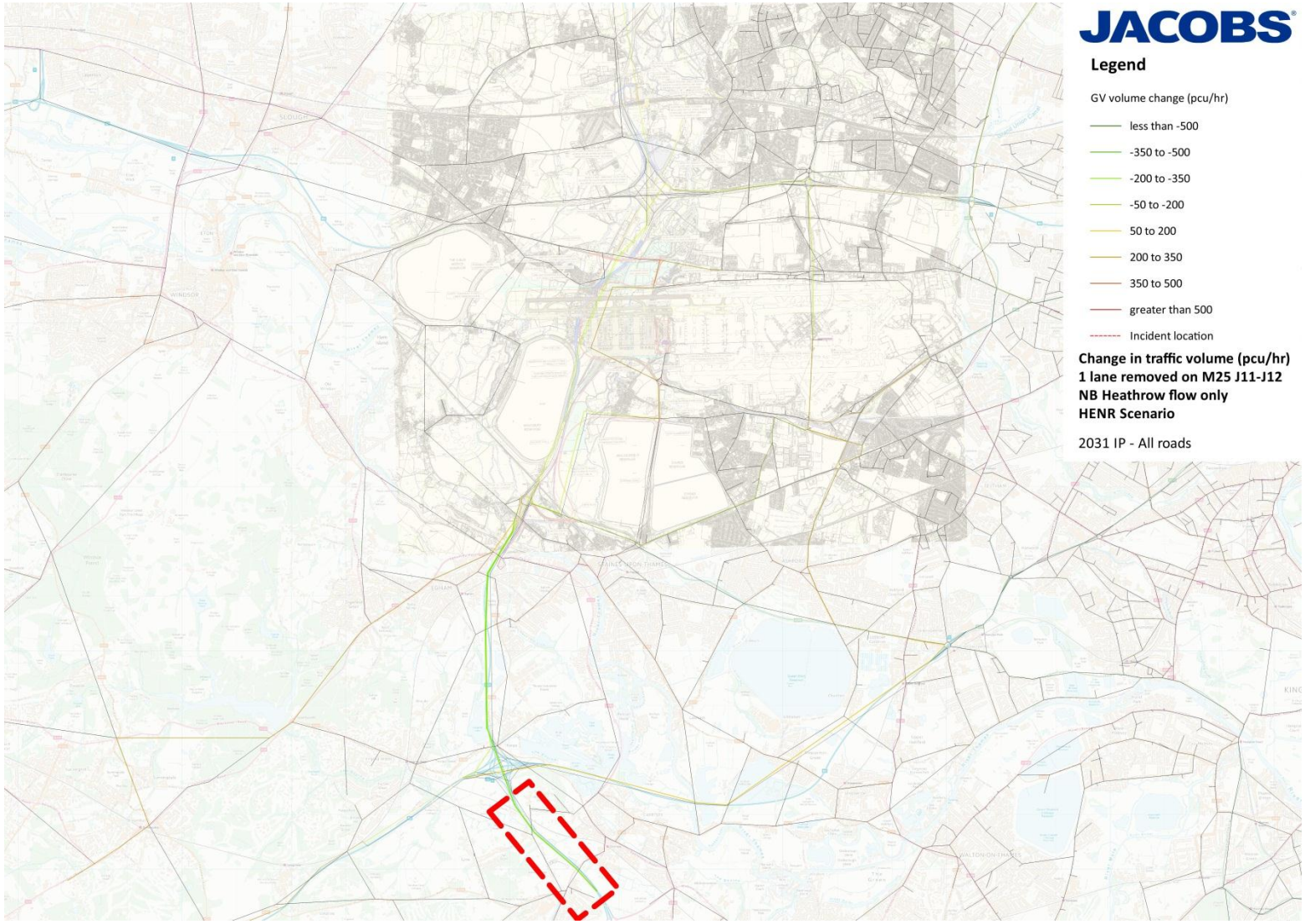

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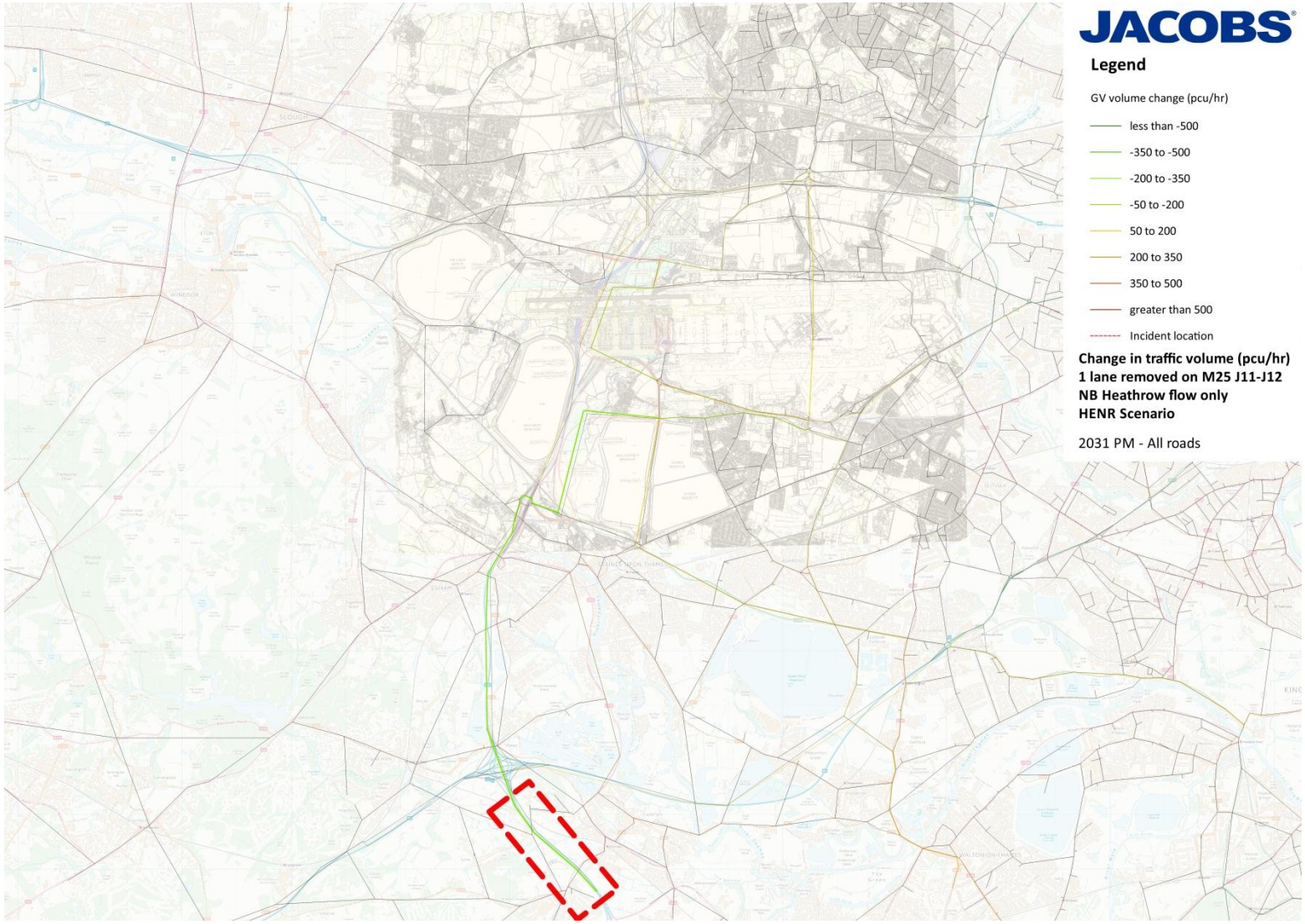
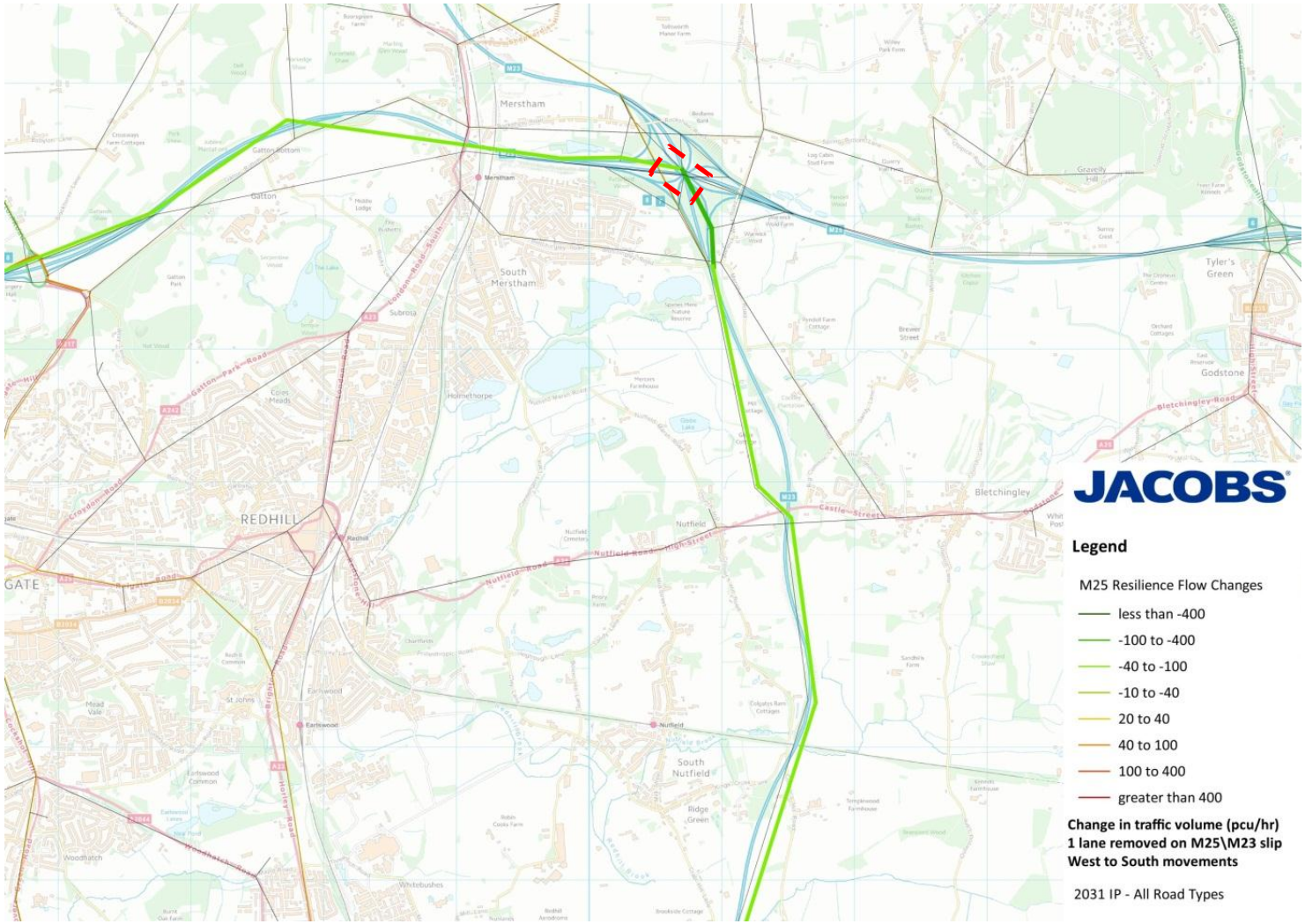
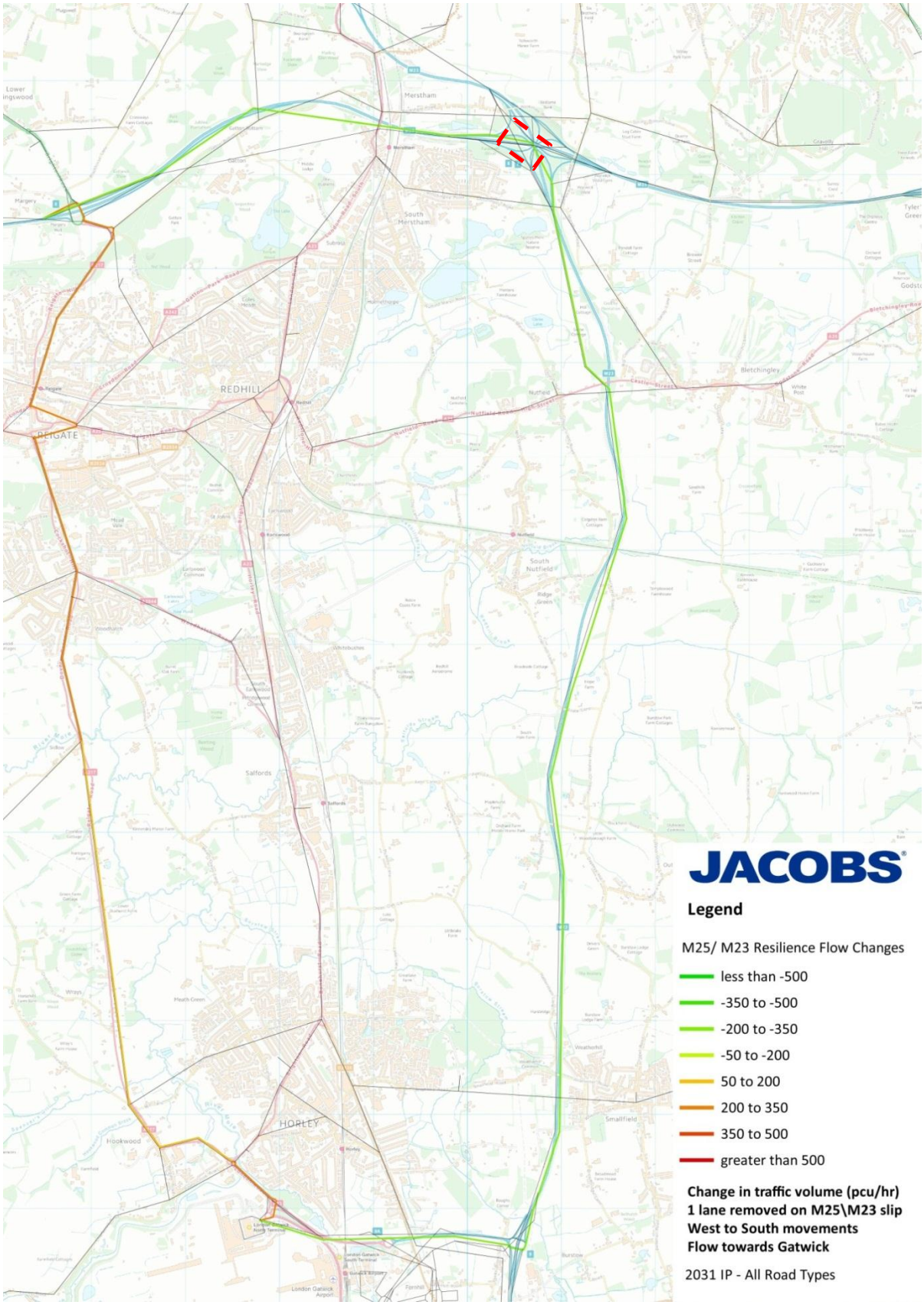


# Appendix E. Gatwick highway analysis figures

**M25 to M23 slip incident, IP flow difference**



**M25 to M23 slip incident, IP flow difference to Gatwick**



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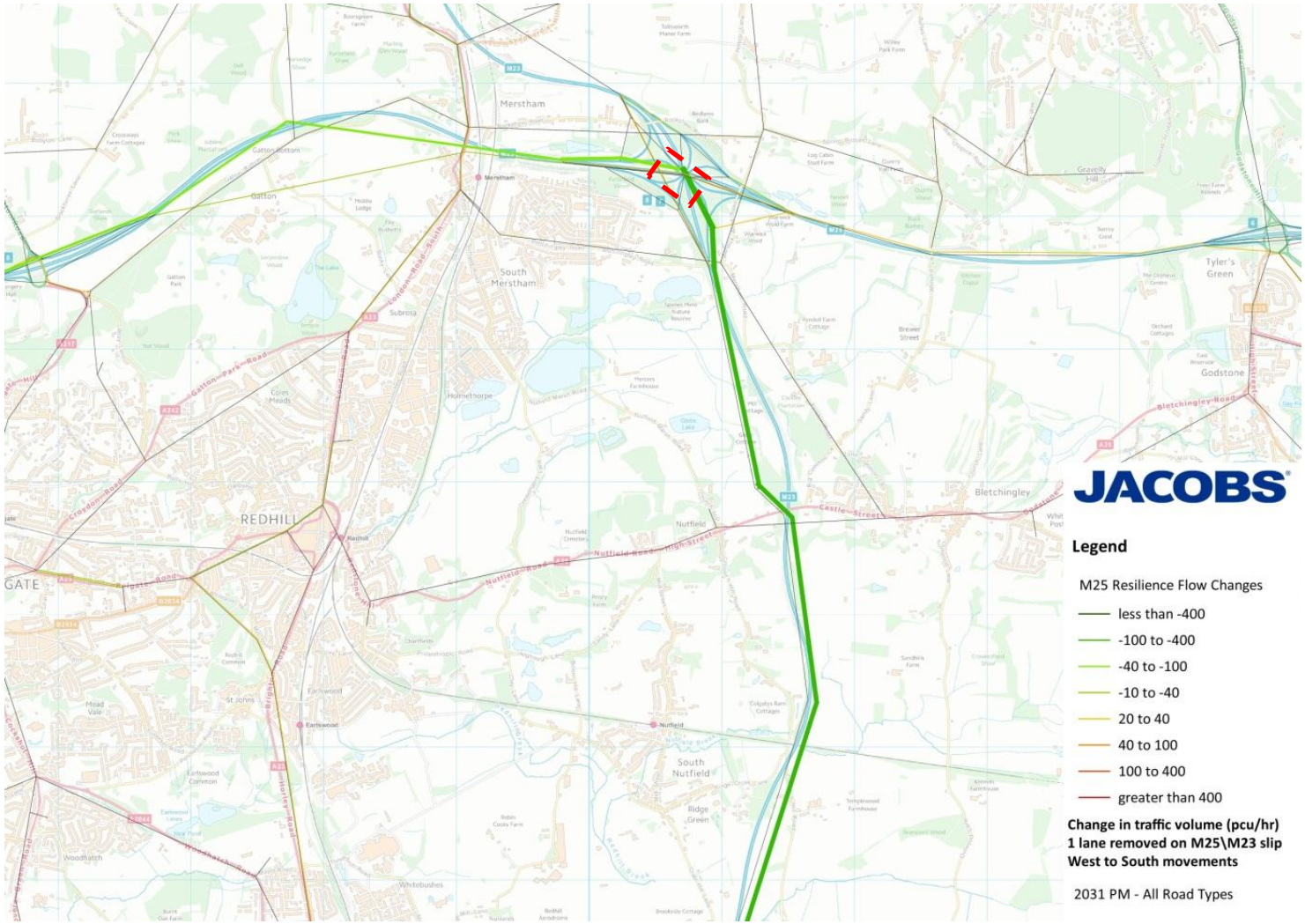

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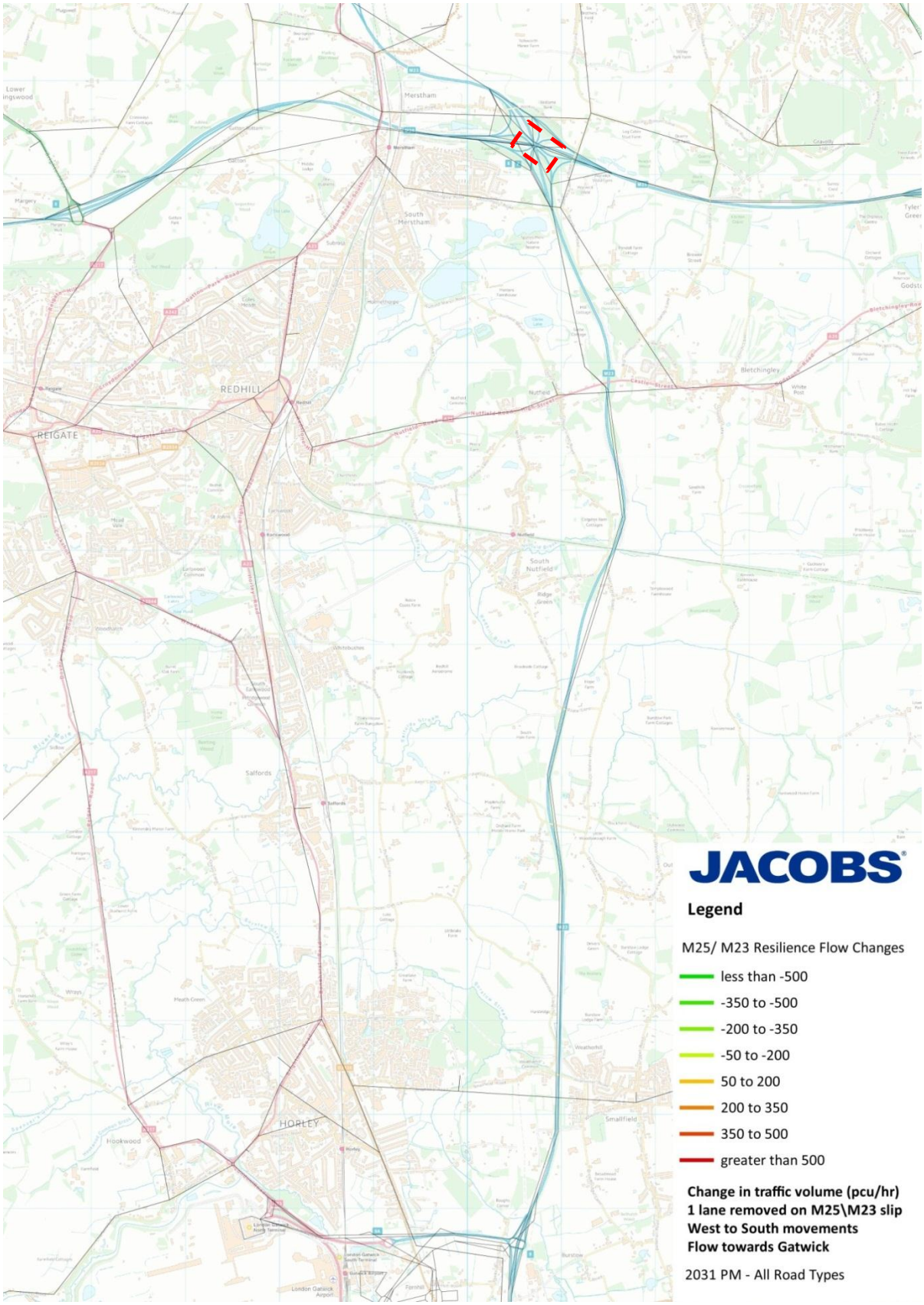
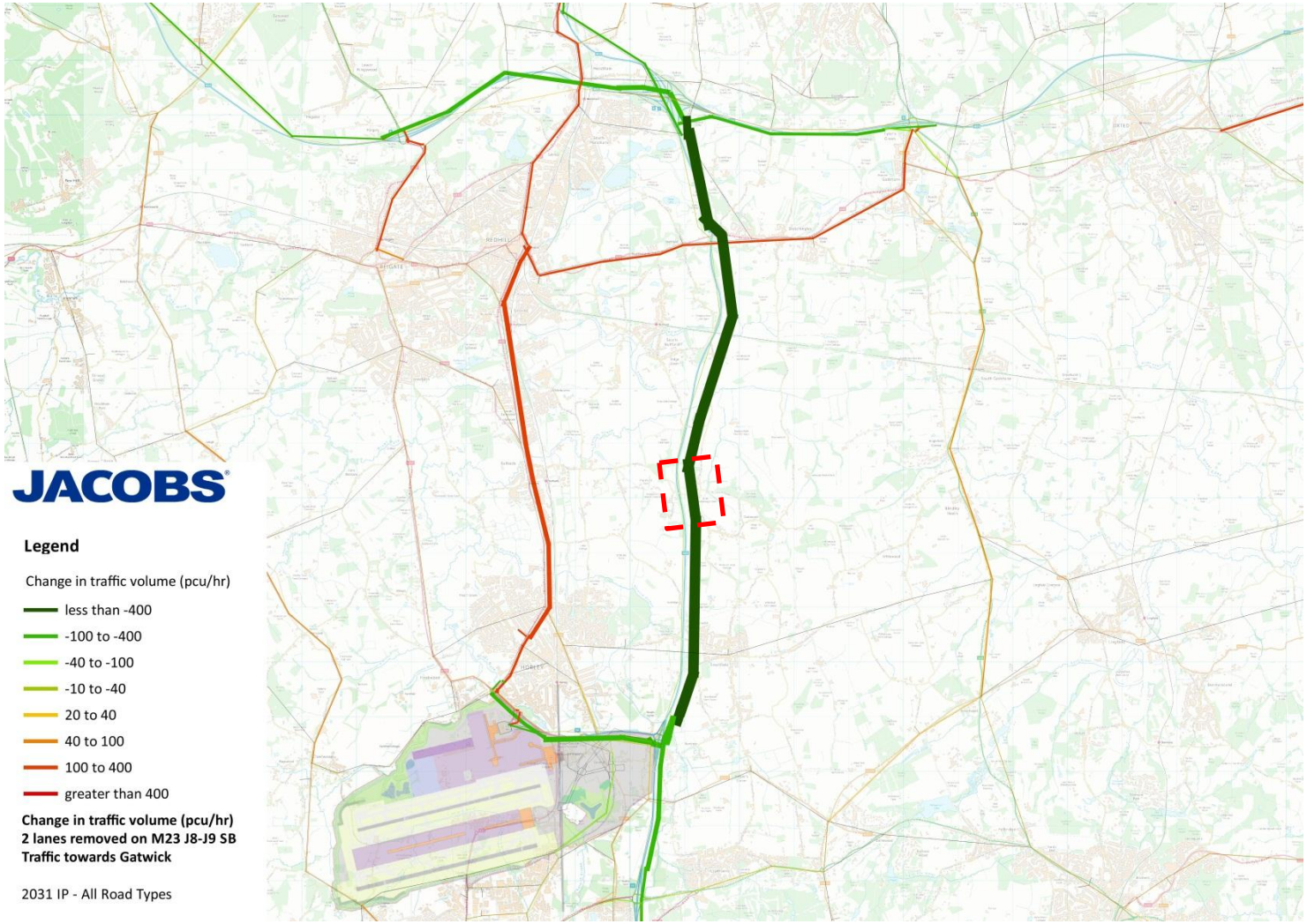


**M23 southbound, IP flow difference**



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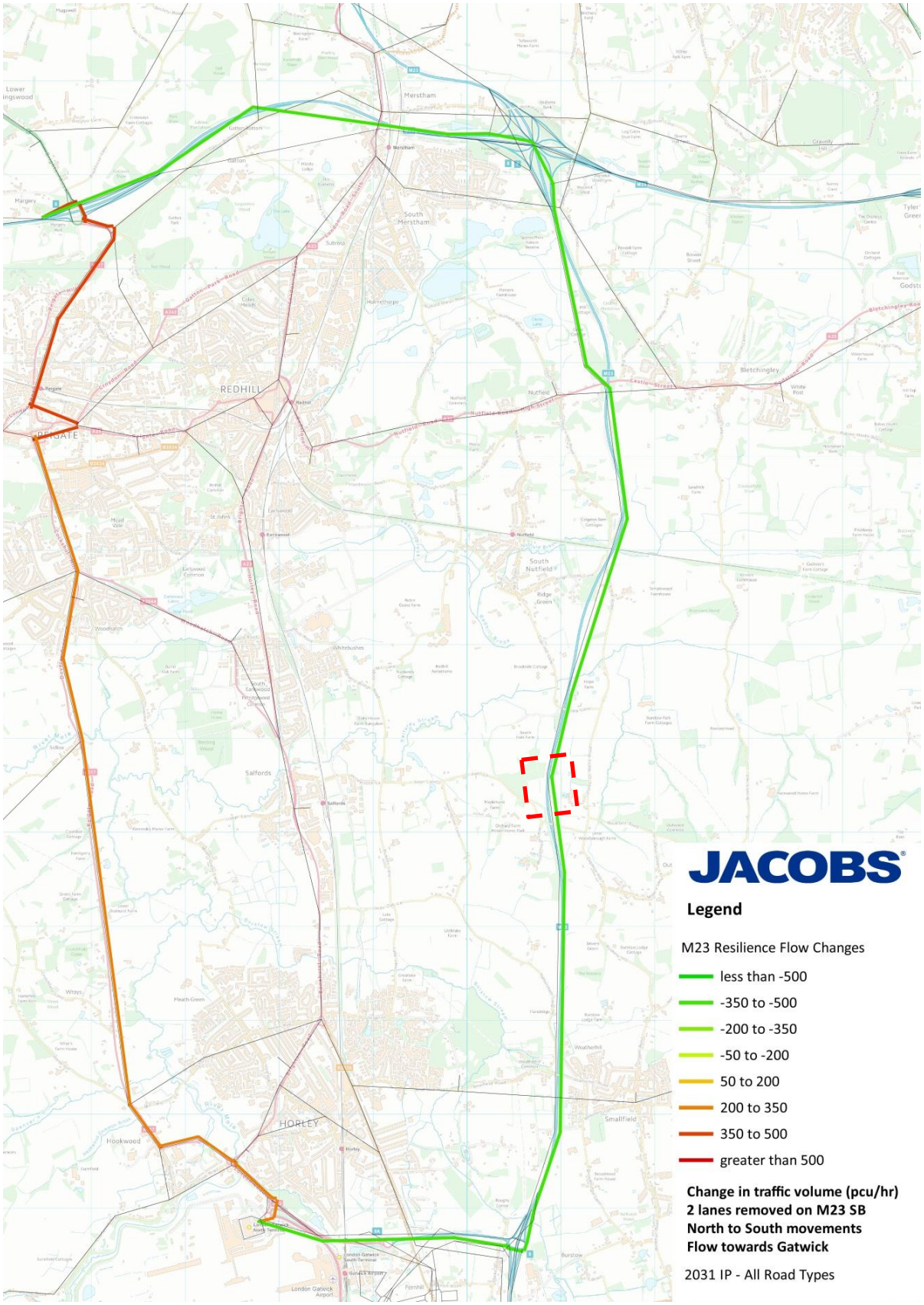

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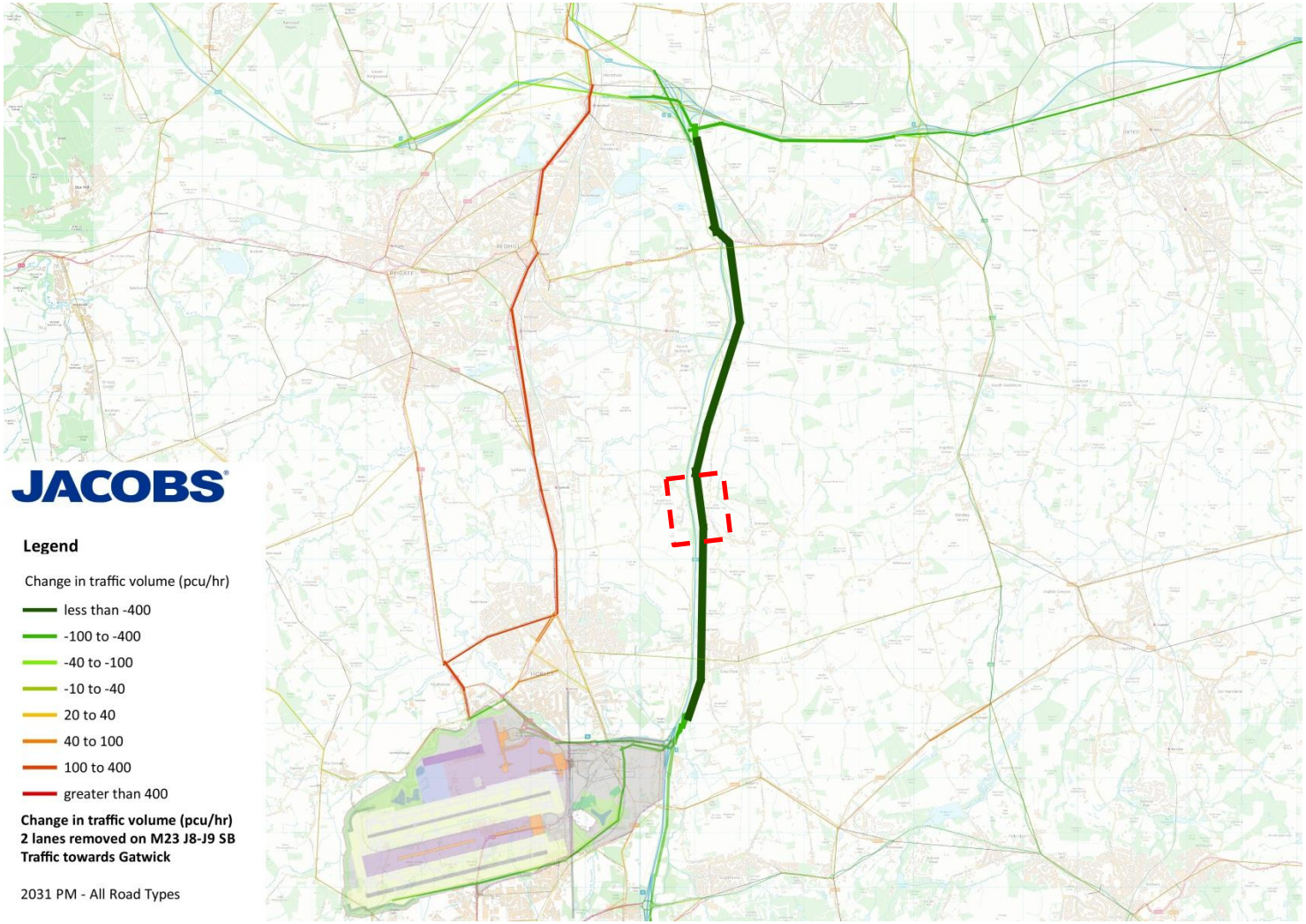

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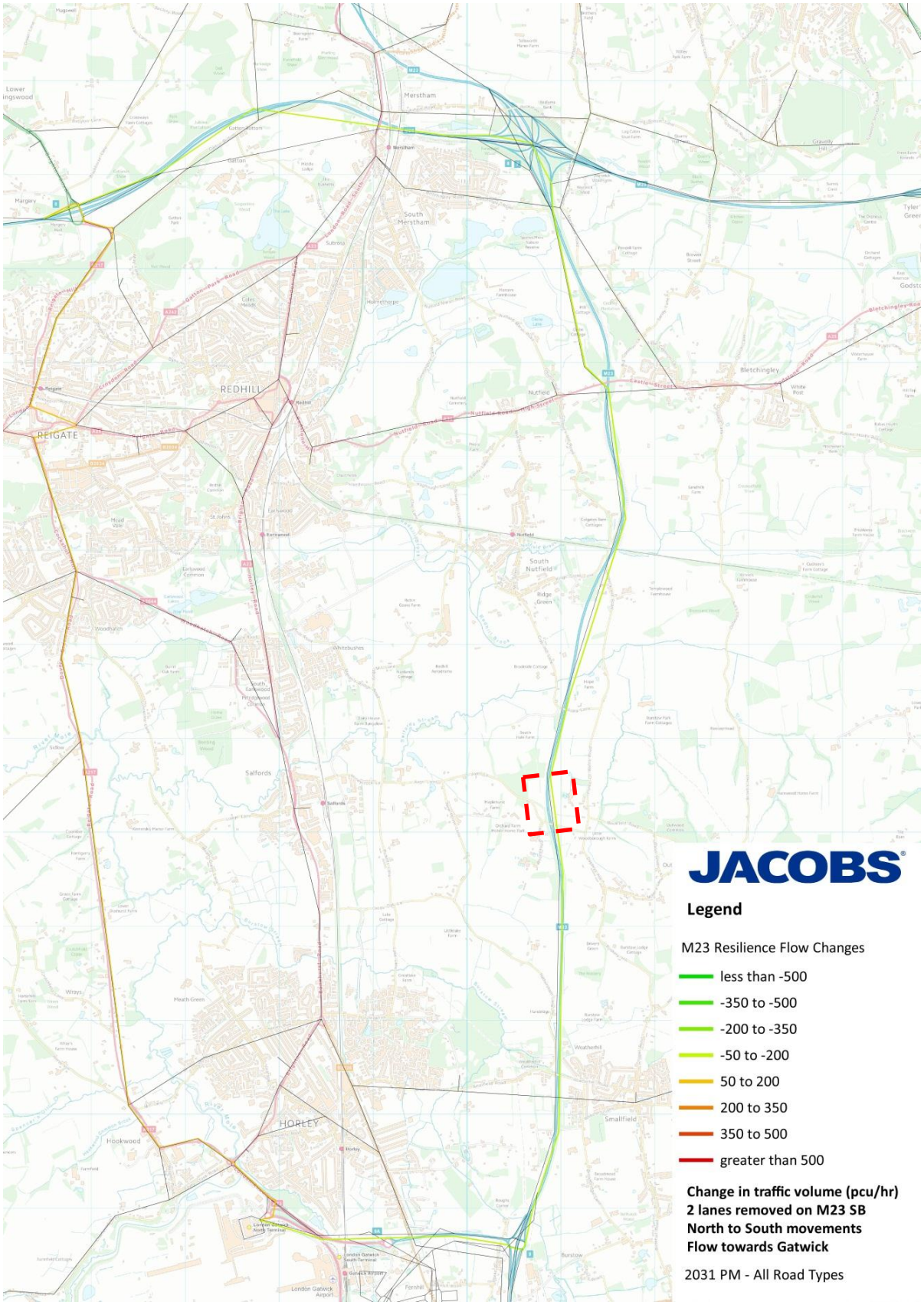

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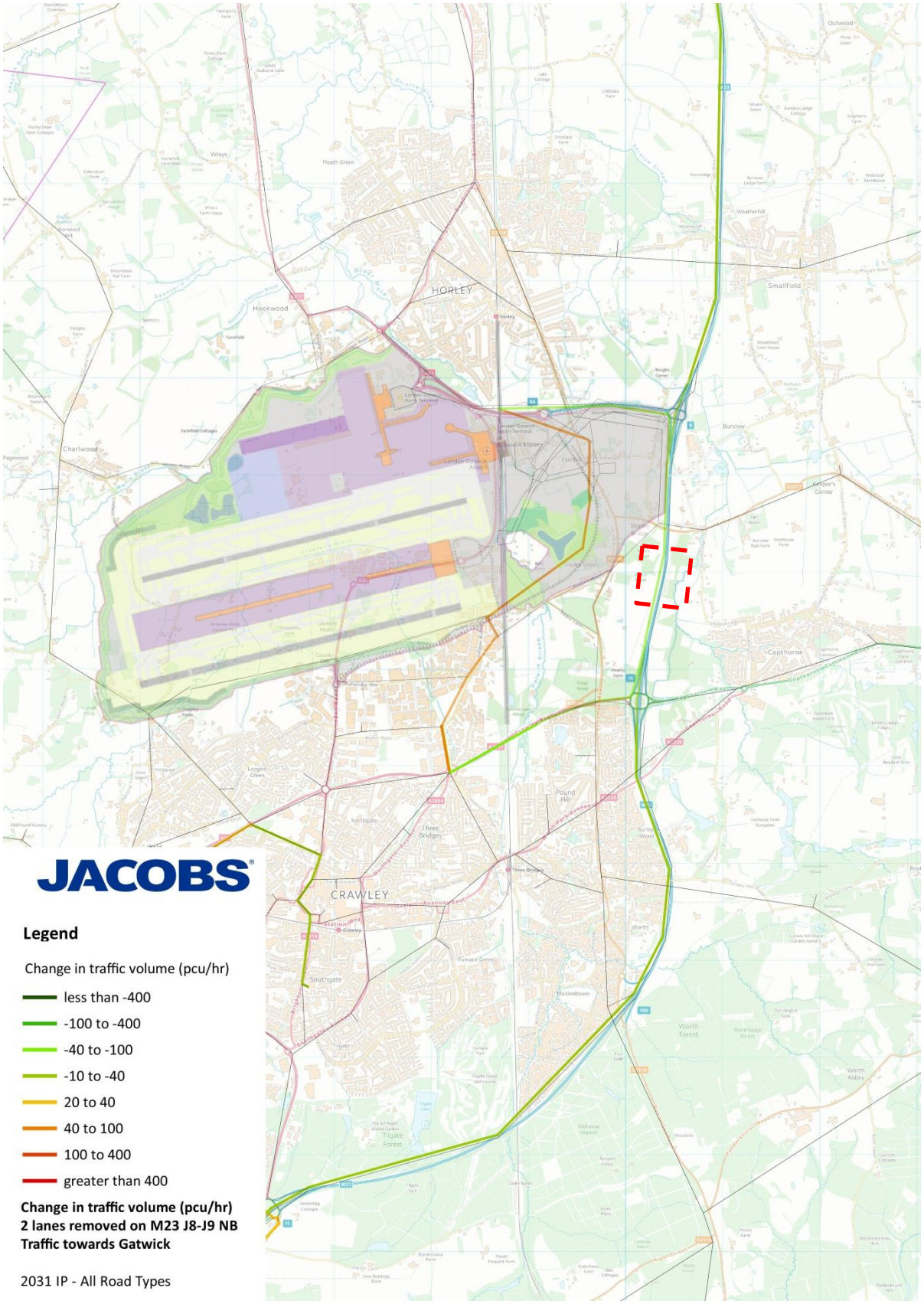

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