

## 4 EXISTING ROAD NETWORK AND BRIDGE PERFORMANCE

This Chapter describes the existing transport network performance in the study area around the Richmond Bridge. Results from traffic surveys are summarised. An assessment of existing network capacity has been undertaken indicating network deficiencies at key roads and intersections.

### 4.1 SITE VISIT

A site visit was undertaken on Friday 17th June 2011 to observe the existing traffic patterns within the study area. Both morning (AM) and afternoon (PM) peak period traffic were observed. Site photos showing network issues are shown in Table 4-1. The following is a summary of key findings from the site observations.

- Bells Line of Road/ Grose Vale Road Intersection. This is a four leg signalised intersection. There are controlled pedestrian crossings across all the approaches. In the AM peak throughput across the stoplines on the western and southern approaches are often affected due to slow moving queues on Bells Line of Road eastbound. Bells Line of Road east of Grose Vale Rd has two existing lanes but narrows down to one lane further to the east. Vehicles on the kerbside lane merge to one lane. This downstream merging slows down vehicles (See Photo 1).
- The eastern approach of Bells Line of Road/ Grose Vale Road intersection has one lane leading to three lanes at the stop line. It has short left and right turn bays dedicated to left turn and right turn vehicles. In the PM peak, through traffic in one lane often blocks left turning traffic. (See Photos 3 and 4).
- A significant volume of traffic (about 500 vehicles per hour) uses Pitt Lane travelling along Riverview Street and then turns left into Grose Vale Road. A possible reason can be delays at Bells Line of Road / Grose Vale Road intersection. The site observation suggests that Pitt Lane provides an attractive alternative route to motorists rather than using the next intersection.
- Kurrajong Road in the eastbound direction immediately after the Richmond Bridge has an uphill gradient. This slows down vehicles.
- Kurrajong Road / Yarramundi Lane / Old Kurrajong Road Intersection. This is a four leg priority intersection. Traffic on Kurrajong Road has priority. All approaches have one single lane. There is no dedicated right turning bay which often blocks the eastbound through traffic. It appears that a significant volume of traffic use Yarramundi Lane instead of using the downstream intersection with Castlereagh Road/Bosworth Street. This is predominantly morning Penrith-bound traffic. In the AM peak right turn vehicles (about 300 vehicles per hour) on Kurrajong Road to Yarramundi Lane often block the eastbound through traffic. This obstruction creates a 'knock-on' effect' to the heavy eastbound traffic leading to congestion on the Bridge (See Photo 2).
- In the PM peak vehicles turning left (about 380 vehicles per hour) at the Yarramundi Lane approach slow down the westbound through traffic on Kurrajong Road. A long queue was observed on Kurrajong Road for westbound traffic and queues often extend to the Castlereagh Road/Bosworth Street intersection.
- Kurrajong Road / Bosworth Street / March Street intersection. In the PM peak westbound traffic experiences significant delays. Queues are observed along the Kurrajong Road / March Street up to its intersection with East Market Street. (See Photo 5)

**Table 4-1 Network Issues Observed During Site Visit**





Photo ID	Location	Photo
1	<p>Bells Line of Road, approximately 100m east of Grose Vale Road.</p> <p>Looking East along Bells Line of Road. Vehicles on the nearside lane have to merge back to form one lane.</p>	
2	<p>Kurrajong Road / Yarramundi Lane intersection.</p> <p>Looking West along Kurrajong Road.</p> <p>Eastbound traffic is blocked by the right turning traffic (the first two cars).</p>	

Photo ID	Location	Photo
3	<p>Bells Line of Road, West of Grose Vale Road.</p> <p>Looking East along Bells Line of Road. Through traffic blocks the turning vehicles to the left turning lane.</p>	
4	<p>Bells Line of Road / Grose Vale Road intersection.</p> <p>Looking east along Bells Line of Road. Traffic discharges across the stop line in a single lane.</p>	
5	<p>Kurrajong Road, approximately 600m west of Bosworth Street.</p> <p>Looking East along Kurrajong Road. Long queues are observed during the PM Peak</p>	

## 4.2 TRAFFIC SURVEY

To satisfy RMS's modelling requirements, Hyder undertook an extensive data collection exercise involving key roads and intersections in the study area. Traffic surveys were undertaken as an input into:

- Micro simulation (Paramics) model calibration and validation.
- Intersection capacity analysis to determine levels of service by using SIDRA.

Three types of survey were undertaken to satisfy the needs and purpose of the project. They were:

- Intersection turning movement counts for the critical peak periods.
- Daily automatic traffic counts for a one week period.
- Queue length surveys at critical intersections.

Surveys were undertaken in three stages as follows:

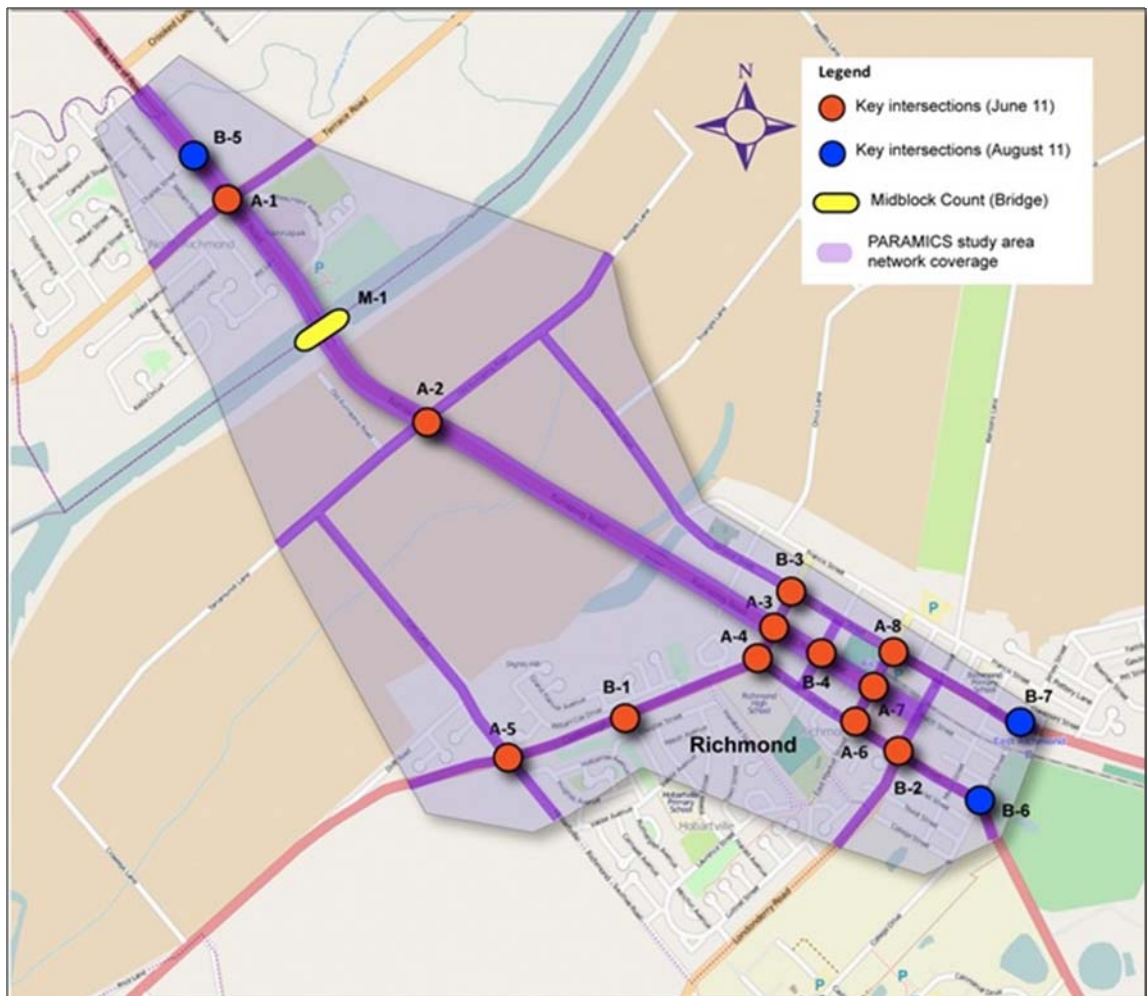
- Stage 1: A survey was undertaken by *Skyhigh* on 17<sup>th</sup> June 2011 at 12 intersections in study area. One week of traffic was counted on Richmond Bridge.
- Stage 2: Following the first workshop with RMS and Hawkesbury City Council additional traffic counts were undertaken during the Yarramundi Lane closure. Yarramundi Lane was closed for road resurfacing between 18<sup>th</sup> July 2011 and 15<sup>th</sup> August 2011. Additional traffic counts were undertaken by *Austraffic* at two intersections on 26<sup>th</sup> July 2011. The traffic data during the Yarramundi Lane closure was used as a sensitivity check through the modelling process.
- Stage 3: Hawkesbury City Council requested traffic counts for an additional three sites. The survey was undertaken by *Austraffic* on 18<sup>th</sup> August 2011 after Yarramundi Lane reopened to traffic.

Table 4-2 summarises traffic surveys undertaken in 2011.

**Table 4-2 Summary of Traffic Survey undertaken for Richmond, 2011**

Stage	Survey Summary
<p>Stage 1 (June 2011) Normal condition, no road closure</p>	<ul style="list-style-type: none"> <li>▪ Mid-block tube count for the period of one week for Richmond Bridge;</li> <li>▪ Intersection turning counts during morning and afternoon peak periods for 12 intersections comprising: <ul style="list-style-type: none"> <li>▪ Bells Line of Road/Grose Vale Road;</li> <li>▪ Kurrajong Road/Yarramundi Lane;</li> <li>▪ Kurrajong Road/Bosworth Street;</li> <li>▪ Castlereagh Road/Lennox Street;</li> <li>▪ Castlereagh Road/Innals Lane;</li> <li>▪ Castlereagh Road/Long Street;</li> <li>▪ Lennox Street/East Market Street;</li> <li>▪ March Street/East Market Street;</li> <li>▪ Windsor Street/East Market Street;</li> <li>▪ Lennox Street/Paget Street;</li> <li>▪ Windsor Street/Bosworth Street;</li> <li>▪ March Street/West Market Street;</li> </ul> </li> <li>▪ Figure 4-1 shows the locations of 12 intersections and mid-block location.</li> </ul>
<p>Stage 2 (July 2011) During Yarramundi Lane closure</p>	<ul style="list-style-type: none"> <li>▪ Intersection turning counts during the morning and afternoon peak periods for two intersections comprising: <ul style="list-style-type: none"> <li>▪ Kurrajong Road / Yarramundi Lane;</li> <li>▪ Kurrajong Road / Bosworth Street.</li> </ul> </li> <li>▪ Queue length surveys for Kurrajong Road / Bosworth Street intersection.</li> </ul>
<p>Stage 3 (August 2011) Normal condition, no road closure</p>	<ul style="list-style-type: none"> <li>▪ Intersection turning counts and queue length surveys during the morning and afternoon peak periods for three additional intersections comprising: <ul style="list-style-type: none"> <li>▪ Bells Line of Road / Charles Street;</li> <li>▪ Lennox Street / Bourke Street;</li> <li>▪ Windsor Street / Bourke Street.</li> </ul> </li> <li>▪ See Figure 4-1 for locations of the three sites.</li> </ul>

Figure 4-1 shows the traffic survey locations in the study area.



**Figure 4-1 Traffic Survey Locations**

**Note:** Intersection A-2 and A-3 were counted again during Yarramundi Lane closure in July 2011 (Stage 2)

All the intersection classified turning movement counts were undertaken for 3 hours in the AM peak (6 am to 9am) and 3 hours in the PM peak (3pm-6pm) using video.

The daily automatic traffic counts (ATC) were conducted for a continuous seven-day period at Bells Line of Road on Richmond Bridge. The ATC survey was conducted as per twelve Austroads standard vehicle classes.

## 4.3 RESULTS OF THE TRAFFIC SURVEY

This section quantifies the daily and peak hour traffic flows on key roads and intersections within the study area. The intersection turning movement data was used to estimate current capacity problems at key intersections. The traffic data also provides a basis to consider likely traffic changes that would result from future growth and short term improvement options. The results are based on survey data recorded from key roads and intersections in 2011.

### 4.3.1 TRAFFIC VOLUMES ON RICHMOND BRIDGE

Table 4-3 shows daily traffic volumes on Richmond Bridge for a typical weekday and weekend. The heavy vehicle number and proportion to total traffic volume is also shown. The results indicate that:

- Richmond Bridge carries between 27,200 and 30,200 vehicles per day on an average weekday;

- The weekend traffic is approximately 15% lower than weekday traffic. The weekend traffic is in the order of 22,400 to 25,800 vehicles per day. The relatively high traffic volumes on the weekend demonstrate the tourism and recreational significance of this route;
- About 1500 heavy vehicles are recorded on the Bridge. The heavy vehicle proportion is about 5% to 6% of total traffic in weekdays. The heavy vehicle proportion during weekends is about of 2 % to 3 % of total traffic.

**Table 4-3 Daily traffic volume on the Richmond Bridge**

Weekday	Total daily flow [two-way]	Heavy Vehicle %
Monday	27,213	5.7%
Tuesday	27,672	5.7%
Wednesday	28,377	6.1%
Thursday	29,015	5.1%
Friday	30,184	5.3%
Saturday	25,809	3.0%
Sunday	22,400	2.2%

Figure 4-2 shows the variation of the hourly traffic profile from Monday to Friday on Richmond Bridge. The AM peak spreads over three hours between 06:00 AM and 09:00 AM, with traffic building up sharply between 6.00 AM and 07:00 AM when reaches its peak. The hour between 07:00 AM and 08:00 AM shows the predominant peak. The PM peak also spreads over three hours between 15:00 PM and 18:00 PM, with traffic volumes gradually starting to build up around 15.00 PM. The PM reaches its peak at 17:00 Hours before it starts to decline sharply. The hour between 16:00 PM and 17:00 PM shows the predominant peak.

As seen, the peak direction in the morning is eastbound towards Richmond. This is mirrored in the afternoon peak with a similar volume of traffic heading westbound towards Kurrajong and beyond. Peak hour traffic volume on the Richmond Bridge is in the order of 1400 to 1500 vehicles per direction.

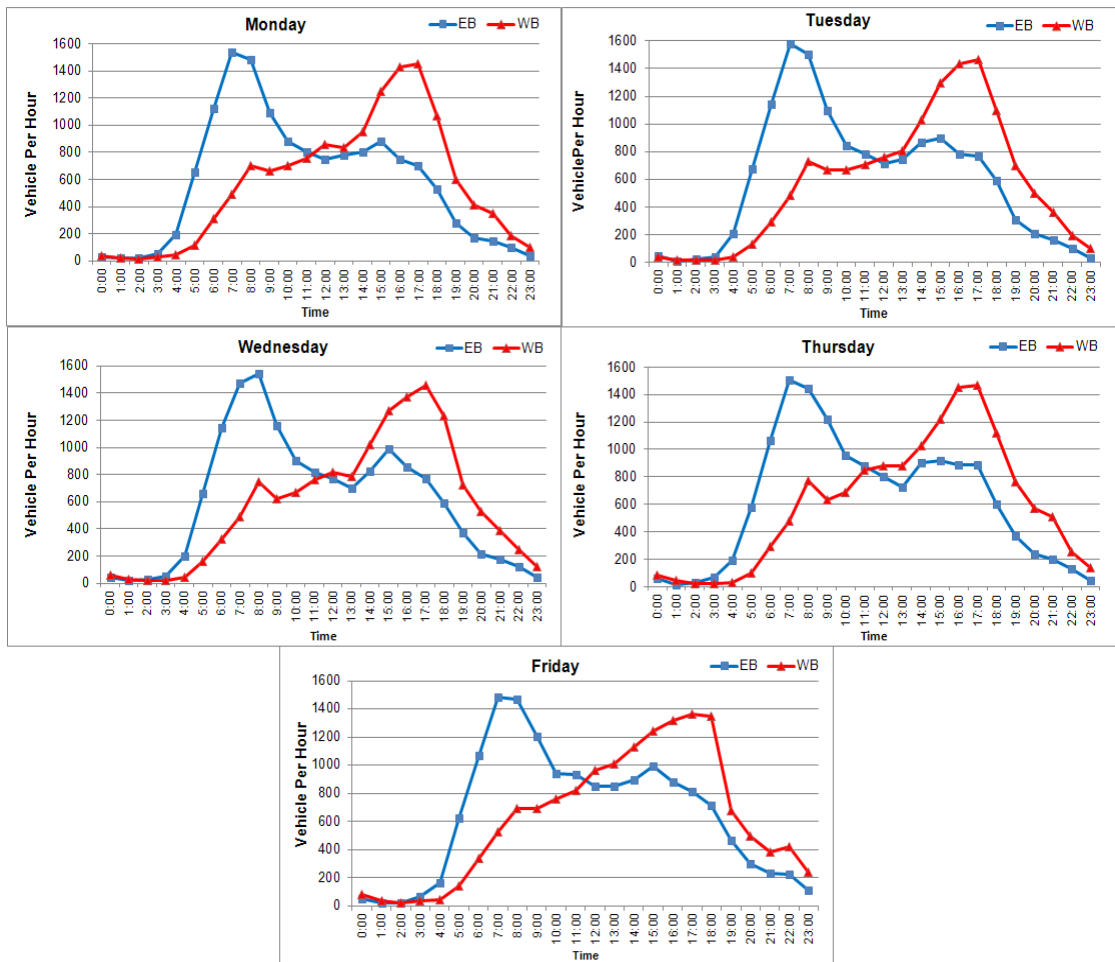


Figure 4-2 Hourly Traffic Profile – Weekdays on Richmond Bridge

### 4.3.2 PEAK HOUR TRAFFIC VOLUMES AT KEY ROADS

Table 4-4 summarises morning and afternoon peak hour traffic volumes on key roads in the study area.



**Table 4-4 Peak hour traffic volumes at key roads**

ID	Location	AM Peak			PM Peak		
		NB/EB	SB/WB	Two-way	NB/EB	SB/WB	Two-way
M-1	Bells Line of Road, Richmond Bridge	1,537	635	2,172	917	1,333	2,250
M-2	Bells Line of Road, west of Gross Vale Road	899	389	1,288	595	741	1,336
M-3	Kurrajong Road, west of Bosworth Street	942	489	1,431	652	855	1,508
M-4	March Street, west of East Market Street	592	367	959	510	501	1,011
M-5	Lenox Street, west of East Market Street	514	240	755	351	576	927
M-6	Windsor Street, west of East Market Street	189	152	341	252	299	551
M-7	March Street, east of East Market Street	304	173	477	357	350	706
M-8	Castlereagh Road, north of Southee Road	317	143	460	254	480	734
M-9	Yarramundi Lane, south of Kurrajong Road	156	336	492	467	162	629
M-10	Lenox Street, east of Paget Street	556	354	910	472	568	1,041
M-11	Windsor Street, east of East Market Street	550	267	817	492	541	1,033

**Note:** Northbound (NB), Eastbound (EB), Southbound (SB), Westbound (WB); Peak 1 hour traffic is estimated from AM peak 2 hour and PM peak 3 hour traffic data. Traffic data in the above table represents one hour traffic.

Table 4-4 summarises AM and PM peak traffic volumes on key roads in the study area. Traffic volumes are presented as one hour volumes in each direction and as two-way volumes. The results showed that:

- The highest two-way traffic volume in the study area was observed on Bells Line of Road on Richmond Bridge. The bridge carried about 2,150 to 2,250 vehicles per hour in the AM and PM peak periods respectively. Bells Line of Road at Richmond Bridge showed typical tidal flow traffic distribution. The eastbound traffic was highest in the AM peak, in the order of 1,500 vehicles per hour, while westbound traffic was highest in the PM peak, in the order of 1,300 vehicles per hour;
- Kurrajong Road, west of Bosworth Street showed the second highest two-way flow in the study area, carrying about 1,400 to 1,500 vehicles per hour for the AM and PM peak periods. Directional traffic distribution at Kurrajong Road, west of Bosworth Street, showed similar contra flow pattern with highest eastbound traffic volumes during the AM peak and highest westbound traffic volumes during the PM peak;
- Bells Line of Road, west of Grose Vale Road, showed one hour two-way traffic volumes in the order of 1,300 vehicles per hour for both AM and PM peak periods. Similarly to the main road section between Richmond and North Richmond, traffic volumes showed a contra flow pattern, with the highest eastbound flow during the AM peak and highest westbound flow during the PM peak;
- The highest one hour two-way traffic volume on March Street was in the order of 950 to 1,000 vehicles per hour west of East Market Street;

- The highest one hour two-way traffic volume on Windsor Street was in the order of 800 to 1,000 vehicles per hour east of East Market Street;
- The highest one hour two-way traffic volume on Lennox Street was in the order of 900 to 1,000 vehicles per hour east of Paget Street;
- The highest one hour two-way traffic volume on Yarramundi Lane was in the order of 500 to 600 vehicles per hour south of Kurrajong Road. Yarramundi Lane showed a contra flow traffic distribution pattern with the highest southbound flow during the AM peak and the highest northbound flow during the PM peak;
- The highest one hour two-way traffic volume on Castlereagh Road was in the order of 450 to 700 vehicles per hour north of Southee Road.

## 4.4 RICHMOND BRIDGE CONDITION

The existing bridge is 212.63m long and consists of 13 spans. It was built in 1905 and widened downstream in 1927. The original superstructure consists of concrete arches and the existing widening consists of two arch shaped steel beams and 215mm reinforced concrete deck. The substructure consists of concrete piers and concrete headstocks.



Figure 4-3 Richmond Bridge

The carriageway between kerbs is 8.53m and carries two traffic lanes. There is a footway on the upstream side with a width of 2.18 m. In addition, there is a 762mm water main attached to the downstream side.

The RMS's bridge inspection regime includes four levels of inspections. Level 3 inspections are structural engineering inspections carried out by an experienced structural engineer with a RMS trained bridge inspector. A "Level 3" inspection of the Richmond Bridge was carried out in August and October 2011 by personnel from RMS. They have concluded that, overall, the bridge is in "fair to good" condition for its age.

The condition of the concrete arches is in fair to good condition with transverse cracking at the apex. The worst crack was observed in Span 13 which is being monitored. All of the pier headstocks are in fair to good condition with minor old flexural cracking at the middle of headstock, possibly due to minor movement of the pier foundation over the years. All the steel beams are in good condition with minor breakdown of paint and corrosion at a few rivets.

Semi detailed analytical studies, including Plane Frame modelling and simple beam modelling, were carried out. Based on the analytical studies, the structural capacity of the bridge is adequate to carry two lanes of Higher Mass Limits General Access Vehicles (ST45.5) and Higher Mass Limits Restricted Access Vehicles (BD68), provided that the bridge is maintained in good condition. The bridge is suitable for widening on the downstream side as an independent structure to the existing structure.

# 5 KEY NETWORK ISSUES

## 5.1 RICHMOND BRIDGE

The traffic capacity of Richmond Bridge was assessed using the appropriate Austroads' Guideline. The hourly distribution of traffic for an average weekday is shown in Figure 5.1. Peak hour traffic volumes on Richmond Bridge were in the order of 1400 to 1500 vehicles per direction. The Austroads' Guideline has suggested an indicative capacity threshold between 1,400 and 1,600 vehicles per hour per lane for a two lane urban arterial road. This indicates that Richmond Bridge is close to saturation traffic level at the peak.

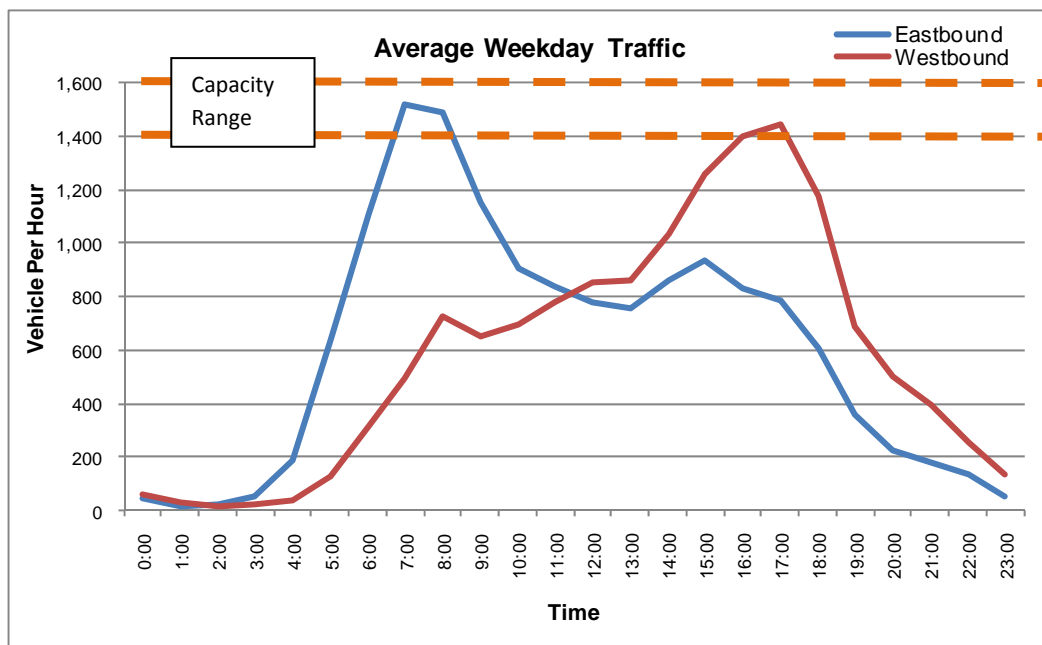


Figure 5-1 Hourly traffic volumes on the Richmond Bridge, June 2011

The posted speed limits on Richmond Bridge and associated sections of Bells Line of Road/Kurrajong Road are between 60 and 80 km/h. The 2011 travel time data indicates that average travel speed of the section of Bells Line of Road/Kurrajong Road is substantially lower, at 10-20km/h, particularly during afternoon peak (PM) in the westbound direction. The average travel speed during morning peak (AM) is recorded between 40 and 50 km/h in the eastbound direction (See Figure 5-2).

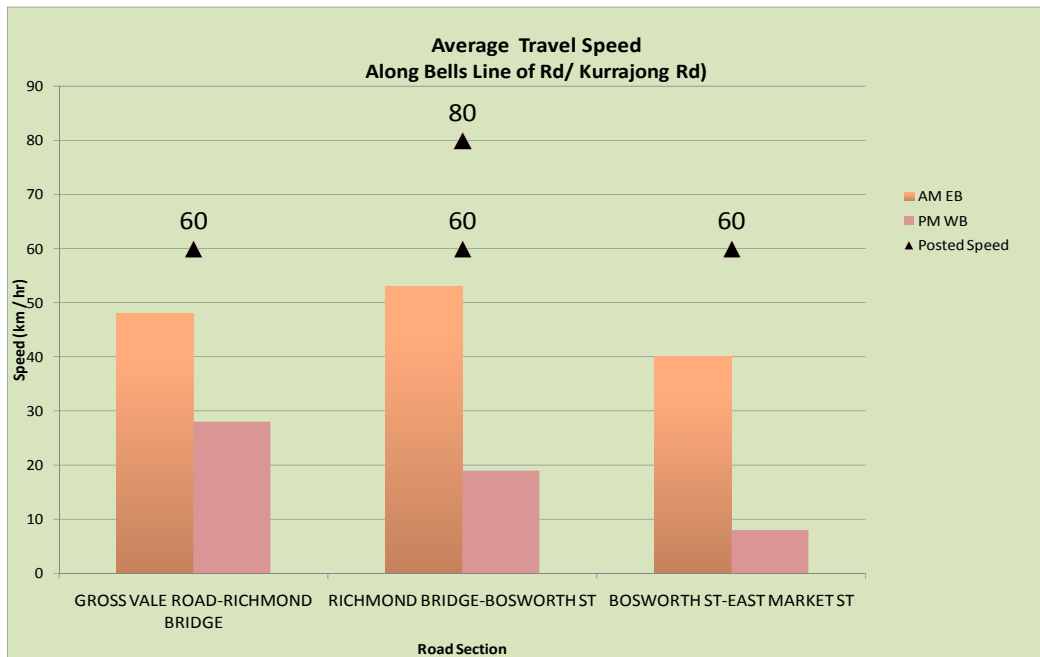


Figure 5-2 Average travel speed of section of Bells Line of Road/Kurrajong Road, March 2011

## 5.2 KEY INTERSECTIONS

The capacity of the section of Bells Line of Road and Kurrajong Road between Grose Vale Road and East Market Street is strongly influenced by key intersections and by the bridge.

A total of 13 intersections within the study area have been analysed (using SIDRA) to determine their respective operating performance. The performance of an intersection can be measured by the intersection average delay per vehicle which in turns leads to a “level of service” measure for the intersection. These measures are:

- Level of Service A – good operation;
- Level of Service B – good operation with acceptable delays and spare capacity;
- Level of Service C – satisfactory operation;
- Level of Service D – operating near capacity;
- Level of Service E – operating at capacity; incidents at signals will cause excessive delays; and
- Level of Service F – extra capacity required.

The modelling investigation has found that during AM and PM peak periods, some turn movements at adjoining key intersections with Bells Line of Road/Kurrajong Road adversely impact the operation of Richmond Bridge and road approaches. The analysis has identified network operational issues at the following three key intersections:

1. Bells Line of Road/Grose Vale Road (traffic light controlled);
2. Kurrajong Road / Yarramundi Lane / Old Kurrajong Road (sign control); and
3. Kurrajong Road/ Bosworth Street (traffic light controlled).

Figure 5-3 shows the location of the above three intersections. Detailed SIDRA modelling results for 2011 traffic conditions are included in **Appendix 4** for both morning and afternoon peak periods.



Figure 5-3 Locations of adjoining three key intersections

Detailed network operational issues were identified for these three key intersections using the 'micro-simulation' Paramics model.

Key existing network issues for AM and PM peak periods are presented in Tables 5-1 and 5-2. Screenshots from the Paramics models are shown from Figures 5-4 to 5-13 to illustrate the location and nature of each network issue.

**Table 5-1 Key network issues-AM Peak**

ID	Location	Key Issues	Paramics Snapshot
1	Bells Line of Road/Grose Vale Rd Intersection	<ul style="list-style-type: none"> <li>High right turning movements (500 veh/h) from Grose Vale Road to Bells Line of Road. In line with current situation, the model predicts long queues with low LoS F.</li> </ul>	Figure 5-4
		<ul style="list-style-type: none"> <li>Currently there is no separate bus bay for the Bus stop on Bells Line of Road immediately east of Grose Vale Rd. Buses occasionally block the eastbound kerb side lane. Our site visit indicates occasional kerb side lane blockage due to buses, thus affecting signal operation. According to the available bus time table about ten buses use this bus stop between 7:00 AM and 9:00 AM.</li> <li>Two eastbound through lanes on Bells Line of Road merge to one lane east of Grose Vale Road. The merge impedes eastbound through traffic and affects signal operation.</li> </ul>	Figure 5-5
2	Kurrajong Road/Yarramundi Lane intersection	<ul style="list-style-type: none"> <li>There is no exclusive right turn bay on Kurrajong Road western approach that can accommodate turning traffic into Yarramundi Lane. The high right turning traffic (350 veh/h) on Kurrajong Road to Yarramundi Lane blocks eastbound through traffic. Once traffic is interrupted, eastbound through traffic needs additional time to accelerate that causes a potential 'knock-on' effect from Yarramundi Lane upstream to the Bridge.</li> </ul>	Figure 5-6 Figure 5-7
3	Kurrajong Road/Bosworth Street intersection	<ul style="list-style-type: none"> <li>There is no exclusive right turn bay on Kurrajong Road western approach. The eastbound right turn traffic shares one lane with through traffic. The eastbound right turning traffic (370 veh/h) shares one lane with through traffic. Occasional long queues (west of Chapel St) are observed along the western approach to the intersection.</li> </ul>	Figure 5-8



Figure 5-4 Grose Vale Road approach-Typical AM Peak queue

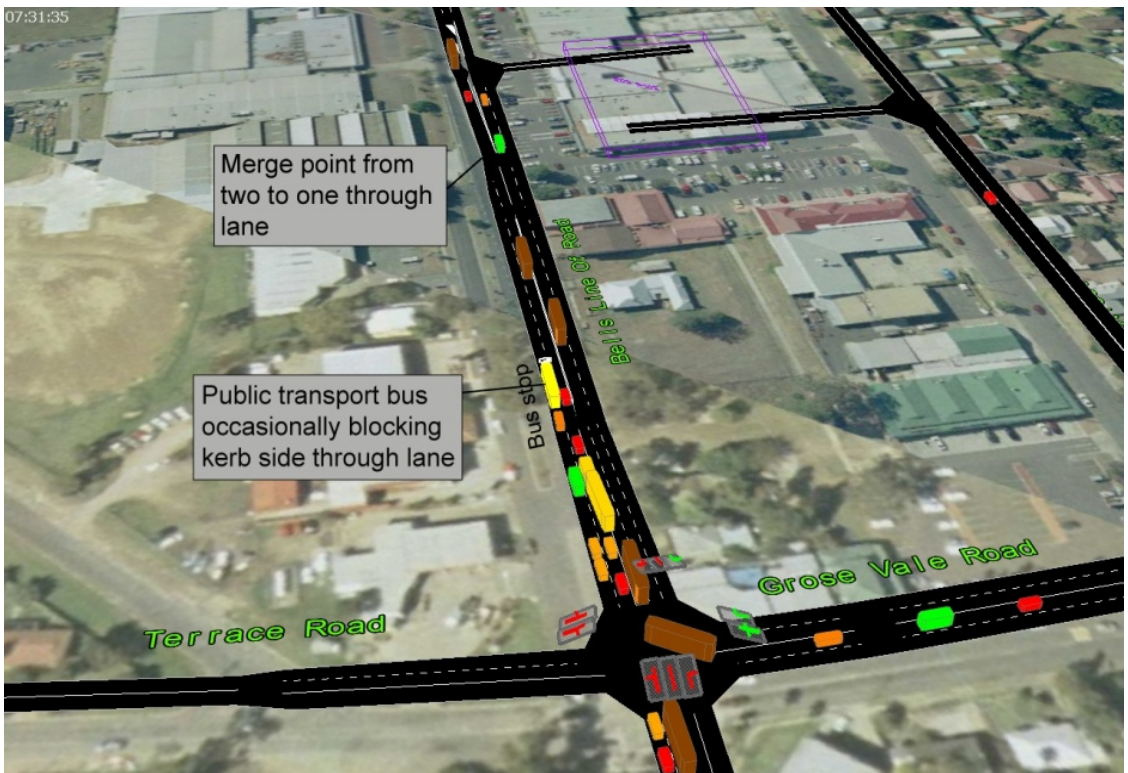


Figure 5-5 Bells Line of Road east of Grose Vale Road-showing PT bus and merge point issues, AM Peak





Figure 5-6 Right turn from Kurrajong Rd to Yarramundi Lane blocking eastbound through traffic, AM peak



Figure 5-7 Eastbound traffic is occasionally stopped on the bridge due to downstream through traffic interruption at Yarramundi Lane, AM Peak

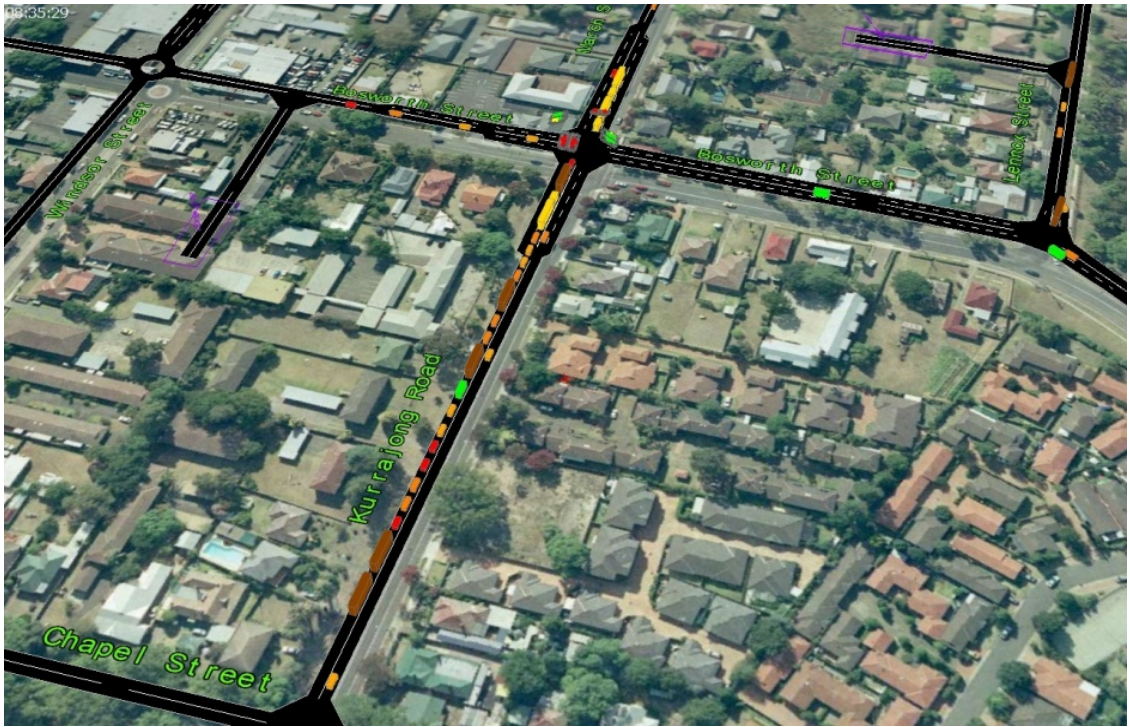


Figure 5-8 Kurrajong Road/Bosworth Street intersection, typical queue along western approach, AM Peak

Table 5-2 Key network issues -PM Peak

ID	Location	Key Issues	Paramics Snapshot
1	Bells Line of Road/Grose Vale Rd Intersection	<ul style="list-style-type: none"> <li>There is only one through lane on Bells Line of Road in the westbound direction. It was observed that westbound through traffic experiences long queues and high delays. The model suggests that occasionally the queue extends upstream to the bridge. Westbound traffic that turns left from North Richmond Shopping Centre also causes delays to Bells Line of Road westbound through traffic.</li> </ul>	<p>Figure 5-9 Figure 5-10</p>
2	Kurrajong Road/Yarramundi Lane intersection	<ul style="list-style-type: none"> <li>High left turning traffic (380 veh/h) from Yarramundi Lane tends to force its way out before it merges with Kurrajong Road mainstream westbound traffic. The site visit indicates that potential aggressive left turning vehicles frequently impede westbound through traffic. This phenomenon causes a 'knock-on' effect from Yarramundi Lane upstream to Richmond township. The model predicts long queues along Kurrajong Road in the westbound direction (LoS F) as well as long queues on Yarramundi Lane (LoS F).</li> </ul>	<p>Figure 5-11 Figure 5-12</p>
3	Kurrajong Road/Bosworth Street intersection	<ul style="list-style-type: none"> <li>Long queues are observed along March Street in the westbound direction (LoS F). These are residual queues predominantly from westbound traffic interruption (by Yarramundi Lane turning traffic).</li> </ul>	<p>Figure 5-13</p>



Figure 5-9 Bells Line of Road/Grose Vale Rd intersection, typical westbound queue, PM Peak



Figure 5-10 Bells Line of Road/Grose Vale Rd intersection, westbound queue is occasionally expanded to the bridge, PM Peak



Figure 5-11 Kurrajong Rd/Yarramundi Lane intersection, westbound through traffic is frequently interrupted by aggressive left turning vehicles from Yarramundi Lane, PM peak;

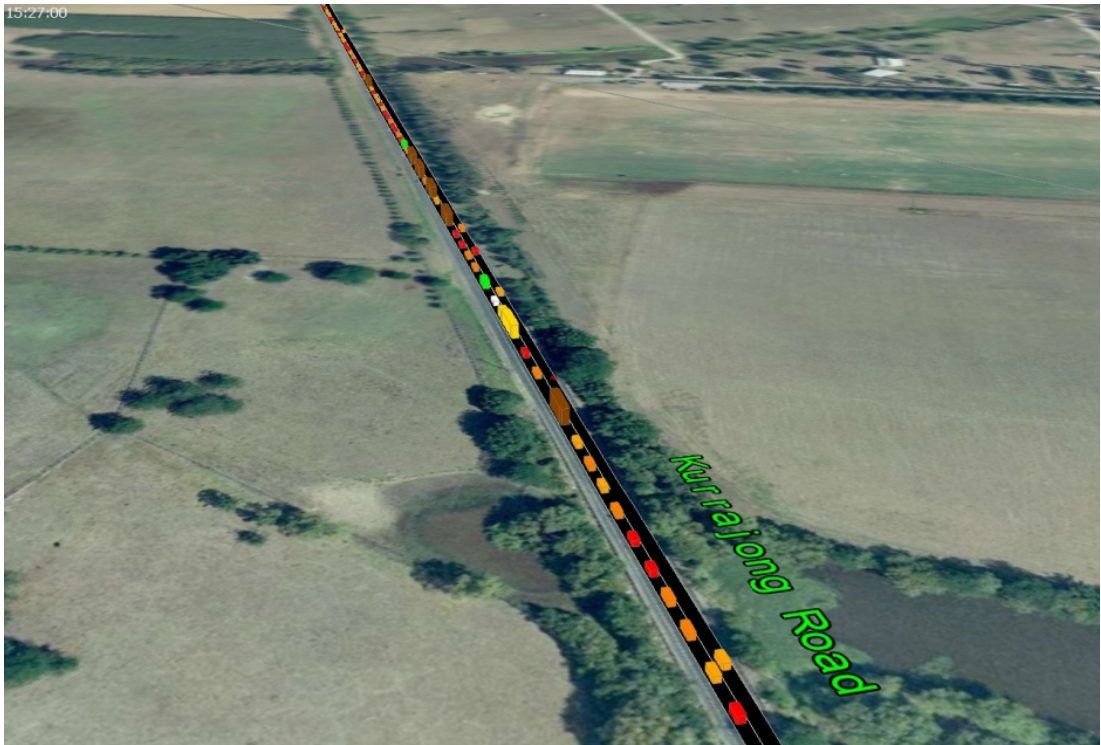


Figure 5-12 Kurrajong Rd, westbound traffic congestion, PM peak

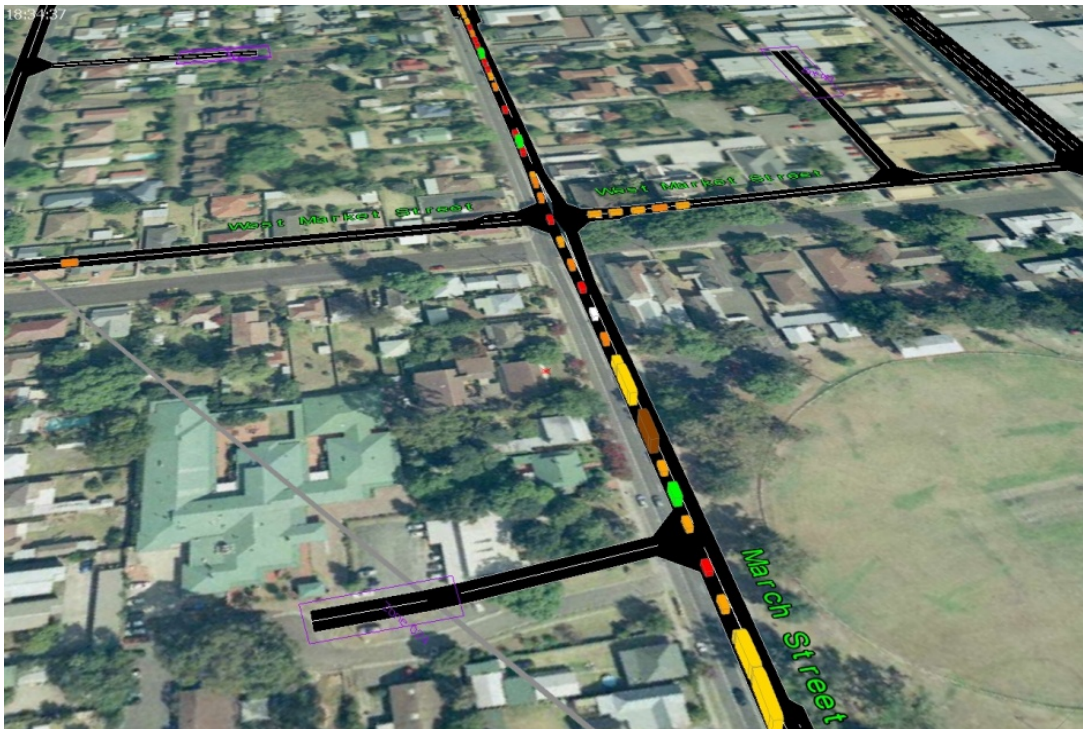


Figure 5-13 Typical PM peak westbound queue along March Street between East Market St and Bosworth St

## 5.3 A SUMMARY OF THE KEY NETWORK ISSUES

The traffic analysis for 2011 suggests that Richmond Bridge is close to saturation traffic levels. During the morning and afternoon peak periods, some turning movements at adjoining key intersections with Bells Line of Road/Kurrajong Road adversely impact the operation of the Richmond Bridge performance. The traffic modelling has identified network operational issues at the following three key intersections:

1. Kurrajong Road / Yarramundi Lane / Old Kurrajong Road (sign control);
2. Bells Line of Road/Grose Vale Road (traffic light controlled); and
3. Kurrajong Road/ Bosworth Street (traffic light controlled).

## 6 PARAMICS MODEL DEVELOPMENT

### 6.1 OVERVIEW

*Paramics* models have been developed to facilitate a more in depth analysis of the operational impacts of the Richmond Bridge and adjoining key intersections. The *Paramics* models were calibrated and validated according to the RMS's *Paramics* modelling guidelines. The models represented 2011 traffic conditions for both morning (AM) peak and afternoon (PM) peak periods:

- AM peak period between 7:00 and 9:00, and
- PM peak period between 15:00 and 18:00.

### 6.2 DEMAND

The initial demand matrix was estimated using Hyder's own Sydney Strategic Transport Model, (SSTM operates in TransCAD) using a sub-area technique. The demand was further refined using data obtained from RMS's Sydney Strategic Model (which operates on an *Emme/2* platform). Further travel zone and network refinements were undertaken for the study area. The demand matrix was calibrated to the RMS's standards using the 2011 traffic counts data.

The demand matrix was estimated separately for two vehicle types:

- Cars/light vehicles.
- Rigid and articulated heavy vehicles.

The proportion of heavy vehicles has been taken directly from classified traffic surveys.

Figure 6-1 shows the *Paramics* model road network and travel zone system.

### 6.3 MODEL CALIBRATION AND VALIDATION

Detailed *Paramics* model calibration and validations are documented in **Appendix 4**. That analysis confirmed that both AM and PM peak were calibrated and validated adequately and the models are fit for this study purpose.

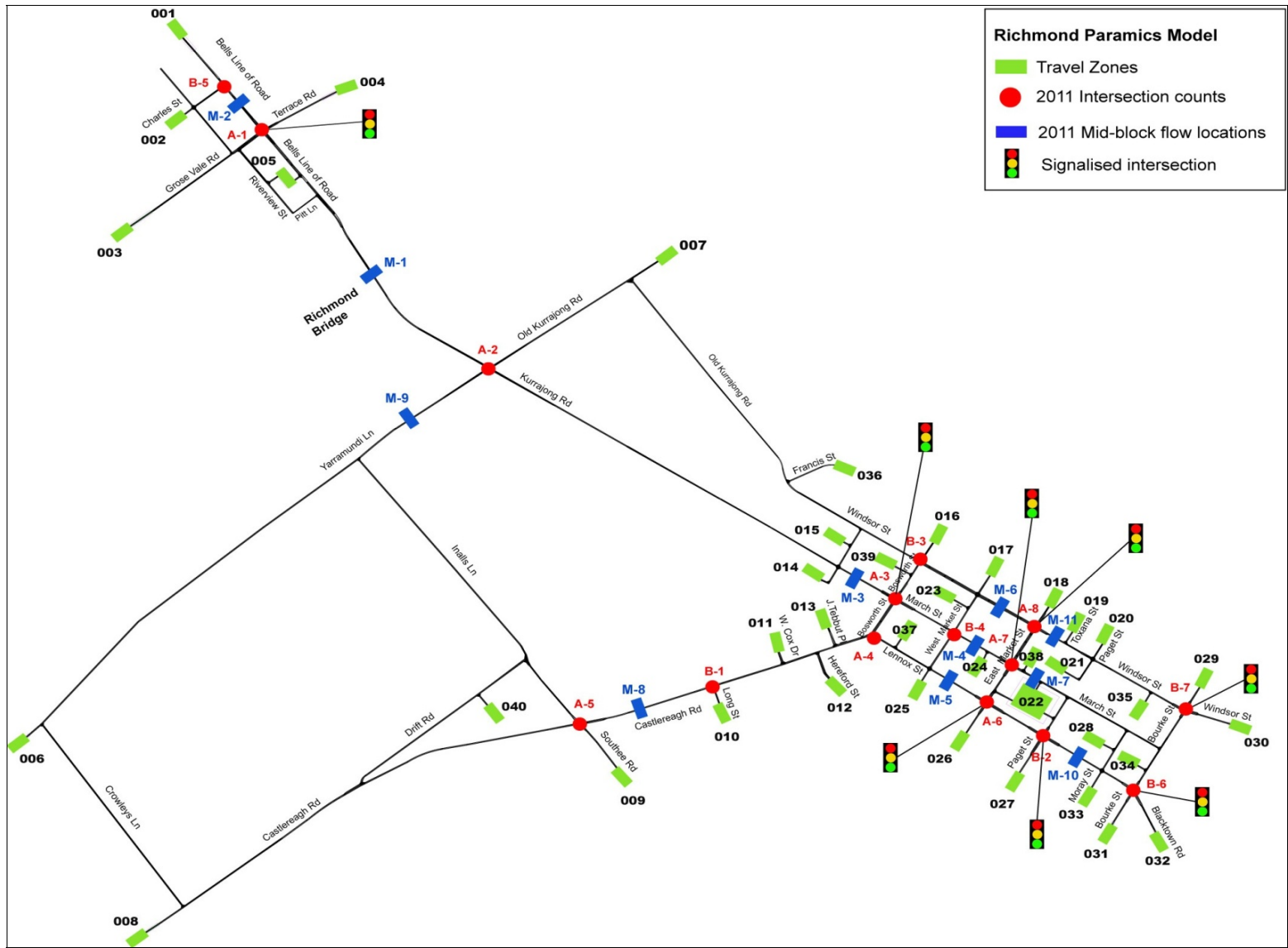


Figure 6-1 Paramics model network and travel zone system



# 7 OPTIONS ASSESSMENT

## 7.1 OPTIONS CONSIDERED

Based on the existing network performance assessment results and modelling investigation, Hyder identified ten (10) preliminary short term improvement options which have potential to improve traffic flow of the section of Bells Line of Road and Kurrajong Road between Grose Vale Road and East Market Street. The short term improvements include a range of localised changes to the following three key intersections to favour major east west movement of traffic on Bells Line of Road and Kurrajong Road:

- Kurrajong Road / Yarramundi Lane / Old Kurrajong Road;
- Bells Line of Road/Grose Vale Road; and
- Kurrajong Road/ Bosworth Street.

The short term options include relatively minor improvements to road and intersections to provide an acceptable level of traffic operation. These options include some intersection widening, prohibiting on-street parking during peak periods and banning some turning movements.

Through the model refinement process, some of these options are combined. In consultation with key stakeholders, eight (8) options have been shortlisted for detailed assessment. Two options rejected were:

- Full closure of Yarramundi Lane.
- New sign to formalise Pitt Lane as an established traffic route for left turning traffic.

The eight shortlisted options are referred to as Options A to H.

Table 7-1 summarises suggested changes to key intersections for eight upgrade options A to H.

**Table 7-1 Options Considered**

Options	Key Intersections	Proposed Changes
<b>Option A</b>	Kurrajong Rd / Yarramundi La / Old Kurrajong Rd	<ul style="list-style-type: none"> <li>▪ An eastbound right turn ban to Yarramundi Lane during AM and PM peak periods.</li> </ul>
<b>Option B</b>	Kurrajong Rd / Yarramundi La / Old Kurrajong Rd	<ul style="list-style-type: none"> <li>▪ An eastbound right turn ban to Yarramundi Lane during AM and PM peak periods.</li> <li>▪ An eastbound left turn ban to Old Kurrajong Road during peak periods.</li> </ul>
<b>Option C</b> (modification to option A)	Kurrajong Rd / Yarramundi La / Old Kurrajong Rd	<ul style="list-style-type: none"> <li>▪ Same as option A.</li> </ul>

Options	Key Intersections	Proposed Changes
	Kurrajong Rd / Bosworth St	<ul style="list-style-type: none"> <li>An eastbound exclusive right turn bay from Kurrajong Road to Bosworth Street.</li> <li>A westbound right turn ban from March Street to Bosworth Street.</li> </ul>
<b>Option D</b>	Bells Line of Rd/ Grose Vale Rd	<ul style="list-style-type: none"> <li>A shared through/left turn lane on Bells Line of Road replacing the existing left turn lane on the eastern approach.</li> <li>An additional westbound short through lane on Bells Line of Road, west of Grose Vale Road.</li> <li>This option allows for all movements at the intersection and may require some widening work.</li> </ul>
<b>Option E</b> (modification to option D)	Bells Line of Rd/ Grose Vale Rd	<ul style="list-style-type: none"> <li>A shared through/left turn lane on Bells Line of Road replacing the existing left turn lane on the eastern approach.</li> <li>An additional westbound short through lane on Bells Line of Road, west of Grose Vale Road.</li> <li>Prohibit on-street parking during peak periods on southern side of Bells Line of Road between Pitt Lane and Grose Vale Road.</li> <li>An eastbound right turn ban from Bells Line of Road into Grose Vale Road.</li> <li>Conversion of the existing eastbound right-turn bay to a second westbound through lane.</li> <li>This option tries to avoid the need for widening at the intersection by banning the eastbound right turn movement.</li> </ul>
<b>Option F</b> (modification to option E)	Bells Line of Rd/ Grose Vale Rd	<ul style="list-style-type: none"> <li>Same as Option E.</li> </ul>
	Kurrajong Rd / Yarramundi La / Old Kurrajong Rd	<ul style="list-style-type: none"> <li>An eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane.</li> </ul>
<b>Option G</b> (combination of options C& E with modification)	Kurrajong Rd / Yarramundi La / Old Kurrajong Rd	<ul style="list-style-type: none"> <li>An eastbound right turn ban to Yarramundi Lane during peak periods.</li> <li>A left turn slip lane out of Yarramundi Lane with an acceleration lane on Kurrajong Road (westbound direction)</li> </ul>
	Kurrajong Rd / Bosworth St	<ul style="list-style-type: none"> <li>Changes same as Option C.</li> </ul>

Options	Key Intersections	Proposed Changes
	Bells Line of Rd/Grose Vale Rd	<ul style="list-style-type: none"> <li>Changes same as Option E.</li> <li>Eastbound merge kerb side lane extended (east of Grose Vale Road intersection).</li> </ul>
<b>Option H</b>	Kurrajong Rd / Yarramundi La / Old Kurrajong Rd	<ul style="list-style-type: none"> <li>An eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane.</li> <li>A left turn slip lane out of Yarramundi Lane with acceleration lane on Kurrajong Road (westbound direction).</li> </ul>
	Bells Line of Rd/Grose Vale Rd	<ul style="list-style-type: none"> <li>Same as Option G.</li> </ul>

## 7.2 KEY TRAFFIC CRITERIA

Each option was assessed in terms of key traffic factors which are most likely to influence the decisions on the best performing option.

Key traffic criteria used to compare performance for each option are:

- **Level of Service (LoS):** An objective of upgrading key intersections will be to improve or maintain an acceptable level of service (LoS) over the short term. The analysis included LoS for Base Case (existing condition) and all options A to H. The LoS are reported at key intersections where relevant.
- **Transport network efficiency of the section of Bells Line of Road and Kurrajong Road between Grose Vale Road and East Market Street:** A fundamental objective in upgrading key intersections is to improve the overall network efficiency. This was quantified in terms of average travel speed improvement on Bells Line of Road/Kurrajong Road which would result from improving key intersection capacity.
- **Impact on the road network:** This factor considers the impact of the upgrade option on other roads in the network. Changes in traffic volumes due to the proposed option are compared against the volumes on the same roads for existing condition. The impact analysis concentrates on key roads where there is a significant increase or decrease in traffic flows as a consequence of the option being considered. As an example proposed turn bans can impact alternative travel routes. The morning and afternoon peak traffic volumes are shown at key intersections.
- **Local accessibility:** The upgrading options involve modifications to the intersections of some local roads with Bells Line of Road/Kurrajong Road, which impact local traffic movements. As an example, proposed right turn bans for different options will affect the way properties are accessed for residents, service and emergency vehicles, and delivery vehicles. Local road connections are maintained by rationalising and re-routing traffic along selected sections of the local road network.






Quantitative measures were identified as being available to assist in the assessment of the performance of each option as described in Table 7-2. All eight options were modelled using Paramics and SIDRA where relevant.

**Table 7-2 Quantitative Measures against Key Traffic Criteria**

ID	Key Criteria	Modelling tool	Measures
1	Option ability to improve Bells Line of Road/Kurrajong Road eastbound traffic flows	Paramics	Average travel speed (km/h)
2	Option ability to improve Bells Line of Road/Kurrajong Road westbound traffic flows	Paramics	Average travel speed (km/h)
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	Vehicle Kilometres Travel led (VKT)
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	Vehicle Hours Travelled (VHT)
5	Option ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	Level of Service (LoS)
6	Option ability to improve key intersections Level of Service	SIDRA	Level of service (LoS)
7	Impact on adjacent intersections	SIDRA	Level of service (LoS) are reported at adjacent intersections in following areas: Area A – Richmond; Area B – Castlereagh ; Area C – North Richmond

For all eight options, the model was assessed for 2011 traffic conditions. Traffic measures for each option were compared with the base case (existing condition). In consultation with RMS, a five-grade colour code (see Table 7-3) is used to show relative performance of each option compared to the base case.

**Table 7-3 Relative Performance of each Option**

Colour code	Relative performance compared to Base Case
 Green	Improvement
 Light green	Slight Improvement
 White	No Change/Minor Change
 Light red	Slightly Worse
 Red	Worse

## 7.3 IMPACT ASSESSMENT

This section presents a detailed impact assessment of each Option A to H against the key traffic criteria identified in previous Section 7.2. The traffic performance of each option is summarised in a table form. Proposed changes to key intersections for each option are also shown graphically. Detailed turning volumes and level of service (LoS) data at key intersections for each option are included in Appendix 4.

### 7.3.1 OPTION A

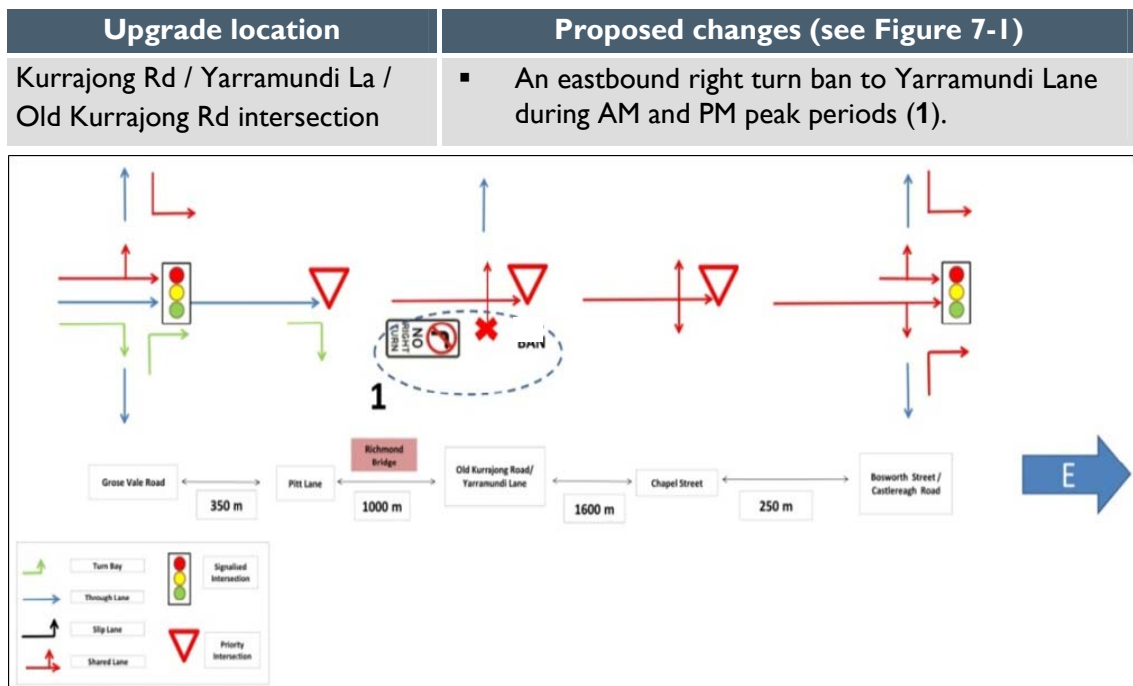


Figure 7-1 Option A Schematic Lane Configuration

The proposed changes to key intersections for Option A are shown graphically in Figure 7-1.

Table 7-4 shows traffic performance of option A against key criteria.

The following points are noted from Option A results shown in Table 7-4:

- The proposed eastbound right turn ban on Kurrajong Road to Yarramundi Lane would divert additional traffic to the adjacent Kurrajong Road/Bosworth Street intersection. This would increase the right turn demand from Kurrajong Road to Bosworth Street. The model forecasts low LoS F at Kurrajong Road/Bosworth Street intersection. ;
- Option A would not improve eastbound traffic flows between Grose Vale Road and East Market Street. The model forecasts a reduction in travel speed (about 35%) for eastbound traffic from 48 km/h (base case) to 31 km/h (Option A);
- Option A would not improve westbound traffic flows between Grose Vale Road and East Market Street. The model forecasts no change in average travel speed in the westbound direction when compared to the base case.
- Option A would slightly increase (up to 3%) the vehicle kilometres travelled (VKT) in the study area network. The VKT is forecast to increase due to the longer distance travelled by right turn vehicles via Bosworth Street instead of Yarramundi Lane;
- Option A would significantly increase (up to 35%) the vehicle hours travelled (VHT) in the study area network. The VHT is forecast to increase due to high delays predicted at the Bosworth Street/Kurrajong Road intersection;
- Option A is forecast to change traffic volumes at the following locations when compared to the base case:
  - Traffic on Kurrajong Road west of Bosworth Street is forecast to increase in the order of 160 to 270 vehicles per hour (about 10% to 18%) during the PM and AM peaks respectively.
  - Traffic on Windsor Street, west of East Market Street, is forecast to increase in the order of 20 to 80 vehicles per hour (about 4% to 24%) during the PM and AM peaks respectively. Traffic increases along Old Kurrajong Road and Windsor Street are forecast due to increased delays along Kurrajong Road, particularly during the AM peak. The forecast traffic increase on Old Kurrajong Road and Windsor Street from the model was in line with actual traffic increases that were counted during the Yarramundi Lane closure in July 2011.
  - Traffic on Yarramundi Lane south of Kurrajong Road is forecast to decrease in the order of 180 to 350 vehicles per hour (about 32% to 67%) during the PM and AM peaks respectively.
  - Traffic on Castlereagh Road south of Bosworth Street is forecast to increase in the order of 180 to 350 vehicles per hour (about 20% to 41%) during the PM and AM peaks respectively.
- Option A would change the local network connectivity. Local accessibility to the few dwellings along the Yarramundi Lane will be affected.
- Option A is likely to have slightly adverse impacts on the adjacent intersections on Castlereagh area (see **Appendix 4** for detailed traffic volumes and LoS).

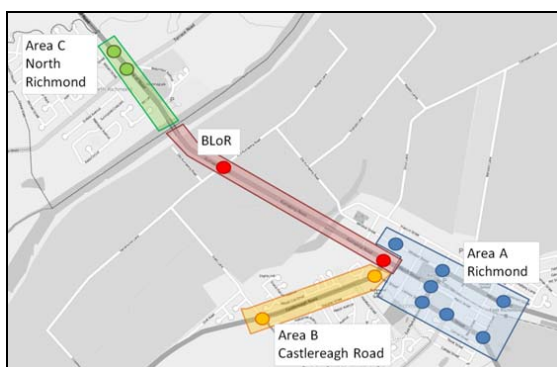
Option A modelling results suggested that banning the eastbound right turn on Kurrajong Road to Yarramundi Lane would adversely impact the operation of the Kurrajong Road/Bosworth Street intersection.

**Table 7-4 Traffic Performance of Option A**

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option A		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> :48 km/h	31 km/h	-35% ▼	■
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> :17 km/h	17 km/h	0%	□
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	40,599	+3% ▲	■
		Paramics	PM	64,826	65,466	+1% ▲	■
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	1,222	+35% ▲	■
		Paramics	PM	2,277	2,944	+29% ▲	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS F/LoS D	-	□
6	<b>Ability to improve key intersections Level of Service at:</b>						
	Kurrajong Road / Yarramundi Lane (Priority) <sup>(5)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS A	-	■
	Kurrajong Road / Bosworth Street (Signals) <sup>(5)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS F/LoS F	-	■
	Bells Line of Road/Gross Vale Road (Signals) <sup>(6)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS D	-	□
7	<b>Impact on adjacent intersections <sup>(7)</sup></b>						
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	Minor Change	-	□
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	Slightly Worse	-	■
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	No Change	-	□

**Note:**

(1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction);(3) Average Speed from East Market Street to Grose Vale Road (westbound direction);(4) Level of Service (LoS) is reported for Grose Vale Road approach;(5) LoS is reported for Kurrajong Road west approach; (6) LoS is reported for Bells Line Road east approach; (7) Impact on adjacent intersections:



*Relative performance compared to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse
■	Worse

## 7.3.2 OPTION B

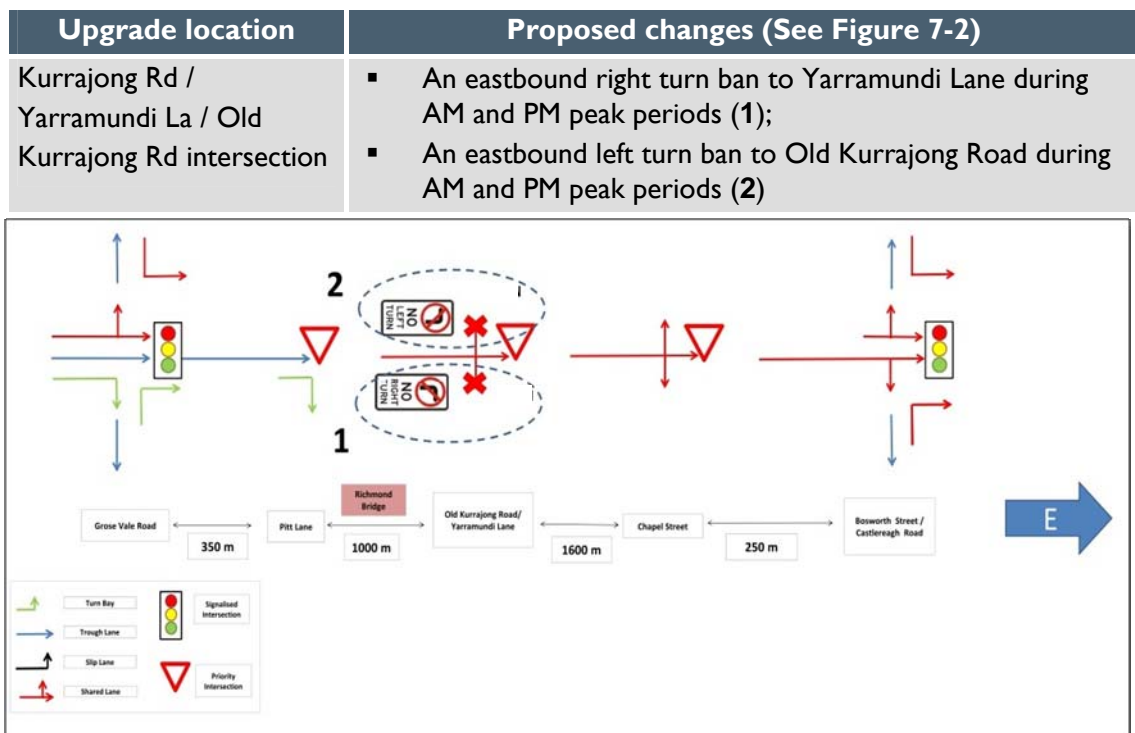


Figure 7-2 Option B Schematic Lane Configuration

The proposed changes to key intersections for option B are shown graphically in Figure 7-2. Table 7-5 shows traffic performance of option B against key criteria. The proposed changes to the network for option B are option A plus eastbound left turn ban to Old Kurrajong Road.

The impact to network operation from option B would be similar to option A, albeit marginally worse. Option B would adversely impact the operation of the Kurrajong Road/Bosworth Street intersection.

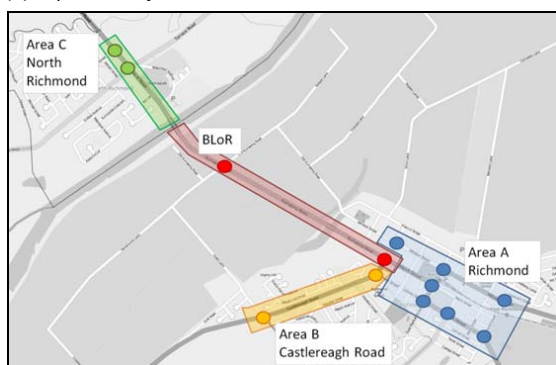


**Table 7-5 -Option B Performance Assessment**

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option B		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> :48 km/h	26 km/h	-46% ▼	■
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> :17 km/h	16 km/h	-6% ▼	■
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	40,565	+3% ▲	■
		Paramics	PM	64,826	65,421	+1% ▲	■
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	1,344	+48% ▲	■
		Paramics	PM	2,277	3,784	+66% ▲	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS F/LoS D	-	□
6	<b>Ability to improve key intersections Level of Service at:</b>						
	Kurrajong Road / Yarramundi Lane (Priority) <sup>(5)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS A	-	■
	Kurrajong Road / Bosworth Street (Signals) <sup>(5)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS F/LoS F	-	■
	Bells Line of Road/Gross Vale Road (Signals) <sup>(6)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS D		□
7	<b>Impact on adjacent intersections <sup>(7)</sup></b>						
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	Minor Change	-	□
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	Slightly Worse	-	■
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	No Change	-	□

**Note:** (1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction);(3) Average Speed from East Market Street to Grose Vale Road (westbound direction);(4) Level of Service (LoS) is reported for Grose Vale Road approach;(5) LoS is reported for Kurrajong Road west approach; (6) LoS is reported for Bells Line Road east approach

(7) Impact on adjacent intersections:



*Relative performance compare to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse
■	Worse

### 7.3.3 OPTION C

Upgrade location	Proposed changes (See Figure 7-3)
Kurrajong Rd / Yarramundi La / Old Kurrajong Rd intersection	<ul style="list-style-type: none"> <li>An eastbound right turn ban to Yarramundi Lane during AM &amp; PM peak periods (1);</li> </ul>
Kurrajong Rd / Bosworth St intersection	<ul style="list-style-type: none"> <li>An eastbound exclusive right turn bay from Kurrajong Road to Bosworth Street with two through lanes in eastbound direction between Chapel Street and Bosworth Street (3);</li> <li>A westbound right turn ban from March Street to Bosworth Street (2).</li> </ul>

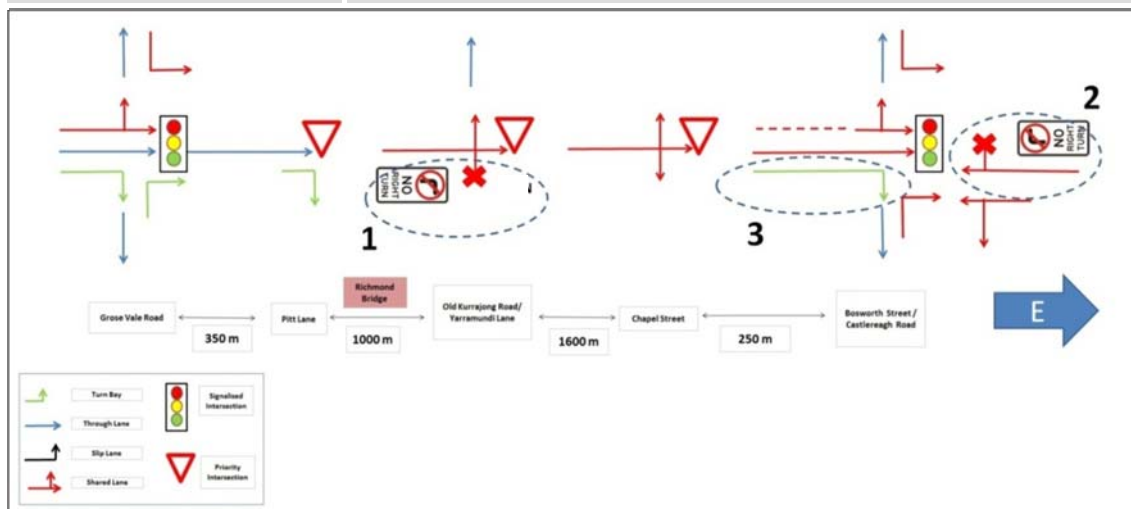


Figure 7-3 Option C Schematic Lane Configuration

The proposed changes to key intersections for Option C are shown graphically in Figure 7-3. Option C is Option A plus an eastbound exclusive right turn bay from Kurrajong Road to Bosworth Street. Table 7-6 shows the traffic performance of Option C against key criteria.

The following points are noted from Option C results shown in Table 7-6:

- Option C is forecast to maintain the LoS at Kurrajong Road/Bosworth Street intersection (LoS C/B). The eastbound exclusive right turn on Kurrajong Road at Bosworth Street would accommodate the increase in right turn demand at Bosworth Street due to banning of right turn at Yarramundi Lane.
- Option C would improve eastbound traffic flows between Grose Vale Road and East Market Street. The model forecasts improvements in travel speed (about 10%) for eastbound traffic from 48 km/h (base case) to 53 km/h (Option C).
- However, Option C would not improve westbound traffic flows between Grose Vale Road and East Market Street. The model forecasts no change in average travel speed in the westbound direction when compared to the base case.
- Similar to Option A, Option C would slightly increase (up to 3%) the vehicle kilometres travelled (VKT) in the study area network. The VKT is forecast to increase due to longer distance travelled by right turn vehicles via Bosworth Street instead of Yarramundi Lane.
- Unlike Option A, Option C would significantly improve (up to 7%) the vehicle hours travelled (VHT) in the study area network. The VHT is forecast to improve due to the improvement (exclusive right turn) at the Bosworth Street/Kurrajong Road intersection.

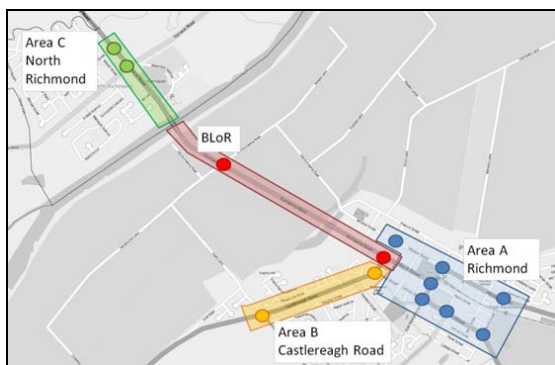
- The proposed turn bans in Option C are forecast to change traffic volumes in a magnitude similar to Option A.
- Similar to Option A, Option C is likely to have slightly adverse impacts on the adjacent intersections on Castlereagh area (see **Appendix 4** for detailed traffic volumes and LoS).

Option C is relatively better than previous Options A and B.

**Table 7-6 Option C Performance Assessment**

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option C		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> :48 km/h	53 km/h	+10% ▲	■
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> :17 km/h	17 km/h	0%	□
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	40,543	+3% ▲	■
		Paramics	PM	64,826	65,478	+1% ▲	■
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	897	-1% ▼	■
		Paramics	PM	2,277	2,119	-7% ▼	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS F/LoS D	-	□
<b>6 Ability to improve key intersections Level of Service at:</b>							
	Kurrajong Road / Yarramundi Lane (Priority) <sup>(5)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS A	-	■
	Kurrajong Road / Bosworth Street (Signals) <sup>(5) (6)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS C/LoS B	-	□
	Bells Line of Road/Grose Vale Road (Signals) <sup>(7)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS D	-	□
<b>7 Impact on adjacent intersections <sup>(8)</sup></b>							
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	Minor Change	-	□
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	Slightly Worse	-	■
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	No Change	-	□

**Note:** (1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction);(3) Average Speed from East Market Street to Grose Vale Road (westbound direction);(4) Level of Service (LoS) is reported for Grose Vale Road approach;(5) LoS is reported for Kurrajong Road west approach;(6) Without right turn bay at Bosworth St intersection, model predicts LoS F (Option A). (7) LoS is reported for Bells Line Road east approach  
(8) Impact on adjacent intersections



*Relative performance compared to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse
■	Worse

## 7.3.4 OPTION D

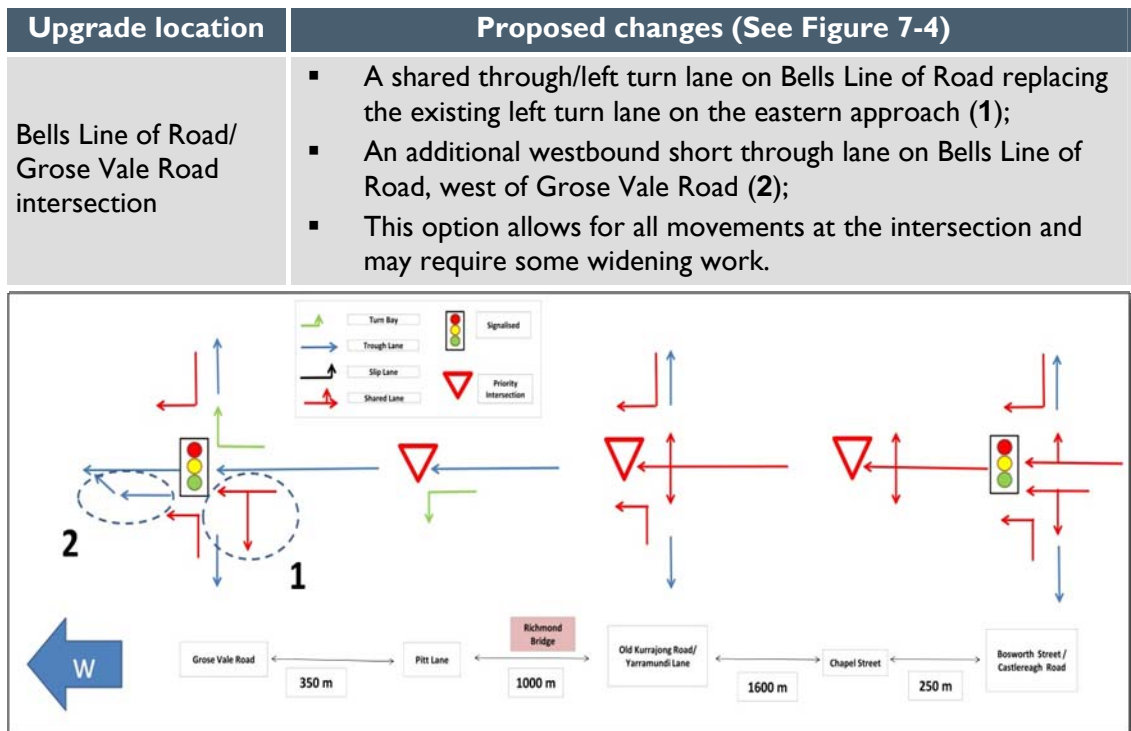


Figure 7-4 Option D Schematic Lane Configuration

The proposed changes to key intersections for Option D are shown graphically in Figure 7-4.

Unlike Options A to C, Option D investigates improving westbound flows on Bells Line of Road and Kurrajong Road. Changes are proposed at Bells Line of Road/Grose Vale Road intersection alone. Table 7-7 shows the traffic performance of Option D against key criteria.

The following points are noted from the Option D results shown in Table 7-7:

- As expected, Option D would not improve eastbound traffic flows between Grose Vale Road and East Market Street. The model forecasts no change in average travel speed in the eastbound direction when compared to the base case.
- Option D is forecast to improve LoS for westbound traffic at Bells Line of Road/Grose Vale Road intersection for the afternoon (PM) peak.
- Option D would marginally improve westbound traffic flows between Grose Vale Road and East Market Street in the afternoon peak. The model forecasts slight improvements in travel speed (about 6%) for westbound traffic from 17 km/h (base case) to 18 km/h (Option C). During the afternoon peak, the heavy westbound left turn (about 380 vehicles per hour) from Yarramundi lane impedes Kurrajong Road traffic flows, particularly for the section between Bosworth Street and Yarramundi Lane. However, the model shows improvements in traffic flow on Kurrajong Road/Bells Line of Road between Yarramundi Lane and Grose Vale Road. The analysis therefore identifies the need to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road.
- In line with predicted marginal travel speed improvement for westbound traffic, Option D would slightly improve (up to 2%) vehicle hours travelled (VHT) in the study area network. There would be no change in the vehicle kilometres travelled (VKT) for Option D.

- The Option D is unlikely to change traffic volumes and associated LoS at other adjacent intersections in the Richmond, North Richmond and Castlereagh Road areas. (see **Appendix 4** for detailed traffic volumes and LoS).

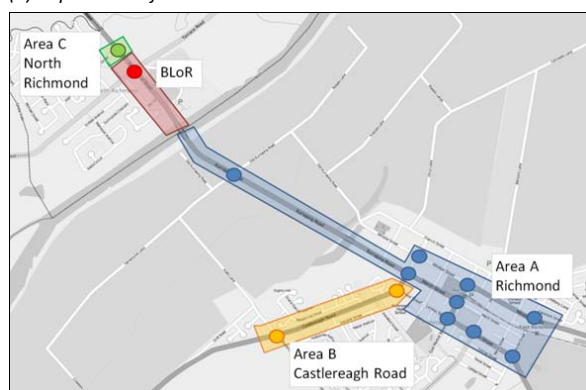
In general, Option D is forecast to marginally improve westbound traffic flows between Grose Vale Road and East Market Street in the PM peak. The proposed improvements at Bells Line of Road/Grose Vale Road intersection are forecast to improve LoS for westbound traffic in PM peak. The analysis identifies the need to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road.

**Table 7-7 Option D Performance Assessment**

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option D		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> :48 km/h	48 km/h	0%	□
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> :17 km/h	18 km/h	+6% ▲	■
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	39,228	0%	□
		Paramics	PM	64,826	64,829	0%	□
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	914	0%	□
		Paramics	PM	2,277	2,237	-2% ▼	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS F/LoS D	-	□
6	<b>Ability to improve key intersections Level of Service at:</b>						
	Kurrajong Road / Yarramundi Lane (Priority) <sup>(5)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS B	-	□
	Kurrajong Road / Bosworth Street (Signals) <sup>(5)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS B/LoS C	-	□
	Bells Line of Road/Grose Vale Road(Signal) <sup>(6)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS B	-	■
7	<b>Impact on adjacent intersections <sup>(7)</sup></b>						
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	No change	-	□
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	No change	-	□
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	No change	-	□

**Note:** (1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction);(3) Average Speed from East Market Street to Grose Vale Road (westbound direction);(4) Level of Service (LoS) is reported for Grose Vale Road approach; (5) LoS is reported for Kurrajong Road west approach; (6) LoS is reported for Bells Line of Road east approach;

(7) Impact on adjacent intersections:



*Relative performance compared to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse

## 7.3.5 OPTION E

Upgrade location	Proposed changes (See Figure 7-5)
Bells Line of Road/Grose Vale Road intersection	<ul style="list-style-type: none"> <li>▪ A shared through/left turn lane on Bells Line of Road replacing the existing left turn lane on the eastern approach (1);</li> <li>▪ An additional westbound short through lane on Bells Line of Road, west of Grose Vale Road (2);</li> <li>▪ Prohibit on-street parking during peak periods on southern side of Bells Line of Road between Pitt Lane and Grose Vale Road (3);</li> <li>▪ An eastbound right turn ban from Bells Line of Road into Grose Vale Road (4);</li> <li>▪ Conversion of the existing eastbound right-turn bay to a second westbound through lane (2).</li> <li>▪ This option tries to avoid the need for widening at the intersection by banning the eastbound right turn movement;</li> </ul>

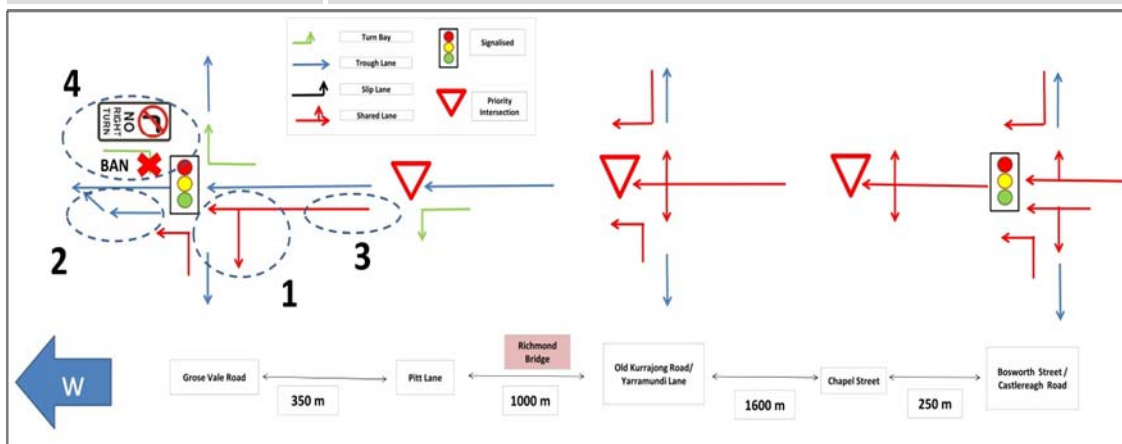


Figure 7-5 Option E Schematic Lane Configuration

The proposed changes to key intersections for option E are shown graphically in Figure 7-5.

Option E is a modification to Option D. Additional changes include a ban on-street parking during peak periods on the eastern approach to the Bells Line of Road/Grose Vale Road intersection. An eastern right turn ban on Bells Line of Road into Grose Vale Road avoids potential widening. Table 7-8 shows the traffic performance of Option E against key criteria.

The impact to network operations from Option E would be similar to Option D. In general, Option E is forecast to marginally improve westbound traffic flows between Grose Vale Road and East Market Street in the PM peak. The proposed improvements at the Bells Line of Road/Grose Vale Road intersection are forecast to improve LoS for westbound traffic at the intersection for the PM peak. The analysis identifies the need to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road.

The proposed eastbound right turn ban from Bells Line of Road to Grose Vale Road would redirect additional traffic to the adjacent intersection of Bells Line of Road and Charles Street. Currently, the Charles Street intersection has priority control. The model forecasts traffic increasing to Charles Street in the order of 40 to 70 vehicles per hour. The queue length for right turning traffic into Charles Street is not predicted to exceed the existing right turn bay on Bells Line of Road at Charles Street. However, this ban could impact local accessibility in North Richmond including access to North Richmond Shopping Centre from the west.

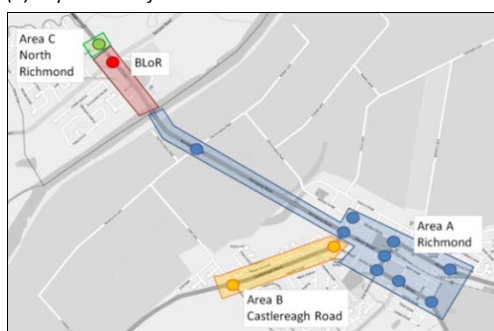


**Table 7-8 -Option E Performance Assessment**

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option E		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> :48 km/h	48 km/h	0%	□
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> :17 km/h	18 km/h	+6% ▲	■
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	39,235	0%	□
		Paramics	PM	64,826	64,840	0%	□
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	897	-1% ▼	■
		Paramics	PM	2,277	2,210	-3% ▼	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS F/LoS D	-	□
6	<b>Ability to improve key intersections Level of Service at:</b>						
	Kurrajong Road / Yarramundi Lane (Priority) <sup>(5)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS B	-	□
	Kurrajong Road / Bosworth Street (Signals) <sup>(5)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS B/LoS C	-	□
	Bells Line of Road/Grose Vale Road(Signal) <sup>(6)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS B	-	■
7	<b>Impact on adjacent intersections <sup>(7)</sup></b>						
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	No change	-	□
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	No change	-	□
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	Slightly Worse	-	■

**Note:** (1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction); (3) Average Speed from East Market Street to Grose Vale Road (westbound direction);(4) Level of Service (LoS) is reported for Grose Vale Road approach; (5) LoS is reported for Kurrajong Road west approach; (6) LoS is reported for Bells Line of Road east approach;

(7) Impact on adjacent intersections:



*Relative performance compared to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse
■	Worse

## 7.3.6 OPTION F

Upgrade location	Proposed changes (See Figure 7-6)
Bells Line of Road/Grose Vale Road intersection	<ul style="list-style-type: none"> <li>Proposed changes are as per Option E</li> </ul>
Kurrajong Road / Yarramundi Lane/Old Kurrajong Road intersection	<ul style="list-style-type: none"> <li>An eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane (1).</li> </ul>

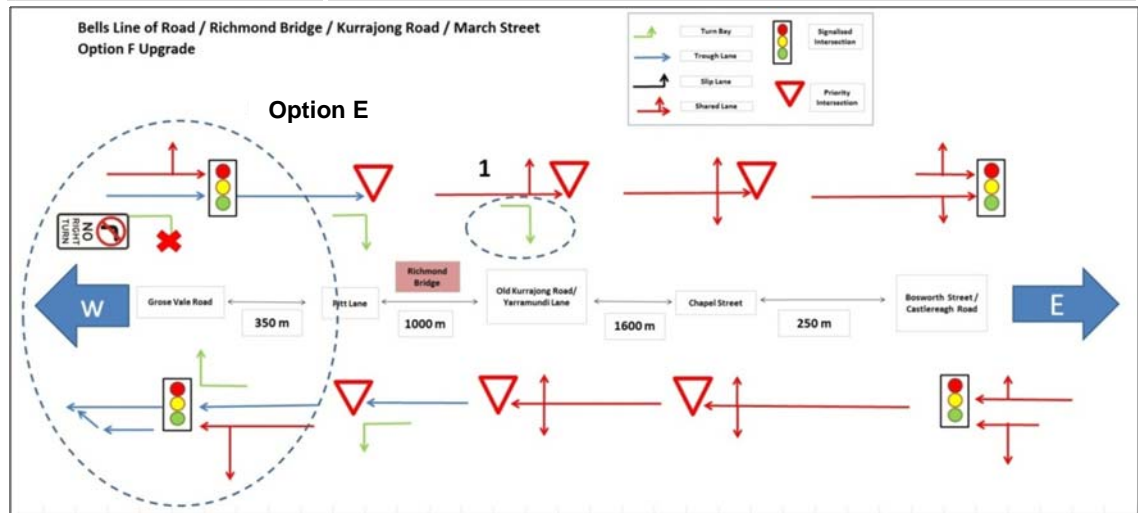


Figure 7-6 Option F Schematic Lane Configuration

The proposed changes to key intersections for Option F are shown graphically in Figure 7-6. Option F is a modification to Option E with the additional change of an eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane.. Option F is investigated because intersection widening at Kurrajong Road/Bosworth Street to create an eastbound exclusive right turn bay (as per Option C) may have timing implications due to the need for potential property acquisition. In addition, an eastbound right turn ban on Kurrajong Road to Yarramundi Lane (as per Options A, B & C) may have potential accessibility issues for the local community.

Table 7-9 shows traffic performance of Option F against key criteria:

- In general Option F would marginally improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in the AM and PM peaks;
- Similar to Option E, the model forecasts a slight improvement in travel speed (about 6%) for westbound traffic from 17 km/h (base case) to 18 km/h (Option F). During PM peak the heavy westbound left turn (about 380 vehicles per hour) from Yarramundi lane impedes Kurrajong Road traffic flows particularly for the section between Bosworth Street and Yarramundi Lane. The analysis identifies the need to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road;
- The eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane is forecast to marginally improve eastbound traffic flows on Kurrajong Road. The model forecasts a marginal improvement in travel speed (about 6%) for eastbound traffic from 48 km/h (base case) to 51 km/h (Option F) in AM peak;

- In line with predicted travel speed improvement, Option F would slightly improve (up to 3%) vehicle hours travelled (VHT) in the study area network. There will be no change in the vehicle kilometres travelled (VKT) for Option F.
- Option F is unlikely to change traffic volumes and associated LoS at other adjacent intersections in the Richmond and Castlereagh Road areas. The model forecasts minor impacts to adjacent intersections in North Richmond (see **Appendix 4** for detailed traffic volumes and LoS).

In general, Option F is forecast to marginally improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks. The analysis identifies the need to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road westbound direction.

Table 7-9 -Option F Performance Assessment

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option F		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> : 48 km/h	51 km/h	+6 % ▲	■
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> : 17 km/h	18 km/h	+6 % ▲	■
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	39,313	0%	□
		Paramics	PM	64,826	64,846	0%	□
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	894	-1% ▼	■
		Paramics	PM	2,277	2,218	-3% ▼	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS F/LoS D	-	□
6	<b>Ability to improve key intersections Level of Service at:</b>						
	Bells Line of Road/Grose Vale Road (Signal) <sup>(5)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS B	-	■
	Kurrajong Road/Yarramundi Lane (Priority) <sup>(6)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS B	-	■
	Kurrajong Road / Bosworth Street (Signals) <sup>(7)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS B/LoS C	-	□
7	<b>Impact on adjacent intersections <sup>(8)</sup></b>						
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	No Change	-	□
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	No Change	-	□
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	Slightly Worse	-	■

**Note:** (1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction); (3) Average Speed from East Market Street to Grose Vale Road (westbound direction); (4) Level of Service (LoS) is reported for Grose Vale Road approach; (5) LoS is reported for Bells Line of Road east approach; (6) LoS is reported for Kurrajong Road west approach; (7) LoS is reported for Kurrajong Road west approach; (8) Impact on adjacent intersections:



*Relative performance compare to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse
■	Worse

## 7.3.7 OPTION G

Upgrade location	Proposed changes (See Figure 7-7)
Bells Line of Road/Grose Vale Road intersection	<ul style="list-style-type: none"> <li>Proposed changes as per Option E;</li> <li>Eastbound merge kerb side lane extended (east of Grose Vale Road intersection) (2).</li> </ul>
Kurrajong Road/Yarramundi Lane/Old Kurrajong Road intersection	<ul style="list-style-type: none"> <li>Proposed changes as per Option C;</li> <li>A left turn slip lane out of Yarramundi Lane with an acceleration lane on Kurrajong Rd westbound direction (1).</li> </ul>
Kurrajong Road/Bosworth Street intersection	<ul style="list-style-type: none"> <li>Proposed changes as per Option C.</li> </ul>

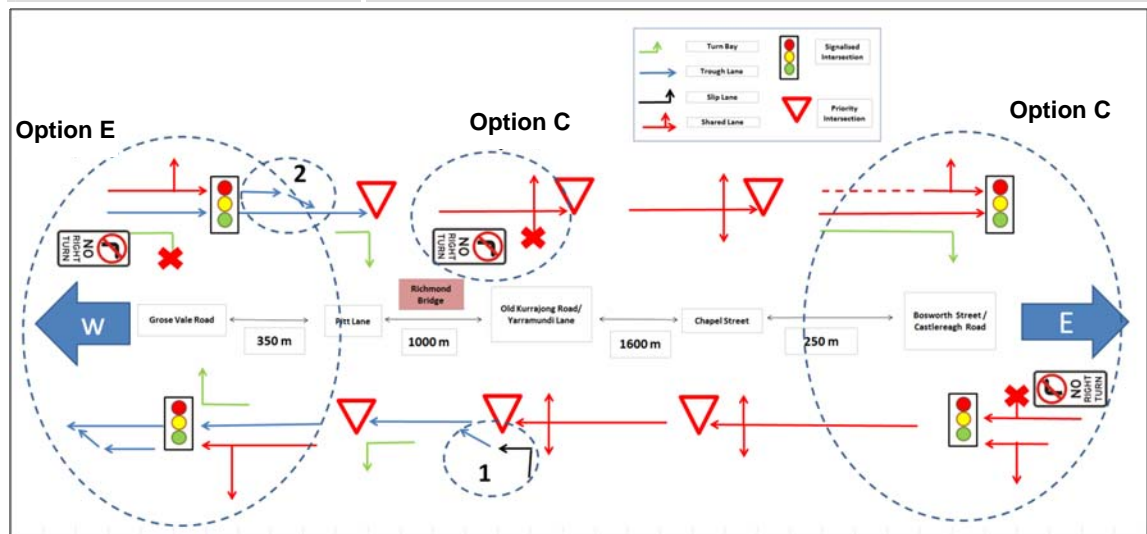


Figure 7-7 Option G Schematic Lane Configuration

The proposed changes to key intersections for Option G are shown graphically in Figure 7-7. Option G is a combination of Options C and E with two additional changes based on modelling outcomes from Options C and E:

- Left turn slip lane out of Yarramundi Lane with an acceleration lane on Kurrajong Road (westbound direction); and
- Eastbound merge kerb side lane extended (east of Grose Vale Road intersection).

Table 7-10 shows traffic performance of Option G against key criteria:

- Option G would improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in the AM and PM peaks.
- The model forecasts significant improvements in travel speed (about 171%) for westbound traffic from 17 km/h (base case) to 46 km/h (Option G) in PM peak. The improved traffic flows are triggered by the combined effect of a left turn slip lane out of Yarramundi Lane and an acceleration lane on Kurrajong Road (westbound direction) together with the improvements at Grose Vale Road intersection.
- Extension of the eastbound merge on Bells Line of Road (east of Grose Vale intersection) is forecast to improve Grose Vale Road traffic in AM peak.

- Similar to Option C, banning the right turn at Yarramundi Lane together with providing an eastbound exclusive right turn bay from Kurrajong Road to Bosworth Street is forecast to improve eastbound traffic flows on Kurrajong Road. The model forecasts improvements in travel speed (about 10%) for eastbound traffic from 48 km/h (base case) to 53 km/h (Option G) in AM peak.
- In line with predicted travel speed improvements for westbound traffic, Option G would improve (up to 32%) vehicle hours travelled (VHT) during the PM peak in the study area network. There would be a minor increase (upto 3%) of vehicle kilometres travelled (VKT) for Option G.
- Option G is unlikely to change traffic volumes and associated LoS at other adjacent intersections in Richmond. The model forecasts minor impacts to adjacent intersections in North Richmond and Castlereagh Road areas (see **Appendix 4** for detailed traffic volumes and LoS).

In general, Option G is forecast to improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks. Option G performs better than Options C and E alone.

**Table 7-10 -Option G Performance Assessment**

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option G		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> :48 km/h	53 km/h	+10 % ▲	■
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> :17 km/h	46 km/h	+171 % ▲	■
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	40,530	+3 % ▲	■
		Paramics	PM	64,826	65,470	+1 % ▲	■
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	895	-1 % ▼	■
		Paramics	PM	2,277	1,558	-32 % ▼	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS D/LoS D	-	■
6	<b>Ability to improve key intersections Level of Service at:</b>						
	Bells Line of Road/Grose Vale Road (Signal) <sup>(5)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS B	-	■
	Kurrajong Road/Yarramundi Lane (Priority) <sup>(6)(7)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS A		■
	Kurrajong Road/Bosworth Street (Signal) <sup>(6)(8)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS C/LoS B	-	■
7	<b>Impact on adjacent intersections <sup>(9)</sup></b>						
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	Minor Change	-	■
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	Slightly Worse	-	■
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	Slightly Worse	-	■

**Note:** (1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction); (3) Average Speed from East Market Street to Grose Vale Road (westbound direction); (4) Level of Service (LoS) is reported for Grose Vale Road approach;(5) LoS is reported for Bells Line of Road east approach;(6) LoS is reported for Kurrajong Road west approach (7) The left turn slip lane out of Yarramundi Lane is expected to improve westbound traffic operation on Kurrajong Road particularly during PM peak. However, SIDRA model forecasts similar LoS for both Base Case and improved case (Option G). This is potentially a limitation of SIDRA. Paramics suggest improvement on Kurrajong Road traffic triggered by left turn slip lane out of Yarramundi Lane. (8) Without additional right turn bay at Bosworth St intersection, model predicts LoS F (Option A).

(9) Impact on adjacent intersections:



*Relative performance compared to Base Case	
■	Improvement
■	Slight Improvement
■	No Change/Minor Change
■	Slightly Worse
■	Worse

### 7.3.8 OPTION H

Upgrade location	Proposed changes (See Figure 7-8)
Bells Line of Road/Grose Vale Road intersection	<ul style="list-style-type: none"> <li>Proposed changes as per Option E;</li> <li>Eastbound merge kerb side lane extended (east of Grose Vale Road intersection) (3).</li> </ul>
Kurrajong Road/Yarramundi Lane/Old Kurrajong Road intersection	<ul style="list-style-type: none"> <li>An eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane (1);</li> <li>A left turn slip lane out of Yarramundi Lane with acceleration lane on Kurrajong Road (westbound direction) (2).</li> </ul>

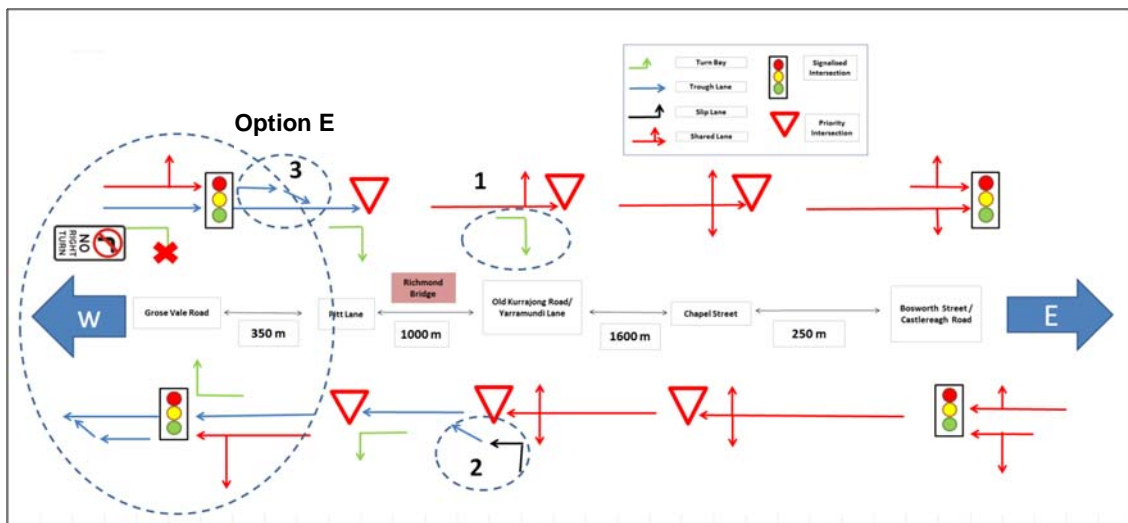


Figure 7-8 Option H Schematic Lane Configuration

The proposed changes to key intersections for option H are shown graphically in Figure 7-8. In general, Option H is a further modification to previous options E/ F. In option H, no improvement is proposed to the Kurrajong Road/Bosworth Street intersection.

Two additional improvements are proposed in Option H based on the modelling outcomes from previous Options E/F. They are:

- Left turn slip lane out of Yarramundi Lane with an acceleration lane on Kurrajong Road (westbound direction)
- Eastbound merge kerb side lane extended (east of Grose Vale Road intersection).

Table 7-11 shows traffic performance of option H against key criteria;

- In general Option H would improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks.
- The model forecasts significant improvement in travel speed (about 171%) for westbound traffic from 17 km/h (base case) to 46 km/h (option H) in PM peak. The improved traffic flows are triggered by the combined effect of a left turn slip lane out of Yarramundi Lane and an acceleration lane on Kurrajong Road (westbound direction).
- The model forecasts a marginal improvement in travel speed (about 4%) for eastbound traffic from 48 km/h (base case) to 50 km/h (Option H) in AM peak.



- Extension of the eastbound merge on Bells Line of Road (east of Grose Vale intersection) is forecast to improve Grose Vale Road traffic, in AM peak.
- In line with predicted travel speed improvements for westbound traffic, Option H would improve (up to 31%) vehicle hours travelled (VHT) during PM peak in the study area network. There will be no change in vehicle kilometres travelled (VKT) for Option H.
- Option H is unlikely to change traffic volumes and associated LoS at other adjacent intersections in Richmond and Castlereagh Road areas. The model forecasts minor impacts to the adjacent intersections in North Richmond (see **Appendix 4** for detailed traffic volumes and LoS).

In general, Option H is forecast to improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks. Option H performs better overall than all other options tested.

**Table 7-11 Option H Performance Assessment**

ID	Traffic Criteria	Modelling Tool	Time Period	Measures		Change [%]	Relative Performance *
				Base Case <sup>(1)</sup>	Option H		
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	Paramics	AM	Avg Speed <sup>(2)</sup> :48 km/h	50 km/h	+4 % ▲	■
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	Paramics	PM	Avg Speed <sup>(3)</sup> :17 km/h	46 km/h	+171 % ▲	■
3	Vehicle Kilometres Travelled, VKT – Study Area Network	Paramics	AM	39,229	39,215	0 %	□
		Paramics	PM	64,826	64,798	0 %	□
4	Vehicle Hours Travelled, VHT – Study Area Network	Paramics	AM	906	895	-1 % ▼	■
		Paramics	PM	2,277	1,562	-31 % ▼	■
5	Ability to improve Grose Vale Road traffic flows <sup>(4)</sup>	SIDRA	AM/PM	LoS F/LoS D	LoS D/LoS D	-	■
6	<b>Ability to improve key intersections Level of Service at:</b>						
	Bells Line of Road/Grose Vale Road (Signal) <sup>(5)</sup>	SIDRA	AM/PM	LoS B/LoS D	LoS B/LoS B	-	■
	Kurrajong Road/Yarramundi Lane (Priority) <sup>(6)(7)</sup>	SIDRA	AM/PM	LoS A/LoS B	LoS A/LoS B		■
	Kurrajong Road/Bosworth Street (Signal) <sup>(8)</sup>	SIDRA	AM/PM	LoS B/LoS C	LoS C/LoS B	-	□
7	<b>Impact on adjacent intersections <sup>(9)</sup></b>						
	Area A-Richmond	SIDRA	AM/PM	LoS A to C	No Change	-	□
	Area B-Castlereagh Road	SIDRA	AM/PM	LoS A to B	No Change	-	□
	Area C-North Richmond	SIDRA	AM/PM	LoS A to C	Slightly Worse	-	■

**Note:** (1) Base case means existing traffic conditions in 2011; (2) Average Speed from Grose Vale Road to East Market Street (eastbound direction); (3) Average Speed from East Market Street to Grose Vale Road (westbound direction); (4) Level of Service (LoS) is reported for Grose Vale Road approach;(5) LoS is reported for Bells Line of Road east approach;(6) LoS is reported for Kurrajong Road west approach (7) The left turn slip lane out of Yarramundi Lane is expected to improve westbound traffic operation on Kurrajong Road particularly during PM peak. However, SIDRA model forecasts similar LoS for both Base Case and improved case (Option G). This is potentially a limitation of SIDRA. Paramics suggest improvement on Kurrajong Road traffic triggered by left turn slip lane out of Yarramundi Lane;(8) LoS is reported for Kurrajong Road west approach; (9) Impact on adjacent intersections:



*Relative performance compare to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse
■	Worse

### 7.3.9 BEST PERFORMING OPTION

This section summarises the key results for each option in terms of the network performance indicators. Each option was assessed in terms of key traffic factors which are most likely to influence decisions on the best performing option. Sections 7.3.1 to 7.3.8 documented the traffic performance of eight (8) short term improvement options which have the potential to improve traffic flows on Bells Line of Road and Kurrajong Road between Grose Vale Road and East Market Street. The short term improvements include a range of localised changes to the following three key intersections that favour the major east west movement of traffic on Bells Line of Road and Kurrajong Road:

- Kurrajong Road / Yarramundi Lane / Old Kurrajong Road;
- Bells Line of Road/Grose Vale Road; and
- Kurrajong Road/ Bosworth Street.

The short term options involve improvements to road and intersections to achieve an acceptable level of traffic operation. These improvements involve some intersection widening, prohibiting on-street parking during peak periods, and banning some right turn movements.

Table 7-12 summarises the network performance of the eight short term improvement options investigated.

Results and conclusions from the investigation are summarised below:

- Options A and B would not improve eastbound and westbound traffic flows between Grose Vale Road and East Market Street. The modelling analysis suggested that banning eastbound right turns on Kurrajong Road to Yarramundi Lane would adversely impact the operation of the Kurrajong Road/Bosworth Street intersection.
- Adding an eastbound exclusive right turn bay on Kurrajong Road at Bosworth Street to Option A formed the basis of Option C. Option C performs relatively better than Options A and B. With this additional improvement in place, Option C would improve eastbound traffic flows between Grose Vale Road and East Market Street.
- Unlike Options A to C, Options D and E investigate improving westbound flows of this section of Bells Line of Road and Kurrajong Road. Proposed improvement at Bells Line of Road Grose Vale Road intersection (Options D and E) would marginally improve westbound traffic flows between Grose Vale Road and East Market Street in PM peak. The analysis identifies the need for to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road.
- Option F is investigated because intersection widening at Kurrajong Road/Bosworth Street (as per Option C) may have timing implications due to the need for potential property acquisition. In addition, the proposed east-bound right turn ban on Kurrajong Road to Yarramundi Lane may have potential accessibility issues for the local community. Instead, in Option F, an eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane is proposed. In general, Option F is marginally forecast to improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks. Option F analysis identifies the need to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road (westbound direction).

- Option G is a combination of Options C and E. Option G is forecast to improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks. Option G performs better than Options C and E alone. However, in Option G, the proposed eastbound right turn ban on Kurrajong Road to Yarramundi Lane may have potential accessibility issues for the local community. In addition, the provision of an exclusive right turn bay on Kurrajong Road to Bosworth Street may have time implications due to the need for potential property acquisition.
- Option H is a further modification to Options E and F. The analysis found that Option H performed relatively better overall than other competing options for the following reasons:
  - Unlike Options A, B, C, and G, Option H eliminates the potential eastbound right turn ban to Yarramundi Lane. Instead, improvements are proposed to the Kurrajong Road/Yarramundi Lane intersection that improves turning traffic performance in and out of Yarramundi Lane. This would also improve local accessibility to Yarramundi Lane.
  - Option H would improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks.
  - Of the seven key traffic assessment criteria, Option H shows improvements in six criteria.
  - In general, improvements identified to Kurrajong Road / Yarramundi Lane / Old Kurrajong Road and Bells Line of Road/Grose Vale Road intersections in Option H are relatively easy to implement in the short term.

Option H has been identified as the preferred option and is further analysed for future traffic conditions in Section 7.4.

Table 7-12 Relative performance \* of upgrade options compared to base case

ID	Traffic Criteria	Time Period	Options considered							
			A	B	C	D	E	F	G	H
1	Ability to improve Bells Line of Road <u>eastbound</u> traffic flows	AM	■	■	■	□	□	■	■	■
2	Ability to improve Bells Line of Road <u>westbound</u> traffic flows	PM	□	■	□	■	■	■	■	■
3	Vehicle Kilometres Travelled, VKT – Study Area Network	AM	■	■	■	□	□	□	■	□
		PM	■	■	■	□	□	□	■	□
4	Vehicle Hours Travelled, VHT – Study Area Network	AM	■	■	■	□	■	■	■	■
		PM	■	■	■	■	■	■	■	■
5	Ability to improve Grose Vale Road traffic flows	AM/PM	□	□	□	□	□	□	■	■
6	<b>Ability to improve key intersection Level of Service with:</b>									
	Bells Line of Road/Grose Vale Road (Signal)	AM/PM	□	□	□	■	■	■	■	■
	Kurrajong Road/Yarramundi Lane (Priority)	AM/PM	■	■	■	□	□	■	■	■
	Kurrajong Road/Bosworth Street (Signal)	AM/PM	■	■	□	□	□	□	□	□
7	<b>Impact on adjacent intersections</b>									
	Area A-Richmond	AM/PM	□	□	□	□	□	□	□	□
	Area B-Castlereagh Road	AM/PM	■	■	■	□	□	□	■	□
	Area C-North Richmond	AM/PM	□	□	□	□	■	■	■	■

*Relative performance compare to Base Case	
■	Improvement
■	Slight Improvement
□	No Change/Minor Change
■	Slightly Worse
■	Worse

## 7.4 FUTURE NETWORK PERFORMANCE

### 7.4.1 TRAFFIC GROWTH

Future traffic growth on Bells Line of Road and Kurrajong Road between Grose Vale Road and East Market Street (study area) will be influenced by the combination of passing (through) and local traffic growth. Future traffic growth in the study area was sourced from RMS's Sydney Strategic Model (which operates in Emme/2). RMS provided traffic forecasts for key roads for each time period up to 2016 and 2021. In future years, both morning and afternoon peak hour traffic was assessed. Table 7-13 shows predicted growth in peak hour traffic related to population and employment increases in the study area.

Table 7-13 Predicted annual growth rates between 2011 and 2021 in the Richmond study area

Time Steps	Average annual growth rate
2011-2016 (5 years)	1.8 %
2011-2021 (10 years)	1.6 %

In the next 5 years (until 2016), peak hour traffic is forecast to grow by approximately 1.8% per annum. In the next 10 years (until 2021), traffic model forecasts peak hour growth in the order of 1.6% per annum. The future growth in the study area was in line with historical growth data observed on Richmond Bridge. Between 2008 and 2011, traffic growth on Richmond Bridge was approximately 1.6% per annum.

The future traffic growth up to 2021 is reported at eleven key locations in the study area. Detailed traffic forecasts on key roads are included in **Appendix 4**. Table 7-14 shows the traffic forecasts up to 2021 on Richmond Bridge and mid-block locations between the three key intersections.

In 2021, the model forecasts east bound traffic demand on Richmond Bridge in the order of 1800 vehicles in AM peak. In PM peak westbound traffic demand on bridge is forecast in the order of 1600 vehicles. Similar traffic demand is forecast on the approach roads to the bridge (i.e. Bells Line of Road/Kurrajong Road between Grose Vale Road and Yarramundi Lane). The future traffic demand (2021) on the bridge and approach roads suggests the need for two through traffic lanes in the peak direction.

Table 7-14 Traffic forecast between 2011 and 2021 at key Locations

Mid-Block Section			Peak Hour Traffic Volumes		
			2011	2016	2021
Bells Line of Rd from Grose Vale Rd to Richmond Bridge	AM	EB	1,513	1,661	1,780
		WB	651	713	806
	PM	EB	874	979	1,044
		WB	1,305	1,458	1,585
Richmond Bridge	AM	EB	1,513	1,661	1,780
		WB	651	713	806
	PM	EB	874	979	1,044
		WB	1,305	1,458	1,585
Kurrajong Rd from Richmond Bridge to Yarramundi Lane	AM	EB	1,513	1,661	1,780
		WB	651	713	806
	PM	EB	874	979	1,044
		WB	1,305	1,458	1,585
Kurrajong Rd from Yarramundi Lane to Bosworth St	AM	EB	1,070	1,161	1,255
		WB	517	565	613
	PM	EB	709	765	822
		WB	858	964	1,040

**Source:** Hyder's future Paramics model. In Paramics, future demand was sourced from RMS Sydney Strategic Model (Emme/2).

**Note:** Eastbound (EB), Westbound (WB).

## 7.4.2 FURTHER ANALYSIS OF OPTION H

In consultation with key stakeholders, Option H was slightly modified and reassessed with on-street parking restrictions during peak hours on both sides of Kurrajong Road between Chapel Street and Bosworth Street. Traffic analysis suggested that this modification would also improve the performance of Kurrajong Road/Bosworth Street intersection. The kerbside lane would provide additional capacity for through traffic during AM and PM peak periods. Currently, eastbound right turn traffic at Kurrajong Road/ Bosworth Street intersection shares one lane with through traffic. The model shows increased use of the kerbside lane for eastbound through traffic, leaving more available capacity for the right turning vehicles.

The improvements identified in Option H were assessed for future traffic conditions in 2016 and 2021. The growth data in the future Paramics model for Option H was assumed in line with the growth figures in Section 7.4.1. Consistent with the previous assessment, future network operational issues for Option H were reassessed at three key intersections and Richmond Bridge. The key points to note are:

- The 2016 model predicts satisfactory operation of the Kurrajong Road/Bosworth Street intersection. For the western approach traffic, the level of service is predicted between C and D during peak hours. In 2021, the model predicts a lower level of service (F) for western approach traffic.

- The analysis suggests the need for an eastbound exclusive right turn lane on Kurrajong Road at the Kurrajong Road/Bosworth Street intersection after 2016. The proposed upgrade is forecast to provide a good level of service (A and B) for western approach traffic up to 2021.
- In the future, Grose Vale Road approach traffic is forecast with a low LoS (F).

Table 7-15 shows the modelled future traffic performance of proposed improvements at relevant approach roads.

In general, the analysis found that proposed improvements would achieve an acceptable level of service for key intersections and Richmond Bridge, over the short time period (0-10 years). Detailed future network performance of the proposed improvements for 2016 and 2021 traffic conditions are included in **Appendix 4**.

**Table 7-15 Performance assessment of proposed improvements at key intersections**

Intersection	Approach	Time Period	Level of Service (LoS)			
			2011 Existing	Option H		Option H with exclusive right turn bay on Kurrajong Rd at Bosworth St
				2016	2021	2021
Kurrajong Road/Bosworth Street (traffic light)	Kurrajong Road western approach	AM	LoS B	LoS C	LoS C	LoS A
		PM	LoS C	LoS D	LoS F	LoS B
Bells Line of Road /Grose Vale Rd (traffic light)	Bells Line of Road eastern approach	AM	LoS B	LoS C	LoS D	LoS D
		PM	LoS D	LoS C	LoS C	LoS C
	Grose Vale Road approach	AM	LoS F	LoS F	LoS F	LoS F
		PM	LoS D	LoS D	LoS E	LoS E
Kurrajong Road/Yarramundi Lane (sign control)	Kurrajong Road western approach	AM	LoS B	LoS A	LoS A	LoS A
	Kurrajong Road eastern approach	PM	LoS F	LoS A	LoS A	LoS A

**Source:** Existing 2011 LoS results except for Kurrajong Rd/ Yarramundi Ln: SIDRA model; Existing 2011 LoS results for Kurrajong Rd/ Yarramundi Ln and Future 2016 & 2021 LoS results: Paramics model.



## 7.4.3 RECOMMENDED ACTIONS

The proposed staging of the preferred option is summarised in Table 7-16 and graphically shown in Figure 7-9. The strategic concept sketches prepared by RMS for proposed intersection improvements are included in Appendix 5.

Table 7-16 Proposed staging of the preferred Option

Time Frame	Upgrade location	Proposed Upgrade
0-5 years Up to 2016	Bells Line of Road/Grose Vale Road	<ul style="list-style-type: none"> <li>▪ Provide a westbound shared through/left turn lane on Bells Line of Road, east of Grose Vale Road replacing the existing left turn lane.</li> <li>▪ Provide an additional westbound short through lane on Bells Line of Road, west of Grose Vale Road.</li> <li>▪ Prohibit on-street parking during peak periods on southern side of Bells Line of Road between Pitt Lane and Grose Vale Road.</li> <li>▪ Ban the eastbound right turn from Bells Line of Road into Grose Vale Road.</li> <li>▪ Conversion of the existing eastbound right-turn bay to a second westbound short through lane.</li> <li>▪ Extend the eastbound merge on Bells Line of Road (east of Grose Vale Road intersection).</li> </ul>
	Kurrajong Road/Yarramundi Lane/Old Kurrajong Road	<ul style="list-style-type: none"> <li>▪ Provide an eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane.</li> <li>▪ Provide a left turn slip lane out of Yarramundi Lane with acceleration lane on Kurrajong Road (westbound direction).</li> </ul>
	Kurrajong Road	<ul style="list-style-type: none"> <li>▪ Prohibit on-street parking during peak periods on both sides of Kurrajong Road between Chapel Street and Bosworth Street.</li> </ul>
5-10 years 2016-2021	Kurrajong Rd / Bosworth Street	<ul style="list-style-type: none"> <li>▪ Provide an exclusive eastbound right turn bay from Kurrajong Road to Bosworth Street;</li> <li>▪ Consider banning the right turn from March Street to Bosworth Street (north).</li> </ul>



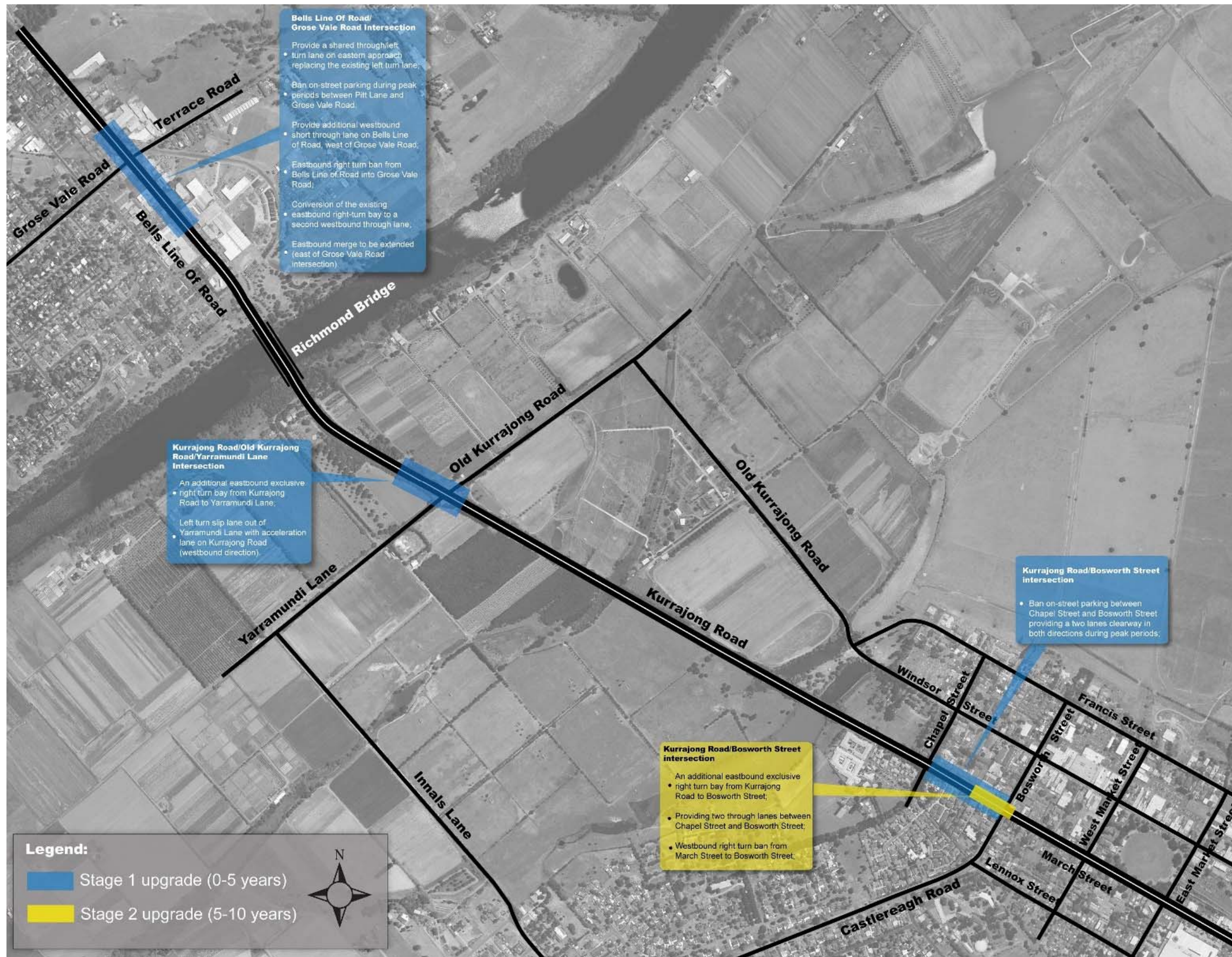


Figure 7-9 Proposed staging of the preferred Option



## 7.4.4 OPTIONS FOR RICHMOND BRIDGE

Section 7.4.1 concluded that future traffic demand (2021) on Richmond Bridge and approach roads suggests the need for two through traffic lanes in the peak direction. Given this, RMS have considered design options for increasing the capacity of the bridge.

In 2011, Richmond Bridge carried about 27,000 vehicles per day; with about 1,400 to 1,500 vehicles per direction (either eastbound or westbound) in the AM and PM peak one hour periods. This is a typical tidal flow pattern, with heavy eastbound flows in the morning (about 1,500 vehicles in one hour) and a significantly lower volume in the westbound direction (about 700 vehicles in one hour). The reverse is true in the evening.

In 2021, the model forecasts eastbound traffic demand on Richmond Bridge in the order of 1800 vehicles in AM peak. Similar traffic volumes are forecast on approach sections of Bells Line of Road/Kurrajong Road between Grose Bells Road and Yarramundi Lane. Future traffic demand (2021) on the bridge and approach roads suggests the need for two through traffic lanes in the peak direction, hence a tidal flow scheme could be considered.

A tidal flow system on Richmond Bridge would provide some complexities and challenges for traffic management particularly regarding right and left turn movements and turn bays on sections of Bells Line of Road between Grose Vale Road and the bridge. It may not be effective in improving traffic flows if future traffic on the bridge in both directions leads to a more balanced flow due to unexpected land use changes in Richmond and North Richmond areas.

Given the above RMS design criteria included:

- Investigation of two options for widening; one option for three traffic lanes with a moveable median and traffic contraflow, and another option for four traffic lanes.
- Span length and superstructure shape of widening to match the existing structure.
- Widening to be a compatible low maintenance structure capable of carrying SMI 600 loads.
- Provide for cyclists on the widened carriageway.
- The water main on the downstream side of the existing bridge may need to be relocated.
- The widened structure to be designed for submergence with holding down bolts because the existing deck level is between the two and five year Average Recurrence Interval (ARI) flood levels.
- Traffic lanes to be arranged to ensure no wheel paths are located at the joint between the existing structure and the new structure.

Ultimately three design options were considered:

### (1) Widening on both sides

The possibility of modification of the existing structure and widening on both sides was investigated at an early stage and not further considered for the following reasons:

- The existing structure would not have the capacity to carry the widening and an independent substructure will be required.
- Strengthening work would be required to the existing deck, which would be expensive.
- RMS Bridge Engineering experience has found that widening on both sides of a bridge is always more expensive than restricting work to one side.

- Relocation of utilities would be required on both the upstream and downstream sides of the bridge, and in the approaches.
- The existing bridge is included in RMS heritage list S170.

Since widening on the upstream side of the bridge would also require modification and strengthening as above, it is concluded that widening on the downstream side is the most suitable alternative.

(2) Widening on the downstream side with a separate structure to create four lanes (2 new and 2 existing) (Figures 7-10 and 7-11)

This option comprises eleven 16.46 metre interior spans and two 16.82 metre end spans of cast-in-situ post tensioned T girders, constructed on the downstream side of the bridge. The girders would be continuous over the piers, and the cross sectional depth varied to match the circular curved soffit of the existing bridge girders. A longitudinal deck joint would be provided between the widening and the existing bridge. This option has the following features:

- The three girder system can provide four traffic lanes and shoulders wide enough to accommodate cyclists in both directions.
- The curved profile of the soffit is considered aesthetically pleasing as it matches the shape of the existing arched structure.
- Location of the piers in line with the existing piers will improve the appearance and eliminate adverse interference with the waterway.
- The cast-in-situ construction method is easier than a precast option in this case, due to the curved shape.
- The initial and ongoing costs for this type of superstructure are lower than the cost of steel materials.
- The longitudinal deck joint will allow for differential movements between the widening and the existing structure, and can be positioned away from wheel paths.
- The cost of maintaining contraflow traffic associated with a three lane option is eliminated.
- The widening is an independent structure designed for SMI 600 loading and can be utilised for two lane two way traffic if the existing aged structure is demolished and replaced in the future.

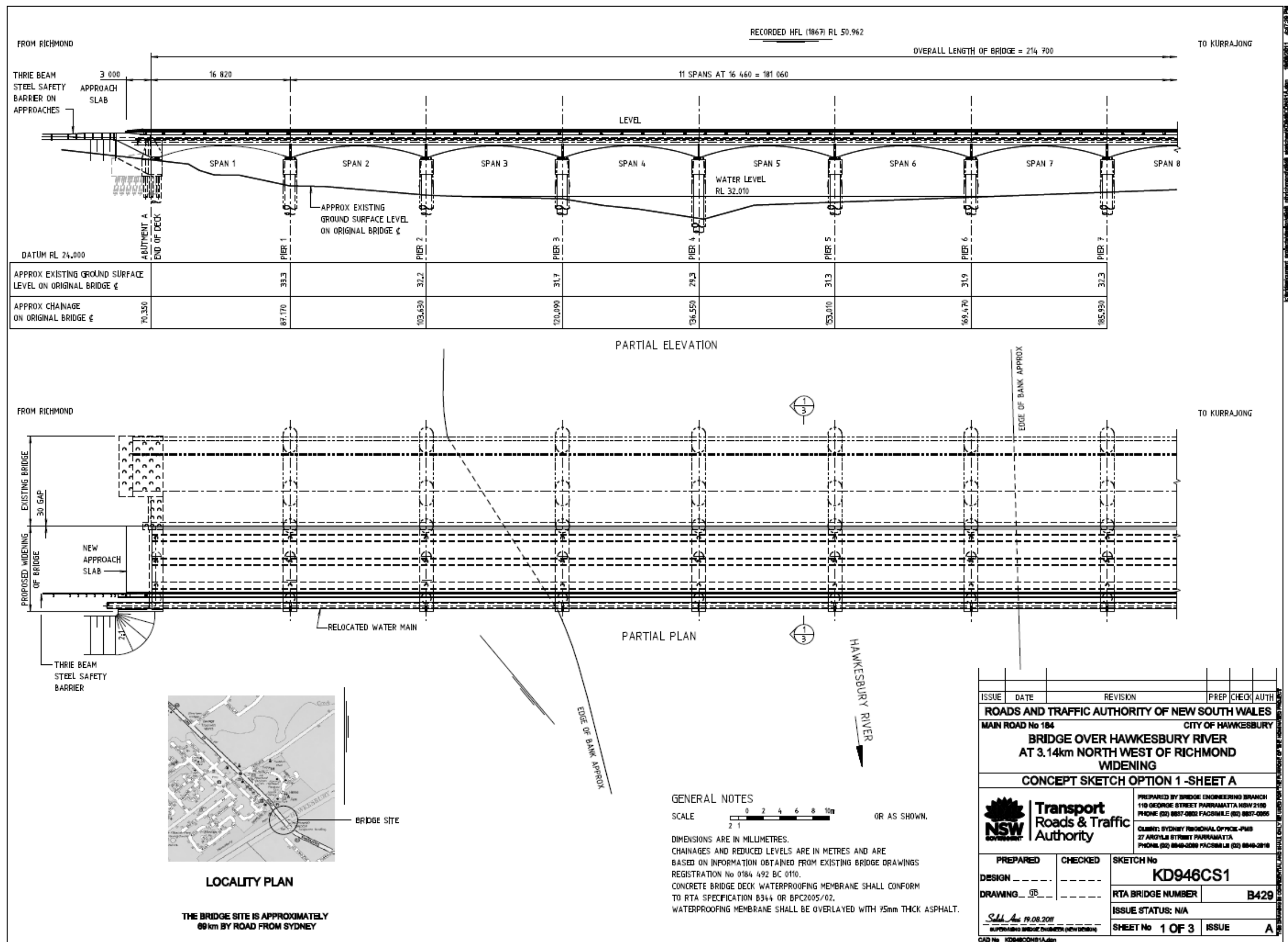


Figure 7-10 –Richmond Bridge Four Lane Option (part only)

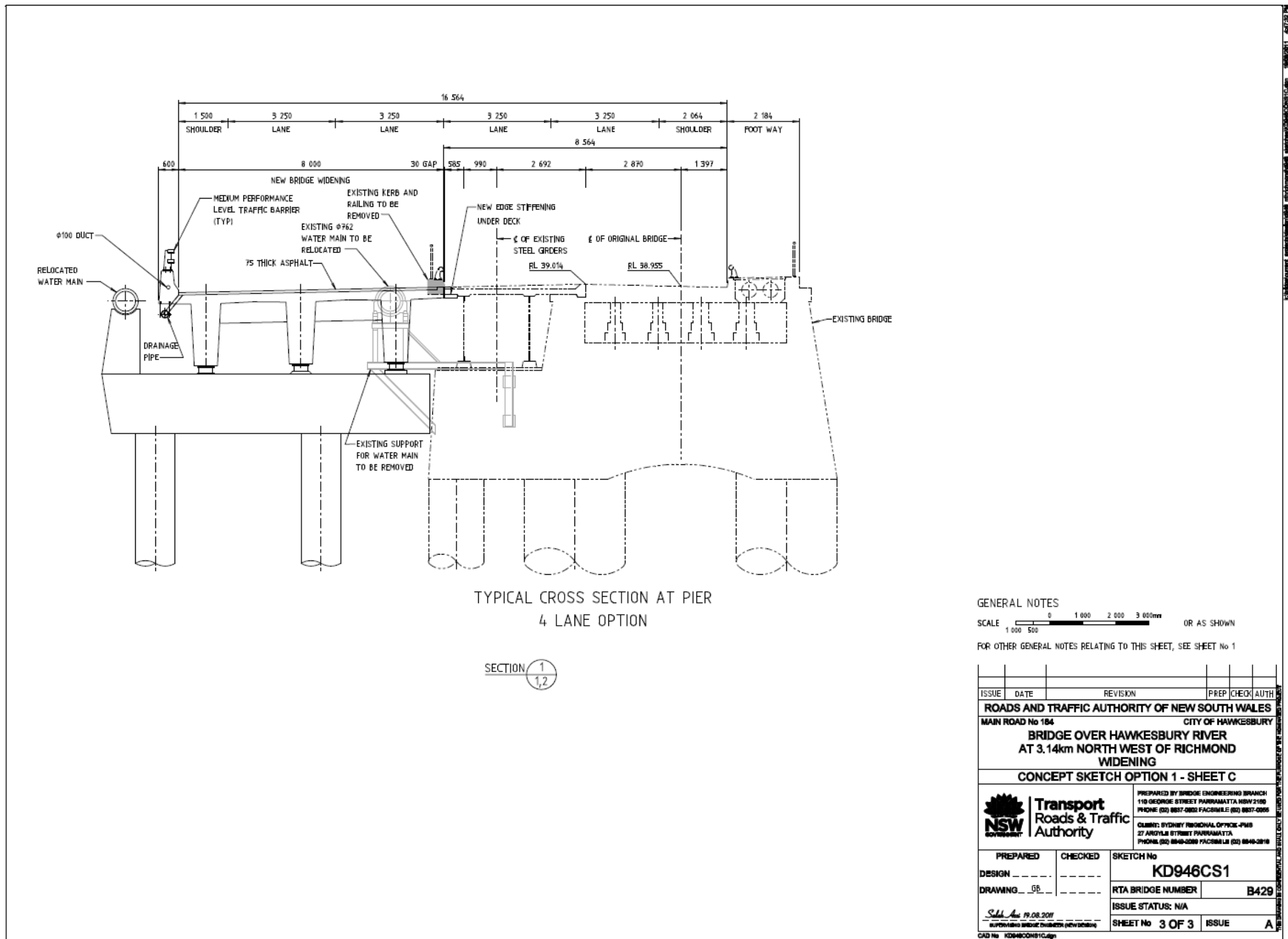


Figure 7-11 – Richmond Bridge 4 Lane Option



(3) Widening on the downstream side with a separate structure to create three lanes (1 new and 2 existing) (Figures 7-12 and 7-13)

This option comprises a cross section with two cast-in-situ post tensioned girders with a monolithic deck slab, constructed on the downstream side of the bridge. The girders would be continuous over the piers, and the cross sectional depth varied to match the circular curved soffit of the existing bridge girders. A longitudinal deck joint would be provided. This option has the following advantages and disadvantages:

Advantages -

- The curved profile of the soffit is considered aesthetically pleasing as it matches the shape of the existing arched structure.
- Location of the piers in line with the existing piers will improve the appearance and eliminate adverse interference with the waterway.
- The cast-in-situ construction method is easier than a precast option in this case, due to the curved shape.
- The initial and ongoing costs for this type of superstructure are lower than the cost of steel materials.
- The longitudinal deck joint will allow for differential movements between the widening and the existing structure, and can be positioned away from wheel paths.

Disadvantages -

- There is an ongoing cost of maintaining contraflow traffic arrangements.
- Though the widening is an independent structure designed for SMI 600 loading, it cannot be utilised to take all road traffic in the event of future replacement of the aging existing structure, as the new carriageway has insufficient width.
- The width of the shoulder is reduced to prevent placing a traffic wheel line above the new longitudinal joint.

The provision of three lanes with contraflow could be the least expensive option without consideration of the ongoing cost of managing the contraflow, but provides a significantly inferior functionality to a four lane option. The shoulder widths are narrower and the new structure would not be able to accommodate two traffic lanes when replacement of the aging existing structure is due.

Stage two of this study will consider these issues in detail in recommending a preferred option to reserve the road corridor for future upgrading.



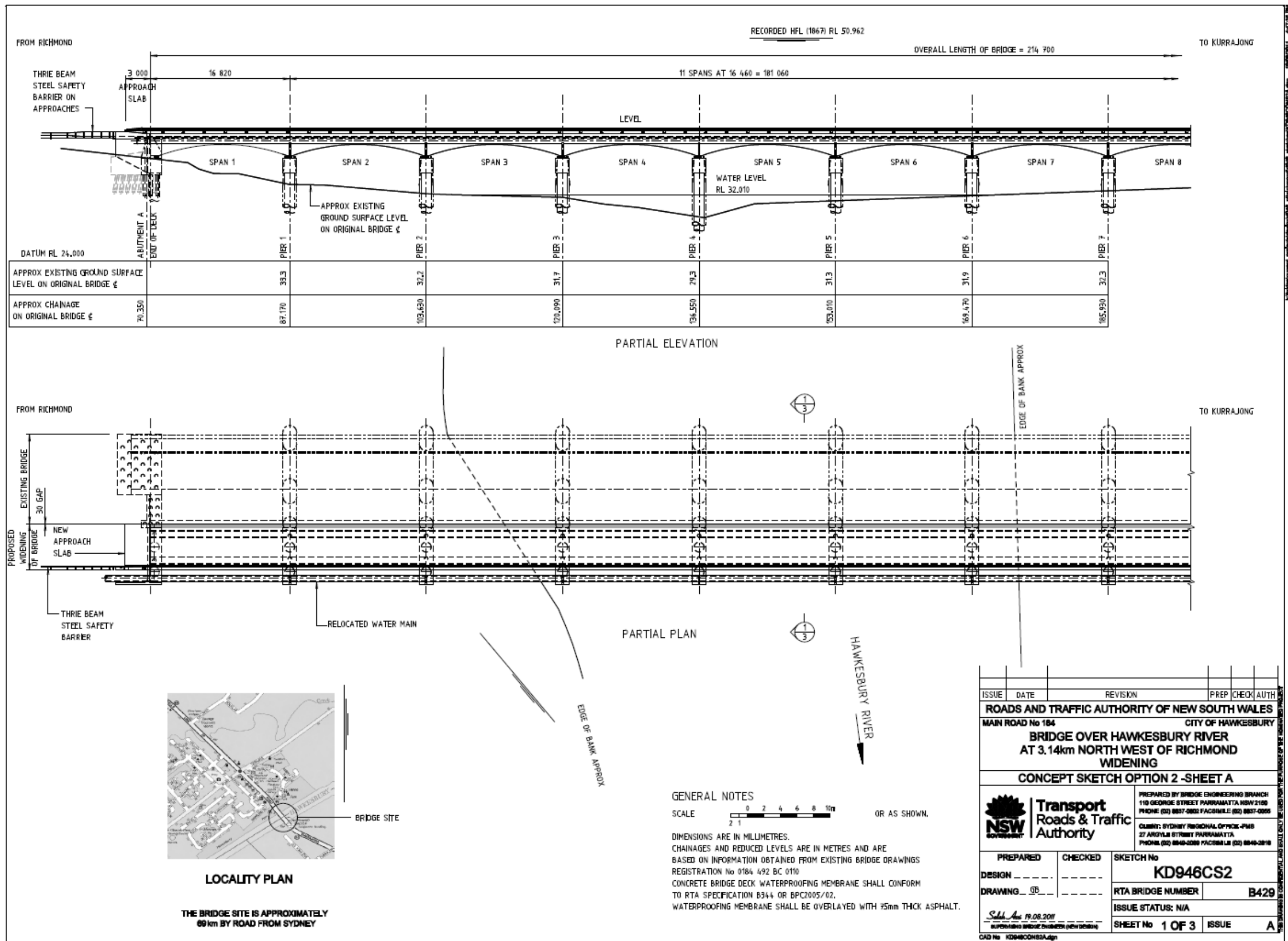


Figure 7-12 – Richmond Bridge 3 lane option (part only)

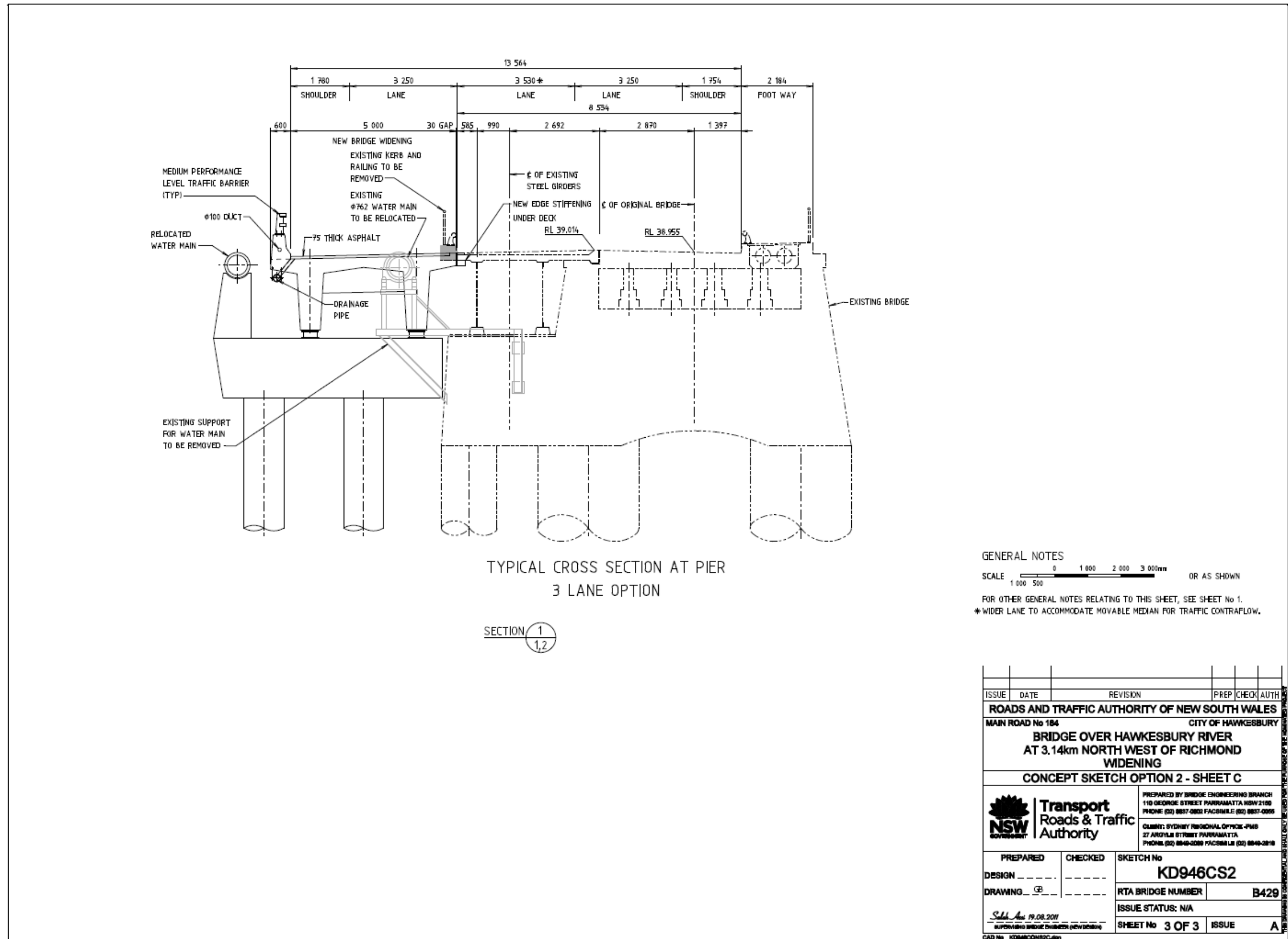


Figure 7-13 – Richmond Bridge Three Lane option

## 8 SUMMARY AND RECOMMENDATIONS

### 8.1 KEY FINDINGS

#### 8.1.1 OVERVIEW

The Bells Line of Road provides a supplementary link (to the Great Western Highway) between the Sydney Basin and the Central West Region of New South Wales. It is also a significant commuter route from the Kurrajong and North Richmond areas to the rapidly growing North-West Growth Sector of Sydney. The route includes the two-lane Richmond Bridge which is the only Hawkesbury River crossing serving the entire residential catchment of North Richmond, Kurrajong, Bilpin, Bell and beyond. During the morning and afternoon peak hours this section of Bells Line of Road experiences considerable levels of traffic congestion.

The purpose of Hyder's traffic study is to assess the traffic performance of Richmond Bridge and section of Bells Line of Road/ Kurrajong Road between Grose Vale Road and East Market Street (the study area). A road based micro-simulation traffic model was developed for the study area. For the micro-simulation model, Hyder used *Paramics* software. For assessing individual intersection capacity, Hyder used *SIDRA* software.

Both *Paramics* and *SIDRA* models provided an assessment tool to identify:

- Key network issues that affect the traffic performance of Richmond Bridge and adjoining approach roads.
- Short term options for improvements to traffic flow. Each option was assessed in terms of key traffic factors which are most likely to influence the decisions on the best performing option.

A consultation process engaging RMS and key stakeholders constituted an important element of the study. Three key stakeholder workshops were undertaken over the course of this project comprising representatives from following organisations:

- RMS;
- Transport for NSW; and
- Hawkesbury City Council.

At the same time, RMS have conducted preliminary investigations into widening of Richmond Bridge.

## 8.1.2 KEY ISSUES

Hyder's analysis was based on new traffic data collected between June and August 2011. In 2011, Richmond Bridge carried approximately 27,000 vehicles per day. This included approximately 1500 heavy vehicles (more than 5% of the total traffic). Peak hour traffic volume on Richmond Bridge was in the order of 1400 to 1500 vehicles per direction. The traffic analysis suggests that Richmond Bridge is close to saturation traffic levels.

During AM and PM peak periods, some turning movements at adjoining key intersections with Bells Line of Road/Kurrajong Road adversely impact the operation of Richmond Bridge. Traffic modelling has identified network operational issues at the following three key intersections:

1. Bells Line of Road/Grose Vale Road (traffic light controlled);
2. Kurrajong Road / Yarramundi Lane / Old Kurrajong Road (sign controlled); and
3. Kurrajong Road/ Bosworth Street (traffic light controlled).

## 8.1.3 OPTIONS CONSIDERED

Three technical workshops were conducted with RMS and key stakeholders. Based on modelling investigation, Hyder has identified some ten preliminary short term improvement options. In consultation with stakeholders, eight options have been shortlisted for detailed assessment. These are referred to as Options A to H. The eight options were assessed under 2011 traffic conditions for both AM and PM peak periods.

Section 7.3 in this report documented traffic performance of the eight short term improvement options which have potential to improve traffic flow of the section of Bells Line of Road and Kurrajong Road between Grose Vale Road and East Market Street. Each option was assessed in terms of key traffic factors which are most likely to influence decisions on the best performing option. The short term options involve minor improvements to road and intersections to achieve an acceptable level of traffic operation. These improvements involve intersection widening, prohibiting on-street parking during peak periods and banning turn movements. The identified improvements at the three key intersections are aimed at improving major east-west movement of traffic on this section of Bells Line of Road and Kurrajong Road.

Quantitative measures were identified to assist in the assessment of the performance of each option as described in Table 7-2 of this report.

## 8.1.4 OPTIONS RESULTS

Results and conclusions from the eight options tested are summarised below:

- Options A and B would not improve eastbound and westbound traffic flows between Grose Vale Road and East Market Street. The modelling analysis suggested that banning eastbound right turns on Kurrajong Road to Yarramundi Lane would adversely impact the operation of the Kurrajong Road/Bosworth Street intersection.
- Adding an eastbound exclusive right turn bay on Kurrajong Road at Bosworth Street to Option A formed the basis of Option C. Option C performs relatively better than Options A and B. With this additional improvement in place, Option C would improve eastbound traffic flows between Grose Vale Road and East Market Street.
- Unlike Options A to C, Options D and E investigate improving westbound flows of this section of Bells Line of Road and Kurrajong Road. Proposed improvement at Bells Line of Road Grose Vale Road intersection (Options D and E) would marginally improve westbound traffic flows between Grose Vale Road and East Market Street in PM peak. The analysis identifies the need for to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road.
- Option F is investigated because intersection widening at Kurrajong Road/Bosworth Street (as per Option C) may have timing implications due to the need for potential property acquisition. In addition, the proposed east-bound right turn ban on Kurrajong Road to Yarramundi Lane may have potential accessibility issues for the local community. Instead, in Option F, an eastbound exclusive right turn bay from Kurrajong Road to Yarramundi Lane is proposed. In general, Option F is marginally forecast to improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks. Option F analysis identifies the need to investigate a left turn slip lane from Yarramundi Lane to Kurrajong Road (westbound direction).
- Option G is a combination of Options C and E. Option G is forecast to improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks. Option G performs better than Options C and E alone. However, in Option G, the proposed eastbound right turn ban on Kurrajong Road to Yarramundi Lane may have potential accessibility issues for the local community. In addition, the provision of an exclusive right turn bay on Kurrajong Road to Bosworth Street may have time implications due to the need for potential property acquisition.
- Option H is a further modification to Options E and F. The analysis found that Option H performed relatively better overall than other competing options for the following reasons:
  - Unlike Options A, B, C, and G, Option H eliminates the potential eastbound right turn ban to Yarramundi Lane. Instead, improvements are proposed to the Kurrajong Road/Yarramundi Lane intersection that improves turning traffic performance in and out of Yarramundi Lane. This would also improve local accessibility to Yarramundi Lane.
  - Option H would improve both eastbound and westbound traffic flows between Grose Vale Road and East Market Street in AM and PM peaks.
  - Of the seven key traffic assessment criteria, Option H shows improvements in six criteria.
  - In general, improvements identified to Kurrajong Road / Yarramundi Lane / Old Kurrajong Road and Bells Line of Road/Grose Vale Road intersections in Option H are relatively easy to implement in the short term.

Option H has been identified as the preferred option and was further analysed for future traffic conditions in 2016 and 2021. The analysis suggests the need for an eastbound exclusive right turn lane on Kurrajong Road at Kurrajong Road/Bosworth Street intersection after 2016.

Lastly RMS have undertaken preliminary analysis on options for upgrading Richmond Bridge. Widening of the bridge on both sides (i.e. upstream and downstream) is not favoured. Two other options (separate structures, both downstream) are feasible. The first involves the addition of two lanes, providing a four lane structure. The second option would provide one additional lane, with a total of three ultimately provided. This option would require the use of 'tidal flow' measures assuming that the current dominant morning and afternoon peak flows remained in place. The costs of tidal flow measures have not been determined at this stage.

## 8.2 RECOMMENDATIONS

The proposed improvements graphically shown in Figure 7.9 and summarised in Table 7.16 can be delivered in two stages. These improvements would achieve an acceptable level of service to key intersections including Richmond Bridge over the short time period (up to 10 years).

This Stage I study has provided an indication of the benefits to traffic flows to be gained from intersection and other improvements in the area of Richmond Bridge. It has produced a preferred option for works to 2021.

The study also included preliminary investigations regarding the structural suitability of the existing bridge and has also considered preliminary concept proposals for the upgrading of Richmond Bridge, likely to be required from 2021 onwards.

The second stage of this work will develop strategic concept design options for upgrading the bridge and approaches between Richmond and North Richmond to meet future demands beyond 2021.