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Kennedy Highway TRARR Analysis

PROJECT No: PRJ18092

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FINAL VERSION 1

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SUMMARY

This report is a performance analysis of Kennedy Highway using TRARR. TRARR is a simulation tool to assess operation level-of-service (LOS) of two-lane highways.

The analysis examined Kennedy Highway in its current configuration and at various future demand scenarios. The analysis showed that Kennedy Highway is operating at LOS D under current demands and will potentially reach LOS E by 2040, or by 2032 if traffic is higher than the historical median trend. The approximate AADT per direction at which this occurs is at 7,000 vehicles, currently the approximate AADT per direction is 4,440.

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1 BACKGROUND AND PROJECT OBJECTIVES

Queensland Department of Transport and Main Roads is reviewing the operational performance of the Kennedy Highway. As part of their review, TMR commissioned ARRB to conduct a TRARR (Traffic on Rural Roads) analysis. The analysis aims at identifying the current demands on Kennedy Highway, and identifying when the traffic volume reaches an unacceptable level-of-service (LOS).

2 MODEL INPUTS AND ASSUMPTIONS

This section outlines the inputs into the TRARR model along with the assumptions that were made as part of the analysis.

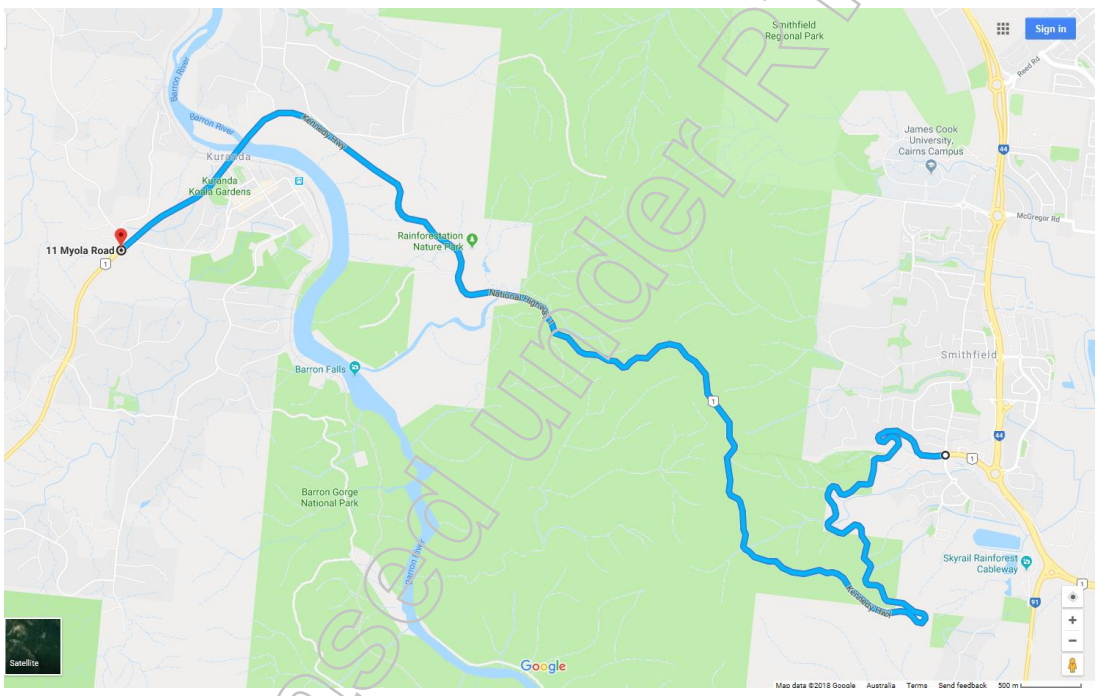
A base case ROAD file was created for the road section which modelled the road as it currently exists with the observed speed limits, barrier lines and overtaking lanes in either direction. The traffic profiles were then modelled on the base case road section and the outputs of each simulation observed. These outputs included mean speeds and percentage following as observed at each observation point along the road. These are plotted in Section 3.

The performance of a section of highway can be measured based on the observed mean speeds and percentages of vehicles following at each interval along the road. As the percentage of vehicles impeded by slower vehicles increases, the mean speeds of all vehicles decrease.

The network that was reviewed is approximately from Cumberland Avenue to Myola Road on Kennedy Highway (approximately 13.6 km), as shown in Figure 2.1.

Slow vehicle turnouts were not encoded because it was assumed that at high traffic volumes motorists are not likely to use them.

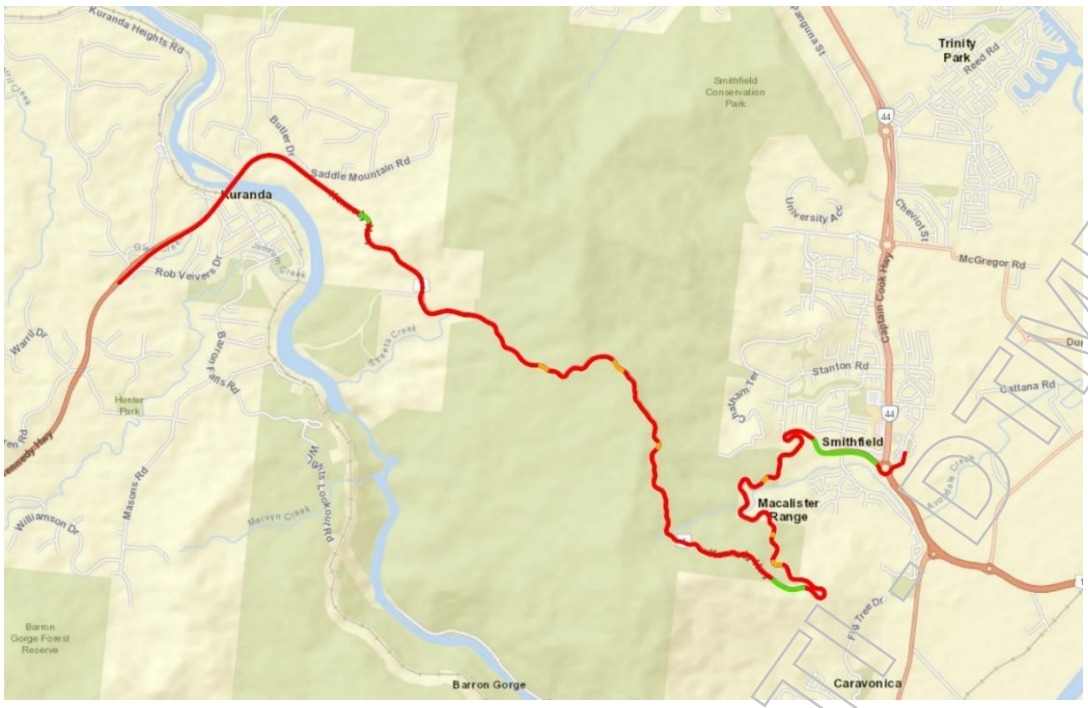
Figure 2.1 Kennedy Highway



Source: Google (2018).

Figure 2.2 identifies the locations of the observed overtaking lanes and slow vehicle turnouts in the direction of Smithfield to Kuranda, the slow vehicle turnouts were not used in this analysis. Figure 2.3 identifies the locations of the observed overtaking lanes and slow vehicle turnouts in the direction of Kuranda to Smithfield, the slow vehicle turnouts were not used in this analysis.

Figure 2.2 Location of overtaking lanes towards Kuranda



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community.

Figure 2.3 Location of overtaking lanes towards Smithfield

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community.

2.1 DEMAND

Average Annual Daily Traffic (AADT) was sourced from Queensland Government (2018a), which is approximately 4,440 vehicles per direction. The analysis focused on peak-hour performance. Peak-hour flow of 10% AADT was applied.

Different scenarios were looked at in the analysis, the peak-hour volumes analysed are shown in Table 2.1.

Table 2.1 Vehicle demand per hour

Scenario	Cars	Cars towing	Rigid	Single Articulated	Double Articulated	Road Train	Total	AADT
Base	382	8	41	12	2	-	445	4,440
600 veh/h	516	10	55	16	2	-	599	6,000
800 veh/h	689	14	74	21	3	-	801	8,000
1000 veh/h	861	17	92	26	4	-	1,000	10,000

Source: Based on Queensland Government (2018a, 2018b).

Based on the average of the 10-year growth factors for the last 10 years, the 25th percentile, median and 75th percentile growth factors were calculated (Based on Queensland Government 2018b). Figure 2.4 shows the number of years versus the vehicle volumes based on the growth rates. The growth rates used are shown in Table 2.2.

Figure 2.4 Vehicle demand growth

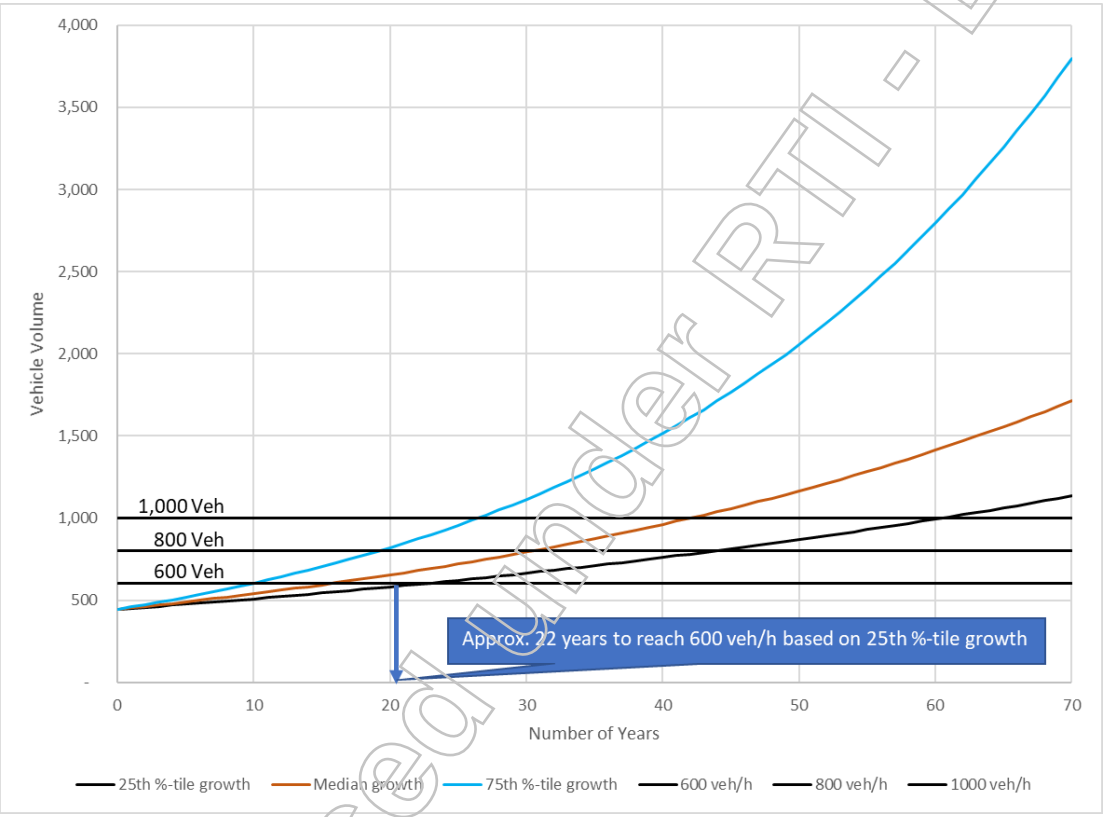


Table 2.2 Average of average 10-year traffic growth factors

	25th %-tile (%)	Median (%)	75th %-tile (%)
Growth rate	1.35	1.95	3.11

Source: Based on Queensland Government (2018b)

The approximate number of years to reach milestone volumes are shown in Table 2.3.

Table 2.3 Estimated time for volume occurrence

Volume	AADT	Number of years given traffic growth rate		
		25th %-tile growth	Median growth	75th %-tile growth
600	6,000	22	15	9
800	8,000	43	30	19
1,000	10,000	60	42	26

2.2 OVERTAKING, VEHICLE ATTRIBUTES AND OTHER ASSUMPTIONS

The assumptions that were made in the TRARR analysis for overtaking, vehicle attributes and other assumptions are shown in Table 2.4. The vehicle parameters used in this project were based on the findings of the on-going Austroads project NTM6025 'Passing lanes – safety and performance'.

Table 2.4 Overtaking, Vehicle Attributes and Other Assumptions

Attribute	Assumption
Time following	Assumed the time between vehicles of 3.8 seconds to be following.
Vehicle parameters	The vehicle file was revised based on the Austroads passing lanes project (not all the parameters in the passing lanes project were used). The key parameters changed include the time spacing of vehicles.
Vehicle composition	The vehicle composition was revised based on the AADT volumes for the road.
Settling down time and model duration	The settling time used was 1,800 seconds The model duration is for 7,600 seconds

2.3 LOS OF TWO-LANE HIGHWAYS

The performance outputs from the TRARR modelling were equated to level of service (LOS) A to F to better conceptualise and compare the highway's performance under current and future traffic volumes.

The Guide to Traffic Management Part 3: Traffic Studies and Analysis (Austroads 2017) distinguishes between three categories of two-lane highways in accordance with the US Highway Capacity Manual (Transportation Research Board 2010). These categories are:

- Class I – Two-lane highways on which motorists expect to travel at relatively high speeds. Two-lane highways that are major intercity routes, primary arterials connecting major traffic generators, daily commuter routes, or primary links in state or national highway networks are generally assigned to Class I. Class I facilities most often serve long-distance trips or provide connecting links between facilities that serve long-distance trips.
- Class II – Two-lane highways on which motorists do not necessarily expect to travel at high speeds. Two-lane highways that function as access routes to Class I facilities, serve as scenic or recreational routes that are not primary arterials, or pass through rugged terrain are generally assigned to Class II. Class II facilities most often serve relatively short trips, the beginning and ending portions of longer trips, or trips for which sightseeing plays a significant role.
- Class III – Two-lane highways serving moderately-developed areas. They may be portions of a Class I or Class II highway that pass through small towns or developed recreational areas. On such segments, local traffic often mixes with through traffic, and the density of unsignalised roadside access points is noticeably higher than in a purely rural area. Class III highways may also be longer segments passing through more spread-out recreational areas, also with increased roadside densities. Such segments are often accompanied by reduced speed limits that reflect the higher level of activity.

According to these definitions, Kennedy Highway is a Class II highway.

The LOS criteria used for these highway classes differ. The Highway Capacity Manual notes:

- The LOS for Class I highways on which efficient mobility is paramount is defined in terms of both percent time-spent-following (PTSF) and average travel speed.
- On Class II highways, mobility is less critical, and the LOS is defined only in terms of percent time-spent-following.
- On Class III highways, high speeds are not expected. Because the length of Class III segments is generally limited, passing restrictions are also not a major concern. In these cases, drivers would like to make steady progress at or near the speed limit. Therefore, on these highways, percent free-flow speed (PFFS) is used to define LOS.

The LOS for Class I, II and III highways are defined in Table 2.5.

Table 2.5 LOS for two-lane highways

LOS	Class I highways		Class II highways PTSF (%)	Class III highways Percent free-flow speed PFFS (%)
	Average travel speed ATS (ATS) (km/h)	Percent time-spent-following PTSF (%)		
A	> 90	≤ 35	< 40	> 91.7
B	> 80 – 90	> 35 - 50	> 40 - 55	> 83.3 - 91.7
C	> 70 – 80	> 50 - 65	> 55 - 70	> 75.0 - 83.3
D	> 60 – 70	> 65 - 80	> 70 - 85	> 66.7 - 75.0
E	≤ 60	> 80	> 85	≤ 66.7

Note: LOS F applies whenever the arrival flow exceeds the segment capacity.
Source: Austroads (2017)

The Highway Capacity Manual describes the conditions for the different levels of performance of two-lane highways in the following terms:

- At LOS A, motorists experience high operating speeds on Class I highways and little difficulty in passing. Platoons of three or more vehicles are rare. On Class II highways, speed would be controlled primarily by roadway conditions. A small amount of platooning would be expected. On Class III highways, drivers should be able to maintain operating speeds close or equal to the free-flow speed (FFS) of the facility.
- At LOS B, passing demand and passing capacity are balanced. On both Class I and Class II highways, the degree of platooning becomes noticeable. Some speed reductions are present on Class I highways. On Class III highways, it becomes difficult to maintain FFS operation, but the speed reduction is still relatively small.
- At LOS C, most vehicles are travelling in platoons. Speeds are noticeably curtailed on all three classes of highway.
- At LOS D, platooning increases significantly. Passing demand is high on both Class I and II facilities but passing capacity approaches zero. A high percentage of vehicles are now travelling in platoons, and PTSF is quite noticeable. On Class III highways, the fall-off from FFS is now significant.
- At LOS E, demand is approaching capacity. Passing on Class I and II highways is virtually impossible, and PTSF is more than 80%. Speeds are seriously curtailed. On Class III highways, speed is less than two-thirds the FFS. The lower limit of this LOS represents capacity.
- LOS F exists whenever arrival flow in one or both directions exceeds the capacity of the segment. Operating conditions are unstable, and heavy congestion exists on all classes of two-lane highway.

3 MODEL RESULTS

This Section provides the modelled results from TRARR for Kennedy Highway. The results are broken into:

- towards Kuranda – Section 3.1
- towards Smithfield – Section 3.2.

Appendix A provides visualisation of the sample outputs for the different volume scenarios.

3.1 TOWARDS KURANDA

Figure 3.1 shows the average ATS for vehicles heading towards Kuranda from Smithfield. The corresponding PTSF is shown in Figure 3.2.

Figure 3.1 Speed – Towards Kuranda comparison

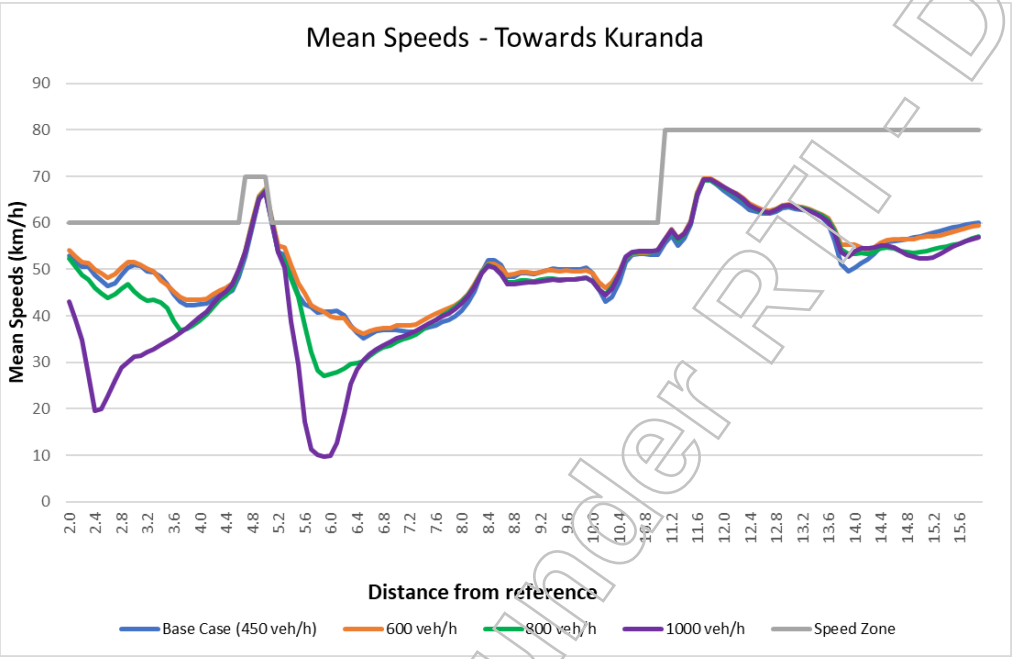
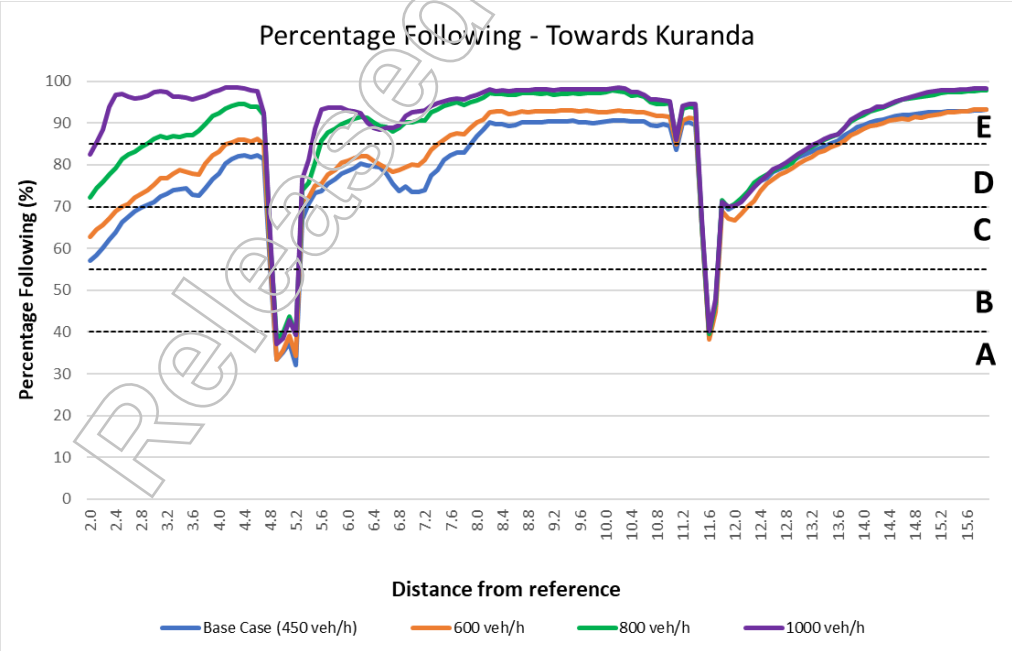


Figure 3.2 Percent time-spent-following (PTSF) – Towards Kuranda comparison



3.2 TOWARDS SMITHFIELD

Figure 3.3shows the average ATS for vehicles heading towards Smithfield from Kuranda. The corresponding PTSF is shown in Figure 3.4.

Figure 3.3 Speed – Towards Smithfield comparison

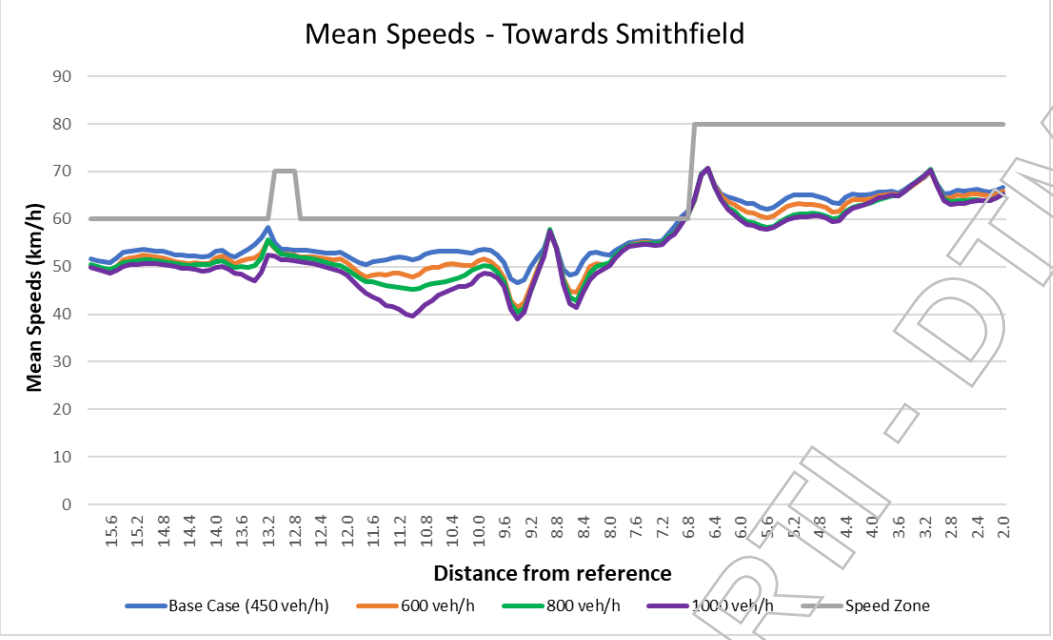


Figure 3.4 Percent time-spent-following (PTSF) – Towards Smithfield comparison

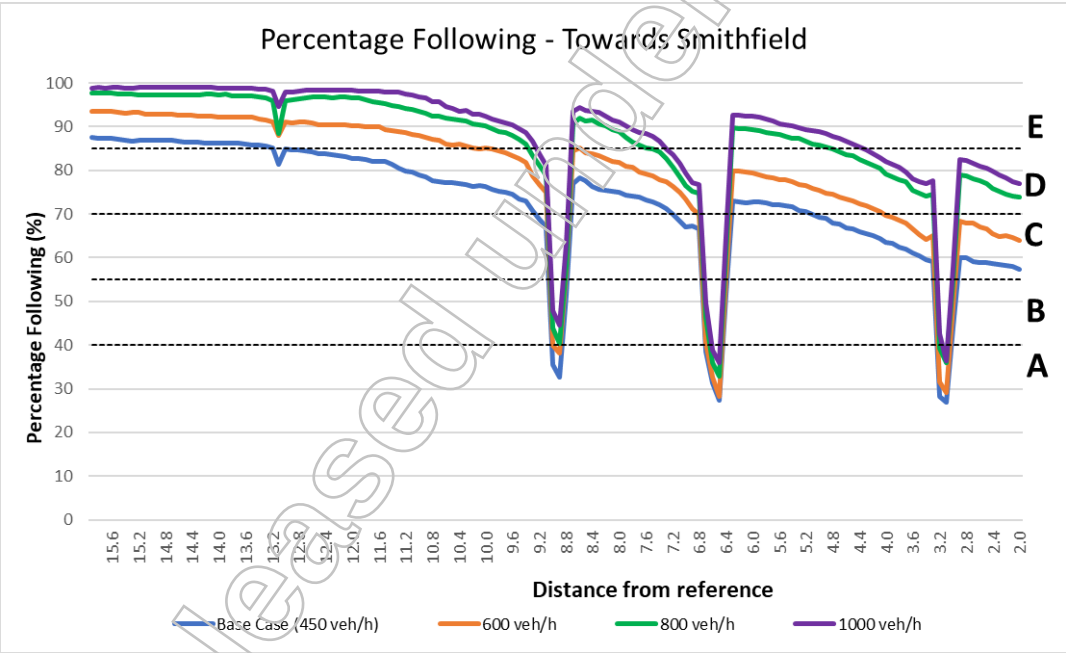


Table 3.1 Percent time-spent-following (PTSF) – vehicle volume

Volume (vehicles per hour)	Towards Kuranda				Towards Smithfield			
	ATS (km/h)	Ratio of average to speed limit[1]	PTSF[2] (%)	LOS	ATS (km/h)	Ratio of average to speed limit[1]	PTSF[2] (%)	LOS
Base Case (445)	50.9	0.772	75.8%	D	56.0	0.849	74.6%	D
600	49.4	0.749	82.9%	D	54.8	0.831	81.5%	D
800	44.8	0.680	88.5%	E	52.4	0.795	87.4%	E
1,000	35.8	0.543	91.6%	E	49.6	0.752	91.3%	E

1 The speed limit is calculated as the weighted average over the entire route. This is calculated to be 66 km/h.

2 PTSF is the aggregated average for 10 random seeds for the whole section.

4 CONCLUSION

TRARR was used to analyse the LOS of Kennedy Highway, between Smithfield and Kuranda, highlighting when and where overtaking lanes may be warranted. The analysis found:

- In the direction of Smithfield to Kuranda
  - The aggregated average LOS for the current demand is LOS D (75.8% PTSF).
  - The average travel speed is 50.9 km/h, against a weighted average free flow operating speed for the entire route of 66 km/h.
- In the direction on Kuranda to Smithfield
  - The aggregated average LOS for the current demand is LOS D (74.6% PTSF).
  - The average travel speed is 56.0 km/h, against a weighted average free flow operating speed for the entire route of 66 km/h.

Currently Kennedy highway is on average operating at LOS D in both directions. If no upgrades are undertaken, the average LOS will become LOS E by 2040 using the median growth rates. If the traffic growth rate is high, LOS E could occur by 2032. The approximate AADT per direction at which this occurs is at 7,000 vehicles, currently the approximate AADT per direction is 4,440.

5 REFERENCES

Austroads 2017, *Guide to traffic management part 3: traffic studies and analysis*, prepared by C Han, I Espada, G Geers & R Mohajerpoor, Austroads publication AGTM03-17, Austroads, Sydney, NSW.

Google 2018, 'Queensland', map data, Google, California, USA.

Transportation Research Board 2016, *Highway capacity manual: HCM 6th edition*, TRB, Washington, DC.

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Queensland Government 2018b, 'Annual Volume Report', QDTMR, Brisbane, QLD.

Appendix A TRARR ANIMATION

The TRARR animation is a new tool that has been developed by ARRB in conjunction with Roads and Maritime Service. Figure A 1 to Figure A 5 are screen captures of the simulations ranging from the 445 (base volume) to 1200 vehicles per hour.

Figure A 1 Base (445 vehicles/hour)

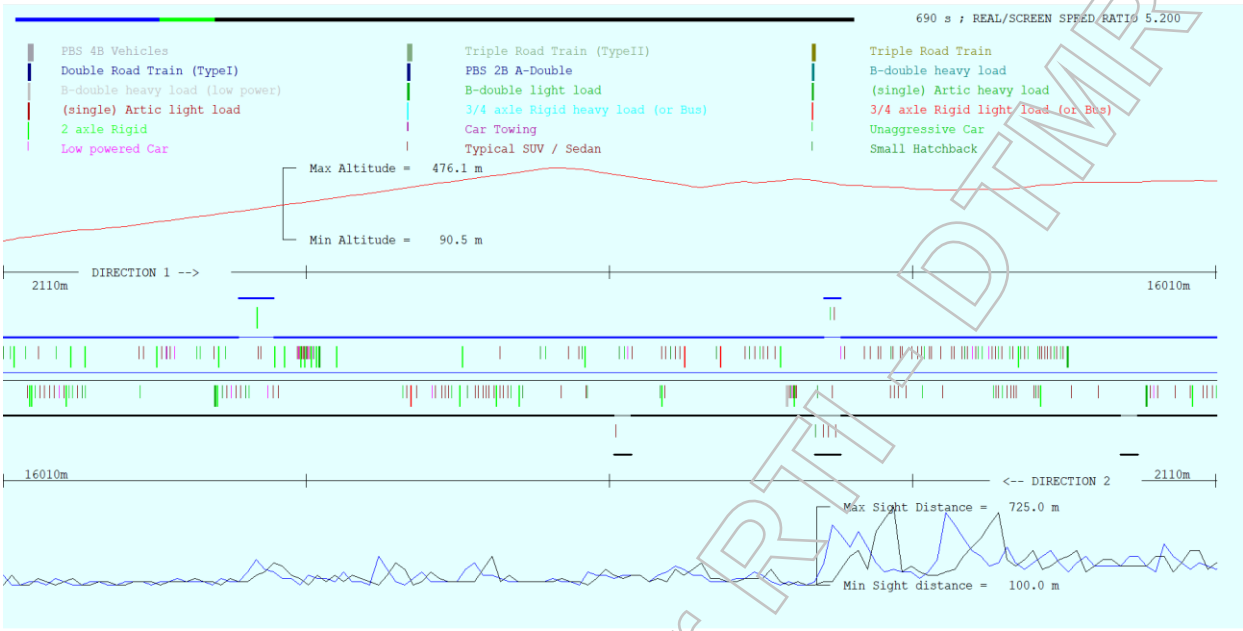


Figure A 2 600 vehicles/hour

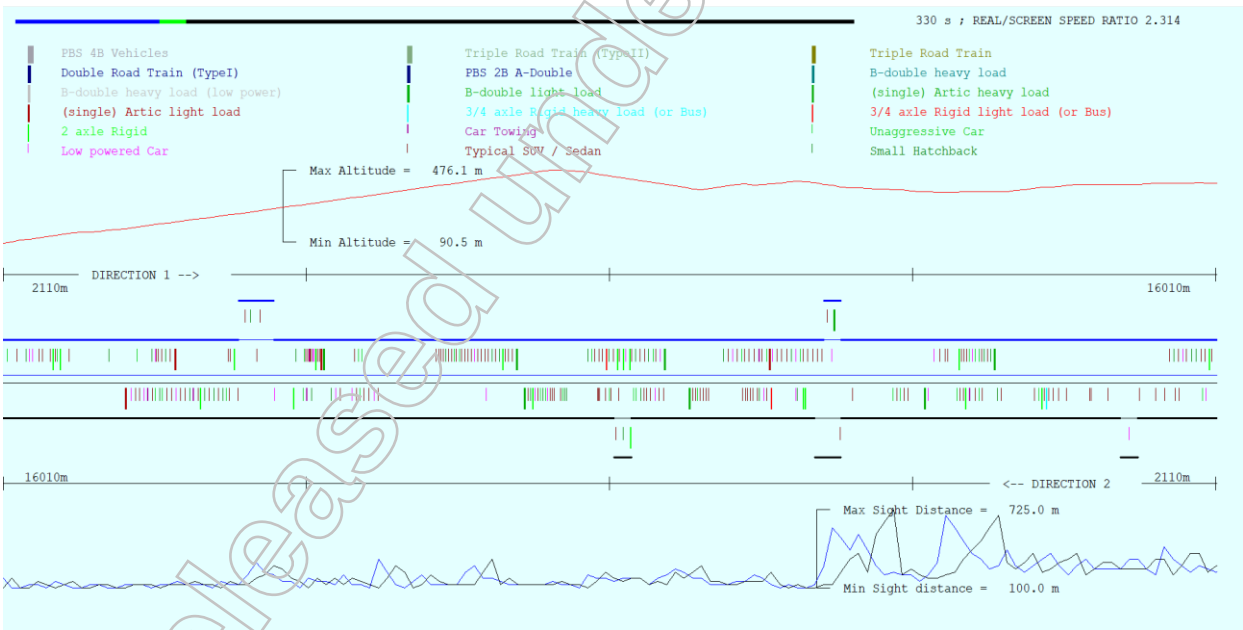


Figure A 3 800 vehicles/hour

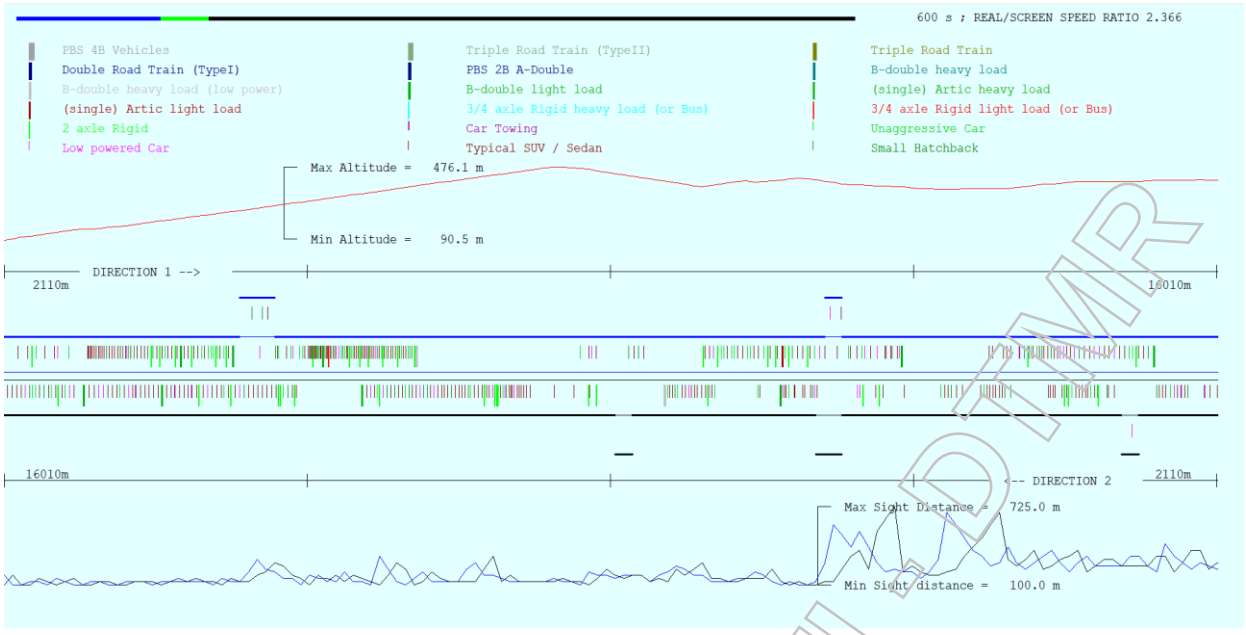


Figure A 4 1000 vehicles/hour

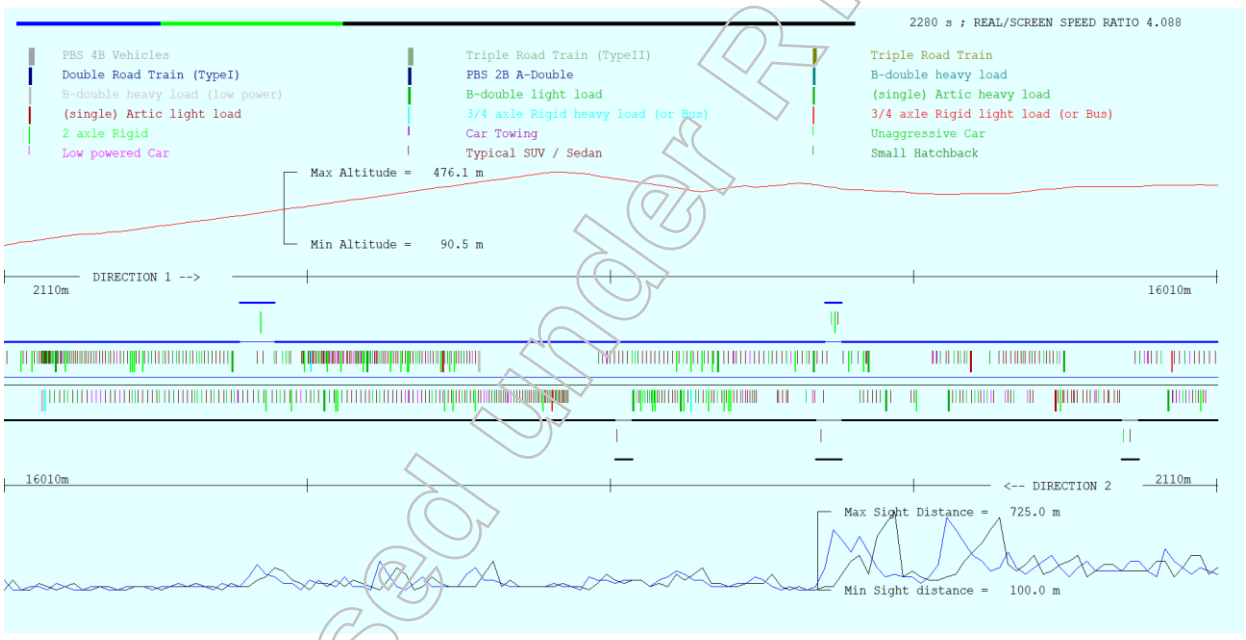
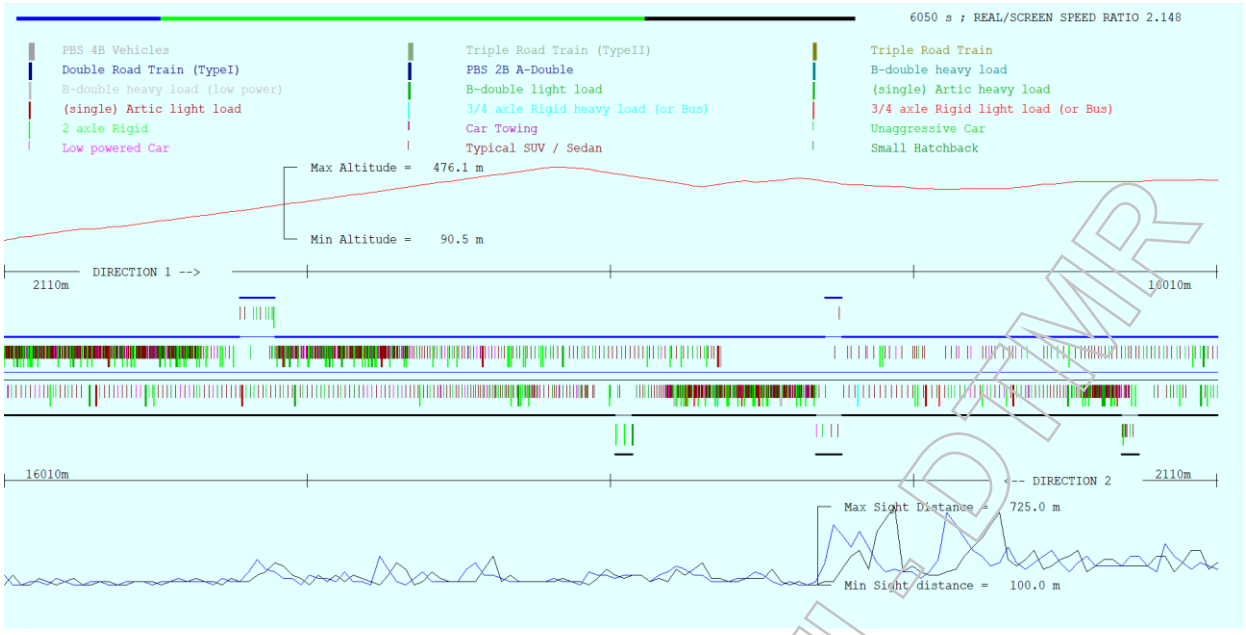


Figure A 5 1200 vehicles/hour



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