SH6/SH8B Intersection Upgrade – Traffic Modelling Assessment

Introduction

This short technical note sets out an operational assessment of the proposed SH6/SH8B intersection upgrade.

The Regional package of Waka Kotahi NZ Transport Agency New Zealand Upgrade Programme includes a determination to build a new roundabout at the SH6/SH8B intersection, to improve road safety and accommodate future traffic growth. This technical note investigates whether a single lane roundabout will adequately cope with growth demands into the medium to long term future.

Proposed Upgrade

It is proposed to upgrade the existing priority-controlled intersection to a roundabout, to improve efficiency and road safety. Based on WSP's local knowledge of Cromwell traffic it is anticipated that a single lane roundabout will cater for traffic demands now and well into the future, while minimising any potential complexities associated with a dual lane roundabout. The assumed single lane roundabout layout is shown in Figure 1.

Figure 1: Proposed improvement to SH6/SH8B intersection

Traffic Assessment

The assessment seeks to provide information on the likely life of a single lane roundabout, given that it is proposed to ensure that the roundabout footprint can be protected to provide a dual lane roundabout in the future. Therefore, an assessment of the operation of the existing intersection layout has not been undertaken.

Operational assessments have been undertaken in both SIDRA and VISSIM – the operation of a roundabout layout can result in a higher variation in results (compared to a signal- controlled intersection) due to site factors such as approach speed, circulatory speed, visibility and vehicle composition.

Base Year Traffic Volumes

The closest NZ Transport Agency telemetry site is located on State Highway 8B between the intersections with State Highway 6 and Sargood Road. The AADT of this site, for the 9-year period between 2010 and 2019, is shown as follows in Figure 2, together with the AADT measured at the next 3 nearest sites.

Site Ref	Description	Year										Growth per annum		
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2010-2015	2015-2019	2010-2019
ID:00600939	Lowburn	3220	3132	3134	3480	3480	3688	4398	4928	5541	6006	2.9%	15.7%	8.7%
ID:00600947	Cromwell	3160	3094	3130	3277	3277	3523	4435	4887	5342	5420	2.3%	13.5%	7.2%
ID:08B00000	Cromwell Deadmans Point Bridge	4659	4657	4621	4904	4904	5179	5975	6570	6919	7315	2.2%	10.3%	5.7%
ID:08B00002	Cromwell near SH6 junction	5194	5147	5020	5444	5444	5584	6729	7290	7779	8491	1.5%	13.0%	6.3%

Figure 2: AADT volumes (in vehicles)

The table shows:

- Growth from 2010 to 2015 was relatively low at around 1.5% per annum at the close-by SH8B site (likely associated with the Global Financial Crisis economic slowdown)
- From 2015 to 2019, growth was significant, with an average of 13% per annum – reflecting the growth in both tourism in Central Otago (and Queenstown Lakes), and the interlinked increase in population to serve the tourist market
- Overall, this generated a 9-year growth of over 6% per annum on this count site

Due to the impact of COVID-19, traffic counts at the intersection itself have not been possible, as they would not be fully representative of the "normal" traffic patterns. The most recent count was carried out in support of CODC Plan Change 13 by Carriageway Consulting Limited and is set out in the Transportation Assessment and subsequent Plan Change evidence presented in 2019. Although the turning count survey was not dated within the evidence it is assumed to have been undertaken in early 2019.

As a means to check the validity of this count (in terms of it being generally representative of traffic volumes in 2019), we have compared this turning count to:

- A 2016 count in support of the Wooing Tree development (CODC Plan Change 12) carried out by WSP (then Opus)
- The two-way link flows at the NZ Transport Agency telemetry site 08B00002 on SH8B (close to the SH6/SH8B intersection), for three weeks in November 2019 (Tue-Thurs inclusive only)

Table 1 shows the results of this comparison, with the following conclusions:

- The 2016 and 2019 counts appear to be the same. This suggests that PC13 presented unfactored 2016 counts, rather than new counts taken in 2019 for this intersection
- Growth is significant between the 2016 count and the TMS link count in 2019, at a total of 28% in the AM peak hour and 17% in the PM peak hour. This is still, however, less than the equivalent of 13% per annum growth shown on the TMS site in Figure 2 – although this figure does show that the greatest increase in traffic volumes was reported between 2015 and 2016

Consequently, we have factored up the original 2016 turning counts by the factors set out in Table 1, to establish a synthesised 2019 set of turning counts for the base year assessment.

Table 1: Counted Turning Movements at SH6/SH8B Intersection

Approach	Movement	AM Peak period (0800-0900)				PM Peak period (1700-1800)			
		PC12 (2016)	PC13 (2019)	TMS (2019)	Factored Count (2019)	PC12 (2016)	PC13 (2019)	TMS (2019)	Factored Count (2019)
SH6 West	Ahead	59	59	-	76	101	101	-	119
	Right	116	116	-	149	167	167	-	196
SH6 East	Left	159	159	-	204	185	185	-	217
	Ahead	93	93	-	119	55	55	-	65
SH8B	Left	116	116	-	149	168	168	-	197
	Right	108	108	-	139	187	187	-	219
SH8B 2-way Total		499	499	640	640	707	707	830	830
Factor (2016 to 2019)		-	-	1.28	-	-	-	1.17	-

Future Year Volumes

The assessment of the proposed intersection upgrade has been carried out at 2039 and 2049. Two growth scenarios have been used:

- "High growth" – we have used the 6.3% per annum linear growth from Figure 2 for the 2010-2019 period as a high growth scenario. Despite the 2015-2019 period showing higher growth than this level, this is thought to be unsustainable in the longer term, particularly when viewed from the current conditions of the COVID-19 pandemic, which is likely to result in suppressed growth (particularly from international tourism) over the next 3-5 years
- "Low growth" – we have used a 50% rate of the high growth scenario. This level of growth is still higher (around double) that of the 2010 to 2015 period, and so still represents a moderate level compared to historic forecasts

It should be noted that the current population projections from Stats NZ from 2018 to 2043, show an increase of less than 1% per annum for the Cromwell area unit – whilst this seems likely to be an underestimate given potential development activity in the area, it does show some context for the 3% per annum used above for the Low growth scenario.

An alternative method to establish likely traffic growth into the future is to consider the individual impact of proposed Plan Changes and other developments in the area (such as Wooing Tree, River Terrace and Shannon Farm). However, there is significant uncertainty over the time frames for delivery of these new residential developments, we have not used a method to determine the likely cumulative effect of development related trips on the SH6/SH8B intersection – instead preferring the consideration of global growth factors, as indicated above.

Table 2 sets out the resultant forecast turning volumes at 2039 and 2049 for the two growth scenarios. We have presented the volumes for the worst-case PM peak hour period only – and the modelling has also only been carried for this critical period.

Table 2: Forecast Turning Movements at SH6/SH8B Intersection

Approach	Movement	PM Peak period (1700-1800)			
		Year 2039		Year 2049	
		Low growth	High growth	Low growth	High growth
SH6 West	Ahead	194	269	231	344
	Right	320	445	383	569
SH6 East	Left	355	493	424	631
	Ahead	106	147	126	187
SH8B	Left	322	447	385	573
	Right	359	498	428	637
Total		1656	2299	1977	2942
Total growth (from 2019)		63%	127%	95%	190%

Assessment Results

Table 3 shows the results of both SIDRA and VISSIM assessments of the following traffic volume scenarios for the proposed single lane roundabout (SIDRA output is also included in Appendix A):

- 2019 base
- 2039 low growth
- 2039 high growth
- 2049 low growth
- 2049 high growth

A number of conclusions can be drawn from the results:

- The SIDRA and VISSIM results are generally well aligned, giving confidence that the forecast operational levels in each scenario are a good representation of the likely performance
- Both low growth scenarios (2039 and 2049) show satisfactory operation of the proposed roundabout, with all movements predicted to operate with LOS A (average delay less than 10 seconds per vehicle), with all maximum queue lengths predicted to be 100m or less. This shows that the roundabout can accommodate traffic volumes comfortably up to 100% higher than the base year 2019 levels
- At 2039 high growth, the roundabout operates satisfactory, although the two SH6 approaches are predicted to move into the LOS B performance level (10 to 20 seconds per vehicle), with the SIDRA results predicting LOS C for the right turn from SH6 West to SH8B. However, maximum queue lengths are still around 150m, on these approaches, and around half that level on the SH8B approach (due to comparatively low volumes passing this approach on the circulatory)
- At 2049 high growth, performance is poor, with overall LOS F+ predicted for the intersection as a whole in both models. Performance is particularly poor on the SH6 West approach – due to a combination of a high approach volume, and high conflicting volume on the circulatory

Table 3: Assessment Results (SIDRA and VISSIM)

VISSIM Results

From	To	PM 2019			PM 2039 Low			PM 2039 High			PM 2049 Low			PM 2049 High		
		Volume (v/h)	Delay (s)	Queue (m)	Volume (v/h)	Delay (s)	Queue (m)	Volume (v/h)	Delay (s)	Queue (m)	Volume (v/h)	Delay (s)	Queue (m)	Volume (v/h)	Delay (s)	Queue (m)
SH6 West	SH6 East	119	1.6	27	194	5.5	42	269	16.2	142	231	9.1	91	344	207.8	510
	SH8B	196	1.6		320	5.8		445	16.0		383	8.8		569	207.2	
SH6 East	SH8B	217	1.7	13	355	5.9	57	493	14.1	160	424	8.4	87	631	54.9	335
	SH6 West	65	1.5		106	6.1		147	15.6		126	8.9		187	56.1	
SH8B	SH6 West	197	1.1	7	322	4.1	41	447	9.0	44	385	5.5	33	573	64.1	491
	SH6 East	219	1.3		359	4.3		498	10.1		428	5.7		637	65.0	
Total		1013	1.5	-	1656	5.1	-	2299	13.0	-	1977	7.4	-	2941	106.3	-

SIDRA Results

From	To	PM 2019			PM 2039 Low			PM 2039 High			PM 2049 Low			PM 2049 High		
		RFC (%)	Delay (s)	Queue (m)	RFC (%)	Delay (s)	Queue (m)	RFC (%)	Delay (s)	Queue (m)	RFC (%)	Delay (s)	Queue (m)	RFC (%)	Delay (s)	Queue (m)
SH6 West	SH6 East	28%	3.4	13	53%	5.1	31	87%	19.0	131	68%	8.3	58	140%	357.0	1355
	SH8B		8.8			10.4			24.3			13.7			362.4	
SH6 East	SH8B	25%	3.5	11	46%	4.7	26	76%	11.1	80	60%	6.6	44	94%	24.2	189
	SH6 West		3.2			4.4			10.8			6.3			23.9	
SH8B	SH6 West	30%	2.8	15	52%	3.2	35	77%	4.1	77	64%	3.6	52	103%	43.6	470
	SH6 East		7.8			8.3			9.2			8.6			48.6	
Total		-	5.3	-	-	6.3	-	2.4	12.8	-	-	8.0	-	-	137.6	-

LOS (delay)

A	Delay less than 10 seconds per vehicle
B	Delay between 10 and 20 seconds per vehicle
C	Delay between 20 and 35 seconds per vehicle
D	Delay between 35 and 50 seconds per vehicle
E	Delay between 50 and 70 seconds per vehicle
F	Delay between 70 and 100 seconds per vehicle
F+	Delay greater than 100 seconds per vehicle

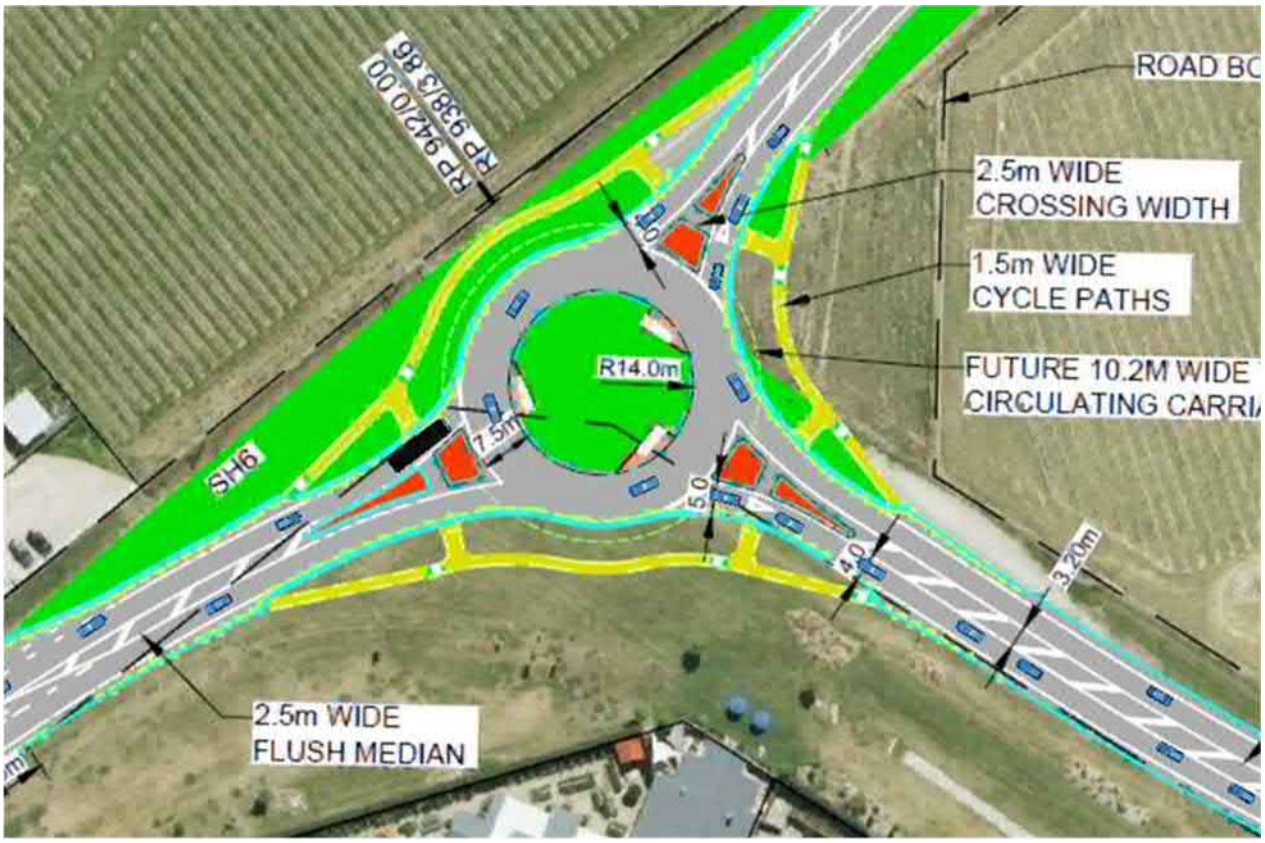

Figure 3: VISSIM screenshot of roundabout operation (2049 low growth)

In conclusion, this suggests that a total growth of around 150% on top of the base 2019 volumes can be accommodated, before the roundabout would need to be upgraded to include two-lane circulatory and approach lanes. Although this could be staged, and the SH6 West approach becomes critical first, all approaches carry significant volumes, and it is recommended that an improvement on all three arms would be required.

From this analysis, it would appear that a reasonable trigger of the second-stage improvement (to a dual-circulatory roundabout) would be once volumes are around 100% higher than the current (2019) volumes, to provide some float time for the initiation of the design and construction of the second stage. From the analysis, this is likely to be between 2035 (assuming high growth) and 2049 (assuming low growth).

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Appendix A – SIDRA Output

INTERSECTION SUMMARY

Site: 101 [2019 Base PM Volumes]

New Site
Site Category: (None)
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	47.5	km/h	47.5	km/h
Travel Distance (Total)	1154.3	veh-km/h	1385.1	pers-km/h
Travel Time (Total)	24.3	veh-h/h	29.2	pers-h/h
Demand Flows (Total)	1066	veh/h	1280	pers/h
Percent Heavy Vehicles (Demand)	5.0	%		
Degree of Saturation	0.304			
Practical Spare Capacity	179.5	%		
Effective Intersection Capacity	3506	veh/h		
Control Delay (Total)	1.57	veh-h/h	1.88	pers-h/h
Control Delay (Average)	5.3	sec	5.3	sec
Control Delay (Worst Lane)	6.7	sec		
Control Delay (Worst Movement)	8.8	sec	8.8	sec
Geometric Delay (Average)	4.4	sec		
Stop-Line Delay (Average)	0.9	sec		
Idling Time (Average)	0.0	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	2.1	veh		
95% Back of Queue - Distance (Worst Lane)	15.1	m		
Queue Storage Ratio (Worst Lane)	0.01			
Total Effective Stops	537	veh/h	645	pers/h
Effective Stop Rate	0.50		0.50	
Proportion Queued	0.37		0.37	
Performance Index	36.2		36.2	
Cost (Total)	594.37	$/h	594.37	$/h
Fuel Consumption (Total)	103.4	L/h		
Carbon Dioxide (Total)	246.4	kg/h		
Hydrocarbons (Total)	0.018	kg/h		
Carbon Monoxide (Total)	0.199	kg/h		
NOx (Total)	0.472	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 0.9 %
Number of Iterations: 4 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 88.1% 1.2% 0.7%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	511,832	veh/y	614,198	pers/y
Delay	752	veh-h/y	902	pers-h/y
Effective Stops	257,886	veh/y	309,463	pers/y
Travel Distance	554,048	veh-km/y	664,858	pers-km/y
Travel Time	11,661	veh-h/y	13,993	pers-h/y
Cost	285,297	$/y	285,297	$/y
Fuel Consumption	49,654	L/y		
Carbon Dioxide	118,255	kg/y		
Hydrocarbons	8	kg/y		
Carbon Monoxide	96	kg/y		
NOx	227	kg/y		

MOVEMENT SUMMARY

Site: 101 [2019 Base PM Volumes]

New Site
Site Category: (None)
Roundabout

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH8B												
4	L2	207	5.0	0.304	2.8	LOS A	2.1	15.1	0.26	0.49	0.26	46.6
6	R2	231	5.0	0.304	7.8	LOS A	2.1	15.1	0.26	0.49	0.26	48.3
Approach		438	5.0	0.304	5.4	LOS A	2.1	15.1	0.26	0.49	0.26	47.5
NorthEast: SH6 North												
7	L2	228	5.0	0.249	3.5	LOS A	1.5	11.3	0.44	0.45	0.44	47.5
8	T1	68	5.0	0.249	3.2	LOS A	1.5	11.3	0.44	0.45	0.44	48.7
Approach		297	5.0	0.249	3.5	LOS A	1.5	11.3	0.44	0.45	0.44	47.8
SouthWest: SH6 South												
2	T1	125	5.0	0.282	3.4	LOS A	1.7	12.5	0.46	0.57	0.46	46.9
3	R2	206	5.0	0.282	8.8	LOS A	1.7	12.5	0.46	0.57	0.46	47.5
Approach		332	5.0	0.282	6.7	LOS A	1.7	12.5	0.46	0.57	0.46	47.3
All Vehicles		1066	5.0	0.304	5.3	LOS A	2.1	15.1	0.37	0.50	0.37	47.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [2039 PM Volumes 3.2%pa]

New Site
Site Category: (None)
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	46.9	km/h	46.9	km/h
Travel Distance (Total)	1887.0	veh-km/h	2264.4	pers-km/h
Travel Time (Total)	40.3	veh-h/h	48.3	pers-h/h
Demand Flows (Total)	1743	veh/h	2092	pers/h
Percent Heavy Vehicles (Demand)	5.0	%		
Degree of Saturation	0.525			
Practical Spare Capacity	62.0	%		
Effective Intersection Capacity	3323	veh/h		
Control Delay (Total)	3.06	veh-h/h	3.68	pers-h/h
Control Delay (Average)	6.3	sec	6.3	sec
Control Delay (Worst Lane)	8.4	sec		
Control Delay (Worst Movement)	10.4	sec	10.4	sec
Geometric Delay (Average)	4.4	sec		
Stop-Line Delay (Average)	1.9	sec		
Idling Time (Average)	0.1	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	4.8	veh		
95% Back of Queue - Distance (Worst Lane)	35.2	m		
Queue Storage Ratio (Worst Lane)	0.03			
Total Effective Stops	1069	veh/h	1282	pers/h
Effective Stop Rate	0.61		0.61	
Proportion Queued	0.60		0.60	
Performance Index	67.1		67.1	
Cost (Total)	1017.76	$/h	1017.76	$/h
Fuel Consumption (Total)	175.1	L/h		
Carbon Dioxide (Total)	417.0	kg/h		
Hydrocarbons (Total)	0.031	kg/h		
Carbon Monoxide (Total)	0.339	kg/h		
NOx (Total)	0.805	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 1.8 %
Number of Iterations: 5 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 2.8% 1.7% 0.9%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	836,716	veh/y	1,004,059	pers/y
Delay	1,470	veh-h/y	1,764	pers-h/y
Effective Stops	512,940	veh/y	615,528	pers/y
Travel Distance	905,754	veh-km/y	1,086,905	pers-km/y
Travel Time	19,325	veh-h/y	23,190	pers-h/y
Cost	488,526	$/y	488,526	$/y
Fuel Consumption	84,063	L/y		
Carbon Dioxide	200,154	kg/y		
Hydrocarbons	15	kg/y		
Carbon Monoxide	163	kg/y		
NOx	386	kg/y		

MOVEMENT SUMMARY

Site: 101 [2039 PM Volumes 3.2%pa]

New Site
Site Category: (None)
Roundabout

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH8B												
4	L2	339	5.0	0.522	3.2	LOS A	4.8	35.2	0.46	0.53	0.46	46.2
6	R2	378	5.0	0.522	8.3	LOS A	4.8	35.2	0.46	0.53	0.46	47.8
Approach		717	5.0	0.522	5.9	LOS A	4.8	35.2	0.46	0.53	0.46	47.0
NorthEast: SH6 North												
7	L2	374	5.0	0.464	4.7	LOS A	3.6	26.3	0.69	0.62	0.69	46.8
8	T1	112	5.0	0.464	4.4	LOS A	3.6	26.3	0.69	0.62	0.69	48.0
Approach		485	5.0	0.464	4.6	LOS A	3.6	26.3	0.69	0.62	0.69	47.1
SouthWest: SH6 South												
2	T1	204	5.0	0.525	5.1	LOS A	4.2	30.9	0.72	0.72	0.74	46.1
3	R2	337	5.0	0.525	10.4	LOS B	4.2	30.9	0.72	0.72	0.74	46.7
Approach		541	5.0	0.525	8.4	LOS A	4.2	30.9	0.72	0.72	0.74	46.5
All Vehicles		1743	5.0	0.525	6.3	LOS A	4.8	35.2	0.60	0.61	0.61	46.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [2039 PM Volumes 6.3%pa]

New Site
Site Category: (None)
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	43.6	km/h	43.6	km/h
Travel Distance (Total)	2619.7	veh-km/h	3143.7	pers-km/h
Travel Time (Total)	60.1	veh-h/h	72.1	pers-h/h
Demand Flows (Total)	2420	veh/h	2904	pers/h
Percent Heavy Vehicles (Demand)	5.0	%		
Degree of Saturation	0.878			
Practical Spare Capacity	-3.2	%		
Effective Intersection Capacity	2755	veh/h		
Control Delay (Total)	8.59	veh-h/h	10.31	pers-h/h
Control Delay (Average)	12.8	sec	12.8	sec
Control Delay (Worst Lane)	22.3	sec		
Control Delay (Worst Movement)	24.3	sec	24.3	sec
Geometric Delay (Average)	4.4	sec		
Stop-Line Delay (Average)	8.4	sec		
Idling Time (Average)	2.5	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	18.0	veh		
95% Back of Queue - Distance (Worst Lane)	131.4	m		
Queue Storage Ratio (Worst Lane)	0.11			
Total Effective Stops	2357	veh/h	2829	pers/h
Effective Stop Rate	0.97		0.97	
Proportion Queued	0.92		0.92	
Performance Index	137.7		137.7	
Cost (Total)	1597.41	$/h	1597.41	$/h
Fuel Consumption (Total)	261.5	L/h		
Carbon Dioxide (Total)	622.2	kg/h		
Hydrocarbons (Total)	0.048	kg/h		
Carbon Monoxide (Total)	0.512	kg/h		
NOx (Total)	1.215	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 2.7 %
Number of Iterations: 7 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 2.2% 1.1% 0.6%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	1,161,600	veh/y	1,393,920	pers/y
Delay	4,125	veh-h/y	4,950	pers-h/y
Effective Stops	1,131,447	veh/y	1,357,737	pers/y
Travel Distance	1,257,461	veh-km/y	1,508,953	pers-km/y
Travel Time	28,829	veh-h/y	34,595	pers-h/y
Cost	766,757	$/y	766,757	$/y
Fuel Consumption	125,504	L/y		
Carbon Dioxide	298,675	kg/y		
Hydrocarbons	23	kg/y		
Carbon Monoxide	246	kg/y		
NOx	583	kg/y		

MOVEMENT SUMMARY

Site: 101 [2039 PM Volumes 6.3%pa]

New Site
Site Category: (None)
Roundabout

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH8B												
4	L2	471	5.0	0.767	4.1	LOS A	10.6	77.4	0.81	0.61	0.81	45.4
6	R2	524	5.0	0.767	9.2	LOS A	10.6	77.4	0.81	0.61	0.81	47.0
Approach		995	5.0	0.767	6.8	LOS A	10.6	77.4	0.81	0.61	0.81	46.2
NorthEast: SH6 North												
7	L2	519	5.0	0.764	11.1	LOS B	10.9	79.9	1.00	1.08	1.35	44.0
8	T1	155	5.0	0.764	10.8	LOS B	10.9	79.9	1.00	1.08	1.35	44.9
Approach		674	5.0	0.764	11.0	LOS B	10.9	79.9	1.00	1.08	1.35	44.2
SouthWest: SH6 South												
2	T1	283	5.0	0.878	19.0	LOS B	18.0	131.4	1.00	1.36	1.83	39.7
3	R2	468	5.0	0.878	24.3	LOS C	18.0	131.4	1.00	1.36	1.83	40.4
Approach		752	5.0	0.878	22.3	LOS C	18.0	131.4	1.00	1.36	1.83	40.1
All Vehicles		2420	5.0	0.878	12.8	LOS B	18.0	131.4	0.92	0.97	1.28	43.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [2049 PM Volumes 3.2%pa]

New Site
Site Category: (None)
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	46.1	km/h	46.1	km/h
Travel Distance (Total)	2252.8	veh-km/h	2703.4	pers-km/h
Travel Time (Total)	48.9	veh-h/h	58.6	pers-h/h
Demand Flows (Total)	2081	veh/h	2497	pers/h
Percent Heavy Vehicles (Demand)	5.0	%		
Degree of Saturation	0.680			
Practical Spare Capacity	25.0	%		
Effective Intersection Capacity	3061	veh/h		
Control Delay (Total)	4.63	veh-h/h	5.55	pers-h/h
Control Delay (Average)	8.0	sec	8.0	sec
Control Delay (Worst Lane)	11.7	sec		
Control Delay (Worst Movement)	13.7	sec	13.7	sec
Geometric Delay (Average)	4.4	sec		
Stop-Line Delay (Average)	3.6	sec		
Idling Time (Average)	0.3	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	7.9	veh		
95% Back of Queue - Distance (Worst Lane)	57.9	m		
Queue Storage Ratio (Worst Lane)	0.05			
Total Effective Stops	1563	veh/h	1876	pers/h
Effective Stop Rate	0.75		0.75	
Proportion Queued	0.76		0.76	
Performance Index	92.4		92.4	
Cost (Total)	1263.59	$/h	1263.59	$/h
Fuel Consumption (Total)	214.8	L/h		
Carbon Dioxide (Total)	511.4	kg/h		
Hydrocarbons (Total)	0.038	kg/h		
Carbon Monoxide (Total)	0.418	kg/h		
NOx (Total)	0.993	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 2.3 %
Number of Iterations: 6 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 2.7% 1.5% 0.8%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	998,905	veh/y	1,198,686	pers/y
Delay	2,220	veh-h/y	2,664	pers-h/y
Effective Stops	750,299	veh/y	900,359	pers/y
Travel Distance	1,081,351	veh-km/y	1,297,621	pers-km/y
Travel Time	23,452	veh-h/y	28,142	pers-h/y
Cost	606,521	$/y	606,521	$/y
Fuel Consumption	103,111	L/y		
Carbon Dioxide	245,458	kg/y		
Hydrocarbons	18	kg/y		
Carbon Monoxide	201	kg/y		
NOx	476	kg/y		

MOVEMENT SUMMARY

Site: 101 [2049 PM Volumes 3.2%pa]

New Site
Site Category: (None)
Roundabout

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH8B												
4	L2	405	5.0	0.640	3.6	LOS A	7.1	51.9	0.61	0.56	0.61	45.9
6	R2	451	5.0	0.640	8.6	LOS A	7.1	51.9	0.61	0.56	0.61	47.5
Approach		856	5.0	0.640	6.2	LOS A	7.1	51.9	0.61	0.56	0.61	46.7
NorthEast: SH6 North												
7	L2	446	5.0	0.602	6.6	LOS A	6.1	44.4	0.84	0.81	0.93	46.2
8	T1	133	5.0	0.602	6.3	LOS A	6.1	44.4	0.84	0.81	0.93	47.3
Approach		579	5.0	0.602	6.5	LOS A	6.1	44.4	0.84	0.81	0.93	46.5
SouthWest: SH6 South												
2	T1	243	5.0	0.680	8.3	LOS A	7.9	57.9	0.89	0.95	1.10	44.7
3	R2	403	5.0	0.680	13.7	LOS B	7.9	57.9	0.89	0.95	1.10	45.3
Approach		646	5.0	0.680	11.7	LOS B	7.9	57.9	0.89	0.95	1.10	45.1
All Vehicles		2081	5.0	0.680	8.0	LOS A	7.9	57.9	0.76	0.75	0.85	46.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [2049 PM Volumes 6.3%pa]

New Site
Site Category: (None)
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	18.2	km/h	18.2	km/h
Travel Distance (Total)	3351.3	veh-km/h	4021.5	pers-km/h
Travel Time (Total)	184.1	veh-h/h	221.0	pers-h/h
Demand Flows (Total)	3096	veh/h	3715	pers/h
Percent Heavy Vehicles (Demand)	5.0	%		
Degree of Saturation	1.379			
Practical Spare Capacity	-38.4	%		
Effective Intersection Capacity	2245	veh/h		
Control Delay (Total)	118.34	veh-h/h	142.01	pers-h/h
Control Delay (Average)	137.6	sec	137.6	sec
Control Delay (Worst Lane)	360.4	sec		
Control Delay (Worst Movement)	362.4	sec	362.4	sec
Geometric Delay (Average)	4.4	sec		
Stop-Line Delay (Average)	133.2	sec		
Idling Time (Average)	98.4	sec		
Intersection Level of Service (LOS)	LOS F			
95% Back of Queue - Vehicles (Worst Lane)	185.6	veh		
95% Back of Queue - Distance (Worst Lane)	1354.5	m		
Queue Storage Ratio (Worst Lane)	1.09			
Total Effective Stops	10186	veh/h	12224	pers/h
Effective Stop Rate	3.29		3.29	
Proportion Queued	1.00		1.00	
Performance Index	686.0		686.0	
Cost (Total)	5144.47	$/h	5144.47	$/h
Fuel Consumption (Total)	522.8	L/h		
Carbon Dioxide (Total)	1241.2	kg/h		
Hydrocarbons (Total)	0.127	kg/h		
Carbon Monoxide (Total)	1.065	kg/h		
NOx (Total)	2.283	kg/h		

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Site Model Variability Index (Iterations 3 to N): 3.9 %
Number of Iterations: 8 (Maximum: 10)
Largest change in Lane Degrees of Saturation for the last three Flow-Capacity Iterations: 1.8% 1.2% 0.7%

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	1,485,979	veh/y	1,783,175	pers/y
Delay	56,805	veh-h/y	68,166	pers-h/y
Effective Stops	4,889,494	veh/y	5,867,393	pers/y
Travel Distance	1,608,616	veh-km/y	1,930,339	pers-km/y
Travel Time	88,382	veh-h/y	106,059	pers-h/y
Cost	2,469,346	$/y	2,469,346	$/y
Fuel Consumption	250,949	L/y		
Carbon Dioxide	595,793	kg/y		
Hydrocarbons	61	kg/y		
Carbon Monoxide	511	kg/y		
NOx	1,096	kg/y		

MOVEMENT SUMMARY

Site: 101 [2049 PM Volumes 6.3%pa]

New Site
Site Category: (None)
Roundabout

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH8B												
4	L2	603	5.0	1.025	43.6	LOS D	64.4	470.2	1.00	1.63	2.47	31.6
6	R2	671	5.0	1.025	48.6	LOS D	64.4	470.2	1.00	1.63	2.47	32.3
Approach		1274	5.0	1.025	46.2	LOS D	64.4	470.2	1.00	1.63	2.47	32.0
NorthEast: SH6 North												
7	L2	664	5.0	0.938	24.2	LOS C	25.9	189.4	1.00	1.49	2.11	38.3
8	T1	197	5.0	0.938	23.9	LOS C	25.9	189.4	1.00	1.49	2.11	38.7
Approach		861	5.0	0.938	24.2	LOS C	25.9	189.4	1.00	1.49	2.11	38.3
SouthWest: SH6 South												
2	T1	362	5.0	1.379	357.0	LOS F	185.6	1354.5	1.00	7.11	13.64	8.7
3	R2	599	5.0	1.379	362.4	LOS F	185.6	1354.5	1.00	7.11	13.64	9.1
Approach		961	5.0	1.379	360.4	LOS F	185.6	1354.5	1.00	7.11	13.64	9.0
All Vehicles		3096	5.0	1.379	137.6	LOS F	185.6	1354.5	1.00	3.29	5.84	18.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

SH6/SH8B Intersection Upgrade – Traffic Modelling Assessment - Addendum

Introduction

This Addendum sets out the results of a revised assessment of the operational performance of the proposed SH6/SH8B intersection upgrade.

Since the original Technical Note was provided, the proposed layout was updated to include a 20m centre island radius, instead of the original 14m radius. This note provides a brief update to the results due to this change.

Proposed Upgrade

An indicative single lane roundabout with 20m central island layout is shown in Figure 1. This layout still allows a future upgrade to include two-lane circulatory and approach lanes when required in the longer term. It should be noted, however, that the design is still undergoing an update to allow for a potential fourth leg to be located to the North West between the SH6 approaches. As this provision is being included purely to prevent preclusion of a future fourth leg, it has not been factored into the modelling.

Similarly the approach geometry on the existing legs will be adjusted slightly from the layout below but this is not expected to have any significant impact on the modelling results.

Figure 1: Proposed improvement to SH6/SH8B intersection – 20m radius island

Traffic Assessment

An operational assessment has been undertaken in SIDRA of the revised layout, and compared with the results of the original 14m radius version, for two scenarios: The VISSIM model has not been updated at this time, but it is expected that the change in operation performance would be

similar in scale to the SIDRA analysis (given that results were similar across all scenarios in the original assessments).

Future Year Volumes

The revised assessment of the proposed intersection upgrade has been carried out at 2039 for both low and high growth scenarios, as the per the original analysis.

Assessment Results

Table 1 shows the results of the SIDRA assessments of the following traffic volume scenarios for the proposed single lane roundabout:

- 2039 low growth – 14m radius centre island
- 2039 low growth – 20m radius centre island
- 2039 high growth – 14m radius centre island
- 2039 high growth – 20m radius centre island

The results show there is a marginal improvement in operation of the roundabout, as would be expected. The predicted improvement in capacity is around 5-10% (as a comparison of the RFC values) – this is equivalent to around 2-3 years of low growth, and 1-2 years of high growth. Queue lengths and delay results also show a marginal improvement in both growth scenarios.

This demonstrates that the trigger points for upgrade to a two-lane circulatory would be slightly extended due to the increase in island diameter.

Table 1: Assessment Results (SIDRA) comparing the 14m and 20m radius island layouts options

SIDRA Results													
From	To	PM 2039 Low						PM 2039 High					
		14m Radius Centre Island			20m Radius Centre Island			14m Radius Centre Island			20m Radius Centre Island		
		RFC (%)	Delay (s)	Queue (m)	RFC (%)	Delay (s)	Queue (m)	RFC (%)	Delay (s)	Queue (m)	RFC (%)	Delay (s)	Queue (m)
SH6 West	SH6 East	53%	5.1	31	49%	3.5	27	87%	19.0	131	80%	11.5	94
	SH8B		10.4			9.9			24.3			17.9	
SH6 East	SH8B	46%	4.7	26	43%	3.9	24	76%	11.1	80	70%	8.2	66
	SH6 West		4.4			3.1			10.8			7.4	
SH8B	SH6 West	52%	3.2	35	50%	2.5	32	77%	4.1	77	72%	3.3	68
	SH6 East		8.3			8.2			9.2			8.9	
Total		-	6.3	-	-	5.6	-	-	12.8	-	-	9.6	-

LOS (delay)

A	Delay less than 10 seconds per vehicle
B	Delay between 10 and 20 seconds per vehicle
C	Delay between 20 and 35 seconds per vehicle
D	Delay between 35 and 50 seconds per vehicle
E	Delay between 50 and 70 seconds per vehicle
F	Delay between 70 and 100 seconds per vehicle
F+	Delay greater than 100 seconds per vehicle

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This Technical Note **("Report")** has been prepared by WSP exclusively for Waka Kotahi NZ Transport Agency **("Client")** in relation to an assessment of the operation of the proposed roundabout at the SH6/SH8B intersection **("Purpose")** and in accordance with the Contract 2646 SH6/SH8B Cromwell Intersection, Standard Form Agreement with the Client dated June 2020. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.