APPENDIX F - Roundabout Traffic Modelling

SNP – SH2/Ngaumutawa Road Intersection

Technical Assessment of Roundabout Options

Date:	16 December 2020	**By:**	s 9(2)(a) [redacted]
Our Ref:	3234711	**Checked:**	s 9(2)(a) [redacted]

1 Background

Waka Kotahi and the Safe Network Programme are investigating the implementation of a roundabout to replace the existing T intersection at:

- SH2/Ngaumutawa Road

The intersection is shown in the aerial in Figure 1.1.

Figure 1.1 SH2/Ngaumutawa Road Intersection

These investigations initially considered the placement of Median Barrier along the corridor from Masterton to Carterton, beginning southwest of the SH2/Ngaumutawa Road Intersection, which would have increased the u-turn movements at the SH2 west approach. It is noted that the design has since progressed to remove the section of median barrier between the SH2 Ngaumutawa Road Intersection and the SH2/Norfolk Road/Cornwall Road intersection. Thus, no allowances have been made for the impact of median barrier on the performance of this intersection.

This Technical Note updates the modelling work previously undertaken as part of the single stage detailed business case in June 2019 by the Safe Roads Alliance.

The preferred option from the business case included an option for a large-scale roundabout at the intersection of SH2/Ngaumutawa Road, with the modelling assumptions as they concern forecast traffic growth outlined below:

- The AADT of 13,216 is based on 2018 data from the counter in Clareville and annual growth is 3.5% based on seven years as this shows a consistent trend.

2 Traffic Volumes and Growth

2.1 Existing Traffic Volumes

The set of peak hour traffic volumes used for the previous modelling have been used and were derived from video surveys of the SH2/Ngaumutawa intersection undertaken on:

- Thursday, 25th October 2018; and
- Saturday 27th October 2018.

No allowances have been made for any changes to the turning arrangement at Buchanan Place or for the placement of median barrier between Ngaumutawa Road and Norfolk Road which would result in additional u-turn movements at the roundabout.

2.1.1 Traffic Growth

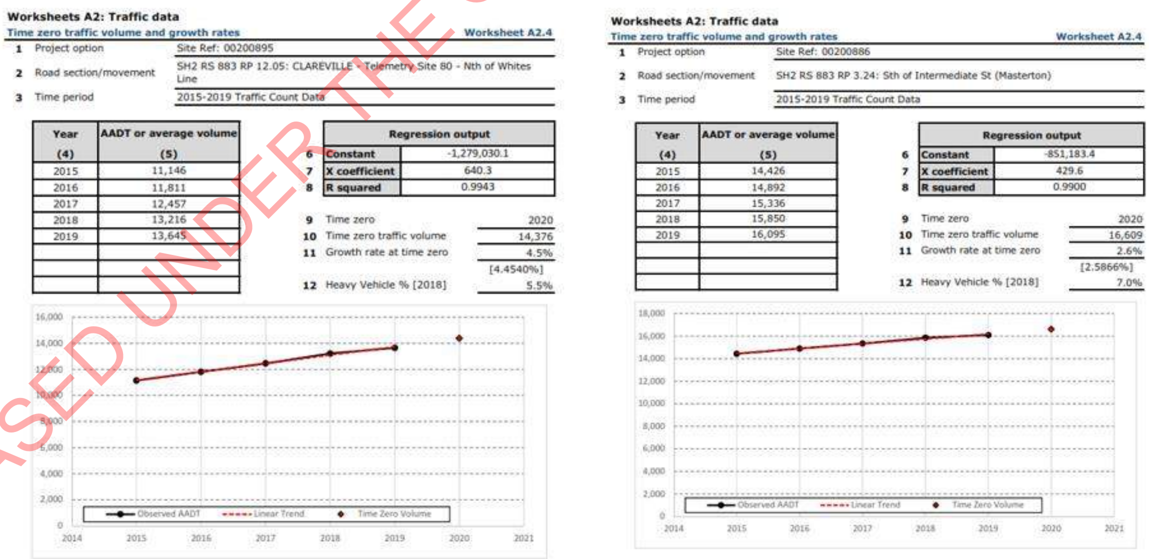
The main source of future year traffic growth is based on:

- Observed historical AADT volumes on SH2;
- Consideration to the level of growth applied in the modelling completed as part of the Single Stage Business Case

a. Historical AADT Growth

The current seven-year AADT volumes and growth is shown in **Figure 2.1**, covering the period 2013 to 2019. This shows an annual two-way traffic growth of 4.5% at the Clareville end of the State Highway and 2.6% at the Masterton end of the State Highway. For reference the intersection is located at the following RS/RPs:

- Ngaumutawa: 002-0083-B/5.418



Worksheets A2: Traffic data
Time zero traffic volume and growth rates — Worksheet A2.4

1 Project option: Site Ref: 00200895
2 Road section/movement: SH2 RS 883 RP 12.05: CLAREVILLE - Telemetry Site 80 - Nth of Whites Line
3 Time period: 2015-2019 Traffic Count Data

Year (4)	AADT or average volume (5)
2015	11,146
2016	11,811
2017	12,457
2018	13,216
2019	13,645

	Regression output	
6	Constant	-1,279,030.1
7	X coefficient	640.3
8	R squared	0.9943

9 Time zero: 2020
10 Time zero traffic volume: 14,376
11 Growth rate at time zero: 4.5% [4.4540%]
12 Heavy Vehicle % [2018]: 5.5%

Worksheets A2: Traffic data
Time zero traffic volume and growth rates — Worksheet A2.4

1 Project option: Site Ref: 00200886
2 Road section/movement: SH2 RS 883 RP 3.24: Sth of Intermediate St (Masterton)
3 Time period: 2015-2019 Traffic Count Data

Year (4)	AADT or average volume (5)
2015	14,426
2016	14,892
2017	15,336
2018	15,850
2019	16,095

	Regression output	
6	Constant	-851,183.4
7	X coefficient	429.6
8	R squared	0.9900

9 Time zero: 2020
10 Time zero traffic volume: 16,609
11 Growth rate at time zero: 2.6% [2.5866%]
12 Heavy Vehicle % [2018]: 7.0%

Figure 2.1 Historic AADT growth south and north of SH2/Ngaumutawa and SH2/Norfolk intersections.

b. Consideration to the level of growth applied in the modelling completed as part of the Single Stage Business Case analysis

The following methodology and assumptions were made as part of the single stage business case:

- Each of the two intersections were modelled in SIDRA for the existing scenario and proposed options. The traffic counts were taken for the AM, IP (Saturday) and PM periods and the gap selection/headway calibrated from on-site video for each time period at each intersection. The queue length in the model has been compared at a high level to the queues on site based on the video footage available.
  - ***The calibration undertaken as part of this work has been maintained in the updated models***
- The AADT of 13,216 was based on 2018 data from the counter in Clareville and annual growth is 3.5% based on seven years as this shows a consistent trend.
  - ***The growth rate of 3.5% has been maintained within this updated model informed by the historic AADT growth.***

3 Assessing Intersection Operation

The operation of the proposed roundabout options has been assessed using the SIDRA transport modelling package.

The critical performance measures used in this assessment are:

- Practical Spare Capacity: measure of the increase possible in the modelled traffic volumes before the roundabout reaches the practical degree of saturation (specified by SIDRA as 0.85 for roundabouts).
- Degree of Saturation: measure of how much of the available capacity of the roundabout is being used with the modelled traffic volumes. Whilst a value of 1.0 indicates that the roundabout is "at capacity", it will not operate efficiently and is likely to experience significant delays and queues. A degree of saturation of 0.90 is commonly used as the maximum value at which a roundabout will operate efficiently and consistently.
- Maximum 95th Percentile Queue: maximum 95th percentile queue in any lane at roundabout. The 95th percentile queue length is the distance to the back of the longest queue that will form 95% of the time. It is likely that during an hour's operation of the roundabout, a queue length equal to the 95th percentile queue will form at least once.
- Level of Service (LOS): An index of the operational performance of traffic on a given roadway, traffic lane or approach which is based on amongst other things the the delay, degree of saturation and density during a given flow period. LOS A represents the best operating conditions from the traveller's perspective and LOS F the worst.

It is noted that the draft business case included an investment KPI to improve the Level of Service at key intersections. Specifically, to improve the performance of the SH2/Ngaumutawa and SH2/Norfolk intersections from a LOS F (baseline in 2018) to a LOS C for 2028. This has been factored into the assessment of the intersection operation.

4 Approach to Assessment

The approach taken for this assessment has been to test differing one lane and two-lane roundabout options developed by the design team and undertake analysis on the lane lengths to advise on a likely acceptable lane length for a 10 year design life.

The observed traffic volumes have been used. Uniform traffic growth of 3.5% is then applied to produce future expected traffic volumes for the current year (2020), which is 2 years on from the base year (2018) volumes and a future 10 year horizon (2030), which is 12 years on from the base year. An in-between year has also been modelled to represent the time at which a practical DoS is met (considered to be 0.9) and beyond which the roundabout is expected to stop operating efficiently and consistently.

The lane lengths can be adjusted as the design develops to fit in with site constraints and design standards without having much effect on the roundabout performance.

Default SIDRA values for roundabout parameters have been retained except for the main ones affecting roundabout performance: central island diameter, circulating lane width and number of circulating lanes. Ongoing design work will refine other aspects of the roundabout, such as the alignment of the approach legs. These changes will have very little impact on the operation of the roundabout. The peak flow factor input for all scenarios has been calculated from the on-site surveys.

5 Current and Future Year Operation

5.1 Existing Intersection Operation

The existing operation of the intersection was modelled as part of the business case. This model has been updated and tested to provide an indication of the expected performance of the intersection at present (2020).

The traffic counts were taken for the AM and PM periods and the gap selection/headway calibrated from on-site video for each time period. The queue length in the model has been compared on site at a high level to the queues on site based on the video.

The modelling indicates the following existing level of service at the intersection as outlined in **Table 5.1**.

Table 5.1 Existing Intersection Operation

Time Period	Traffic Volume Source	Max DoS[1]	Delay [sec]		Max 95th Percentile Queue [m]	Intersection LOS
			Average[2]	Worst[3]		
AM	2020	1.391	18	237 (N)	155 (N)	LOS F on worst approach
	2030	8.647	235	3499 (N)	645 (N)	LOS F on worst approach
PM	2020	2.807	82	849 (N)	450 (N)	LOS F on worst approach
	2030	22.529	925	9744 (N)	1165 (N)	LOS F on worst approach

The existing modelling results indicate that the Ngaumutawa Road approach is currently over capacity, with significant queues and delays for right turners from the minor road. Both State Highway approaches are operating under free flow conditions. The future scenario will further exacerbate the capacity issues on the Ngaumutawa approach leading to excessive queues and delays for right turners from the minor approach.

[1] Maximum degree of saturation.

[2] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[3] Average delay per vehicle for worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Ngaumutawa is annotated as "N").

5.2 Single Lane at Ngaumutawa

A single lane option at Ngaumutawa Road as shown in **Figure 5.1** was modelled. The roundabout form is as below:

- Circulating width: 5.75m
- Island Diameter: 16.00m

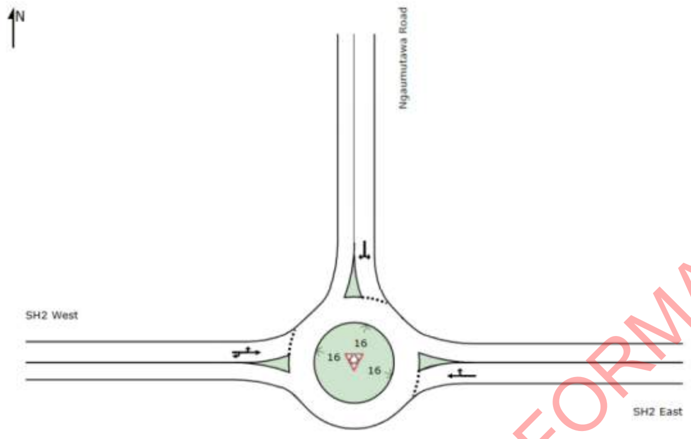


Figure 5.1 Single Lane Arrangement

The outcomes for the single lane at Ngaumutawa Road are shown in **Table 5.2**.

Table 5.2: Operation of a single lane roundabout at Ngaumutawa

Time Period	Traffic Volume Source	Max DoS[4]	Delay [sec]		Max 95th Percentile Queue [m]	Intersection LOS
			Average[5]	Worst[6]		
AM	2020	0.908	7	18 (N)	142 (SH2 W)	LOS A (LOS B on worst approach – Ngaumutawa Rd)
	2021	0.942	8	20 (N)	190 (SH2 W)	LOS A (LOS B on worst approach -Ngaumutawa Rd)
	2030	1.260	75	125 (SH2 W)	1065 (SH2 W)	LOS F (LOS F on worst approach – SH2 W)
PM	2020	0.904	9	19 (N)	142 (SH2 E)	LOS A (LOS B on worst approach – Ngaumutawa Rd)
	2021	0.943	11	22 (N)	179 (SH2 E)	LOS B (LOS C on worst approach – Ngaumutawa Road)
	2030	1.346	85	195 (N)	705 (SH2 E) *Similar on SH2 W	LOS F (LOS F on worst approaches - Ngaumutawa Road and SH2 E)

From the SIDRA results it can be seen that the PM peak hour is most critical to the operation of the intersection when operating as a single lane roundabout.

- The single lane roundabout will operate above practical capacity (above DoS of 0.85) based on existing traffic flows with significant queues expected to be occurring on all approaches, which includes more than 100m queues on both State Highway approaches and just under 50m queues on the Ngaumutawa Road approach
- When compared to the existing intersection operation delays and queues on Ngaumutawa Road would be significantly reduced, however queues on the State Highway will occur where there are none under the existing arrangement.
- The single lane roundabout is not expected to operate efficiently and consistently from opening. An option with more capacity for the State highway approaches is required.

[4] Maximum degree of saturation.

[5] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[6] Average delay per vehicle for the worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Ngaumutawa is annotated as "N").

5.3 Dual Lane at Ngaumutawa

A dual lane option at Ngaumutawa Road as shown in **Figure 5.2** was modelled. The roundabout form is as below:

- Circulating width: 5.75m
- Island Diameter: 16.00m

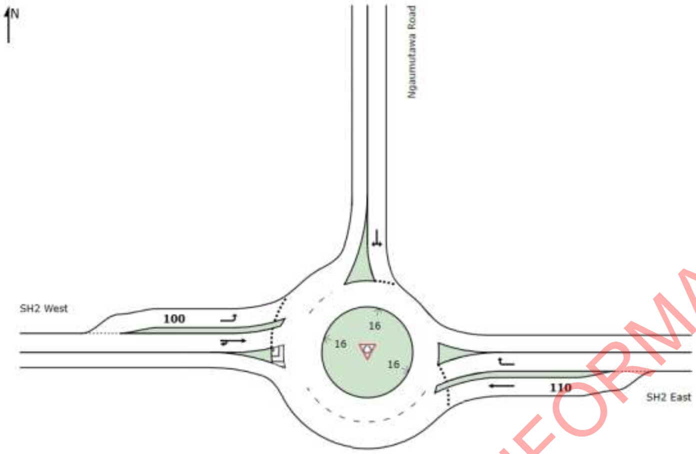


Figure 5.2 Dual Lane Roundabout Option

The outcomes for the Double lane at Ngaumutawa Road are shown in **Table 5.3**.

Table 5.3: Operation of a dual lane roundabout at Ngaumutawa

Time Period	Traffic Volume Source	Max DoS[7]	Delay [sec]		Max 95th Percentile Queue [m]	Intersection LOS
			Average[8]	Worst[9]		
AM	2020	0.589	5	16(N)	35 (SH2 W)	LOS A (LOS B on worst approach – Ngaumutawa Rd)
	2029	0.879	10	54 (N)	106 (N)	LOS A (LOS E on worst approach -Ngaumutawa Rd)
	2030	0.971	13	76 (N)	145(N)	LOS B (LOS F on worst approach – Ngaumutawa Rd)
PM	2020	0.715	6	17 (N)	60 (SH2 E)	LOS A (LOS B on worst approach – Ngaumutawa Rd)
	2026	0.899	11	37 (N)	140 (SH2 E)	LOS B (LOS D on worst approach – Ngaumutawa Road)
	2030	1.143	26	124 (N)	280 (N)	LOS C (LOS F on worst approach - Ngaumutawa Road)

From the SIDRA results it can be seen that the PM peak hour is most critical to the operation of the intersection when operating as a dual lane roundabout.

- The two lane roundabout will be operating below practical capacity (below DoS of 0.85) based on existing traffic flow, with some spare capacity i.e. allowing for some additional traffic to use the roundabout before significant delays are expected.
- Based on the time at which a DoS of more than 0.90 is reached, the roundabout is expected to stop operating efficiently and consistently at some point beyond 2026. Beyond which, additional capacity will need to be provided to the Ngaumutawa approach to prevent further delays, and delay will start forming on the SH2 (E) leg
- Providing a two lane approach (including a short left turn lane) at Ngaumutawa Road would improve the performance of this approach and reduce the delay and queues for movements from Ngaumutawa Road, yet would also result in increasing delay and queues for the SH2 (E) as compared to having a single lane approach on Ngaumutawa Road.
- The modelling indicates that the operation of the roundabout in 2026, would include queues of close to 150m on the SH2 (E) approach and significant delays and queues on Ngaumutawa Road. Notwithstanding, queues and delays on Ngaumuatwa Road are significantly less than the present situation and any future situation under the present arrangement.

[7] Maximum degree of saturation.

[8] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[9] Average delay per vehicle for the worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Ngaumutawa is annotated as "N").

- The LOS of the intersection in 10 years' tir business case albeit with queues and delays on the State Highway, where there presently aren't any.

6 Summary of Paper

Based on the analysis completed above:

- The existing modelling results indicate that the Ngaumutawa Road approach is currently ove capacity, with significant queues and delays for right turners from the minor road.
- Construction of a roundabout at the intersection will significantly improve the level of service for vehicles on Ngaumutawa Road.
- Based on the modelling, a one lane roundabout is not expected to operate efficiently and consistently upon opening.
- Providing additional approach lanes for the roundabout, is expected to result in the roundabout stopping to operate efficiently and consistently at some point beyond 2026, with queues and delay forming on the SH2 (E) and Ngaumutawa Road approaches. Additional capacity will need to be provided to the Ngaumutawa Road approach to prevent further delays on this leg, with the performance SH2 (E) leg (already reaching capacity) to be more compromised by the addition of an another approach lane on Ngaumutawa Road.
- Based on the above, to strike a balance between improving the Ngaumutawa Road approach and not compromising the State Highway too much, a one lane approach on Ngaumutawa Road is considered satisfactory.
- Notwithstanding a single lane approach at Ngaumutawa Road still operated better than the existing intersection arrangement.

It is understood there is some constraint at the intersection location that may limit the ability to provide a two-lane approach on Ngaumutawa Road and or a second departure lane for State Highway traffic.

SNP – SH2/Norfolk Road Intersection

Technical Assessment of Roundabout Options

Date:	16 December 2020	**By:**	s 9(2)(a) [redacted]
Our Ref:	3234711	**Checked:**	s 9(2)(a) [redacted]

1 Background

Waka Kotahi and the Safe Network Programme are investigating the implementation of a roundabout to replace the existing priority cross-roads intersection at:

- SH2/Norfolk Road/Cornwall Road

The intersection is shown in the aerial in Figure 1.1.

Figure 1.1 SH2/Norfolk Road/Cornwall Road Intersection

These investigations also consider the closure of the Norman Avenue/SH2 intersection, which sits approximately 620m southwest of the SH2/Norfolk Road/Cornwall Road intersection. Additionally, the placement of Median Barrier along the corridor from Masterton to Carterton has been considered. The median barrier will sit on the southwest side of the intersection, which will add additional u-turn movements to the SH2 SW approach.

This Technical Note updates the modelling work previously undertaken as part of the single stage detailed business case in June 2019 by the Safe Roads Alliance.

The preferred option from the business case included an option for a large-scale roundabout at the intersection of SH2/Norfolk Road/Cornwall Road Intersection, with the modelling assumptions as they concern forecasted traffic growth outlined below:

- The AADT of 13,216 is based on 2018 data from the counter in Clareville and annual growth is 3.5% based on seven years as this shows a consistent trend.

2 Traffic Volumes and Growth

2.1 Traffic Volumes

The set of peak hour traffic volumes used for the previous modelling have been used and were derived from video surveys of the SH2/Ngaumutawa and SH2/Norfolk/Cornwall Road intersections undertaken on:

- Thursday, 25th October 2018; and
- Saturday 27th October 2018.

2.1.1 Rerouting of traffic and additional turn around movements

Some rerouting of the existing volumes has been undertaken to account for the closure of Norman Avenue. This includes the following:

- All movements on Norman Avenue being rerouted to the Norfolk Road intersection. A scenario with right turn movements from East Taratahi Road being re-directed to Cornwall Road was also tested. However, it is understood that there will be a turnaround facility on SH2 at this point, so these movements have not been re-directed in the likely scenario which is presented here.

Some additional U-turn movements have also been added to the following leg to account for the placement of the median barrier:

- Norfolk Roundabout
  - SH2(SW)

This is assumed to be approximately 3% of the through movements on the opposing legs, with movements split 50% between heavy and light vehicles. Some modification has taken place to account for the lack of commercial uses to the southwest of the roundabout This results in the following estimated movements as shown in Table 2.1.

Table 2.1 Additional U-turn Peak Movements

	Light Vehicles	Heavy Vehicles
SH2 (SW) Leg – Peak period movements	8-12 vehicles	2 vehicles

The peak u-turn movement assumptions have been validated through considering the number of residential and commercial uses to the southwest of the roundabout and their likely peak hour movements. A summary of these validated assumptions is provided in Appendix A.

2.1.2 Traffic Growth

The main source of future year traffic growth is based on:

- Observed historical AADT volumes on SH2;
- Consideration to the level of growth applied in the modelling completed as part of the Single Stage Detailed Business Case

a. Historical AADT Growth

The current seven-year AADT volumes and growth is shown in **Figure 2.1**, covering the period 2013 to 2019. This shows an annual two-way traffic growth of 4.5% at the Clareville end of the State Highway and 2.6% at the Masterton end of the State Highway. For reference the intersection is located at the following RS/RPs:

- Norfolk: 002-0083-B/6.701

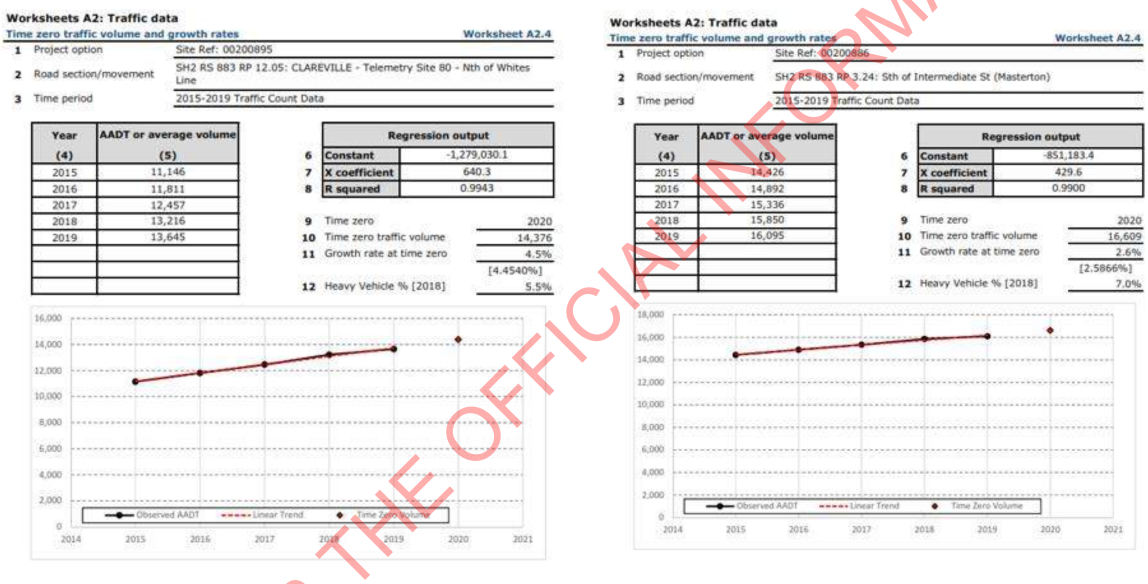


Figure 2.1 Historic AADT growth south and north of SH2/Ngaumutawa and SH2/Norfolk intersections.

b. Consideration to the level of growth applied in the modelling completed as part of the Single Stage Business Case analysis

The following methodology and assumptions were made as part of the single stage business case:

- The intersection was modelled in SIDRA for the existing scenario and proposed options. The traffic counts were taken for the AM and PM periods and the gap selection/headway calibrated from on-site video for each time period at each intersection. The queue length in the model has been compared at a high level to the queues on site based on the video footage available.
  - ***The calibration undertaken as part of this work has been maintained in the updated models***
- The AADT of 13,216 was based on 2018 data from the counter in Clareville and annual growth is 3.5% based on seven years as this shows a consistent trend. A value of 20,000 has been used between Norfolk Road and Ngaumutawa Road based on traffic counts on the Waingawa Bridge.
  - ***The growth rate of 3.5% has been maintained within this updated model informed by the historic AADT growth.***

3 Assessing Intersection Operation

The operation of the proposed roundabout options has been assessed using the SIDRA transport modelling package.

The critical performance measures used in this assessment are:

- Practical Spare Capacity: measure of the increase possible in the modelled traffic volumes before the roundabout reaches the practical degree of saturation (specified by SIDRA as 0.85 for roundabouts).
- Degree of Saturation: measure of how much of the available capacity of the roundabout is being used with the modelled traffic volumes. Whilst a value of 1.0 indicates that the roundabout is "at capacity", it will not operate efficiently and is likely to experience significant delays and queues. A degree of saturation of 0.90 is commonly used as the maximum value at which a roundabout will operate efficiently and consistently.
- Maximum 95th Percentile Queue: maximum 95th percentile queue in any lane at roundabout. The 95th percentile queue length is the distance to the back of the longest queue that will form 95% of the time. It is likely that during an hour's operation of the roundabout, a queue length equal to the 95th percentile queue will form at least once.
- Level of Service (LOS): An index of the operational performance of traffic on a given roadway, traffic lane or approach which is based on amongst other things the delay, degree of saturation and density during a given flow period. LOS A represents the best operating conditions from the traveller's perspective and LOS F the worst.

It is noted that the draft business case included an investment KPI to improve the Level of Service at key intersections. Specifically, to improve the performance of the SH2/Ngaumutawa and SH2/Norfolk intersections from a LOS F (baseline in 2018) to a LOS C for 2028. This has been factored into the assessment of the intersection operation.

4 Approach to Assessment

The approach taken for this assessment has been to test differing one lane and two-lane roundabout options developed by the design team and undertake analysis on the lane lengths to advise on a likely acceptable lane length for a 10 year design life.

The observed traffic volumes have been used with the additional U-turn traffic above applied. Uniform traffic growth of 3.5% is then applied to produce future expected traffic volumes for the current year (2020), which is 2 years on from the base year (2018) volumes and a future 10 year horizon (2030), which is 12 years on from the base year. An in-between year has also been modelled to represent the time at which a practical DoS is met (considered to be 0.9) and beyond which the roundabout is expected to stop operating efficiently and consistently.

The lane lengths can be adjusted as the design develops to fit in with site constraints and design standards without having much effect on the roundabout performance.

Default SIDRA values for roundabout parameters have been retained except for the main ones affecting roundabout performance: central island diameter, circulating lane width and number of circulating lanes. The peak flow factor input for all scenarios has been calculated from the on-site surveys.

Ongoing design work will refine other aspects of the roundabout, such as the alignment of the approach legs. These changes will have very little impact on the operation of the roundabout.

5 Current and Future Year Operation

5.1 Existing Intersection Operation

The existing arrangement at Norfolk Road has been modelled as a stop control as shown in **Figure 5.1** was modelled. The intersection form is below:

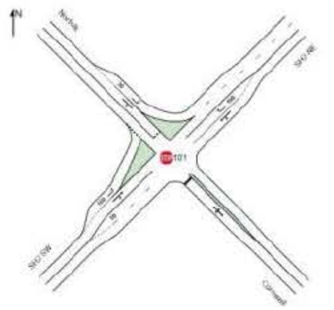


Figure 5.1: Existing Intersection Form

The existing operation of the intersection was modelled as part of the business case. This model has been updated (to include redistribution of traffic from/to Norman Avenue) and tested to provide an indication of the expected performance of the intersection at present (2020). The modelling indicates the following existing level of service at the intersection as outlined in **Table 5.1**.

Table 5.1 Anticipated Existing Intersection Performance

Time Period	Traffic Volume Source	Max DoS[1]	Delay [sec]		Max 95th Percentile Queue [m]	Intersection LOS
			Average[2]	Worst[3]		
AM	2020	2.674	28	1561 (C)	116 (C)	LOS F on worst approach
	2030	7.799	335	3290 (N)	1625 SH2 NE)	LOS F on worst approach
PM	2020	2.613	30	874 (N)	142 (N)	LOS F on worst approach
	2030	11.307	193	4905 (N)	674 (SH2 NE)	LOS F on all approaches

The existing modelling indicates that the intersection is over capacity, with significant queues and delays for through and right turners from the minor road. Which are worse than those modelled in the business case model, owing to the redistributed movements and the growth applied. In the future, significant queues are expected on the SH2 (NE) approach due to the demand for right turns into Norfolk Road.

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1 Maximum degree of saturation.

2 Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

3 Average delay per vehicle for worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Norfolk is annotated as "N" and Cornwall as "C").

5.2 Single Lane at Norfolk

A single lane option at Norfolk Road (which would allow for future proofing into two lanes) as shown in **Figure 5.2** was modelled. The roundabout form is below:

- Circulating width: 7.2m
- Island Diameter: 18m

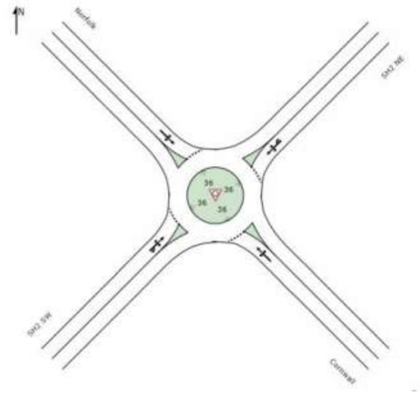


Figure 5.2 Single Lane Roundabout

The outcomes for the Single Lane at Norfolk are shown in Error! Reference source not found.**Table 5.2**.

Table 5.2: Operation of a single lane roundabout at Norfolk

Time Period	Traffic Volume Source	Max DoS[4]	Delay [sec] Average[5]	Worst[6]	Max 95th Percentile Queue [m]	Intersection LOS
AM	2020	0.799	6	23(N)	74 (SH2 SW)	LOS A (LOS B on worst approach – *minor approaches*)
	2024	0.920	13	62 (N)	155 (SH2 SW)	LOS B (LOS E on worst approach – *Norfolk Road*)
	2030	1.175	49	161 (N)	555 (SH2 SW)	LOS D (LOS F on worst approach – *Norfolk Road*)
PM	2020	0.759	6	20 (C)	73 (SH2 NE)	LOS A (LOS B on worst approach – *minor approaches*)
	2026	0.919	10	38 (N)	170 (SH2 NE)	LOS B (LOS C on worst approach – *minor approaches*)
	2030	1.090	31	113 (N)	570 (SH2 NE)	LOS C (LOS F on worst approach)

From the SIDRA results it can be seen that the AM peak hour is most critical to the operation of the intersection when operating as a single lane roundabout.

- A single lane roundabout will operate just below practical capacity (DoS of 0.85) based on existing traffic flows. With a small amount of additional traffic flow the single lane roundabout option will reach capacity, at which point users will experience excessive delays.
- Compared to the existing intersection with a single lane roundabout will significantly improve performance on both the Norfolk Road and Cornwall Road approaches, though will result in queues and delays on the SH approaches, where there currently aren't any.
- By 2024 significant delays (more than 60 seconds) will start to occur on the Norfolk Road approach, with queues of more than 150m forming on the SH2 (SW) approach in the AM period and more than 100m queues forming on both SH approaches in the PM period.
- By the year 2030, the single lane roundabout will be operating at a LOS D, with long queues and delays on the SH (SW) and Norfolk Road approach.

[4] Maximum degree of saturation.

[5] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[6] Average delay per vehicle for the worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Norfolk is annotated as "N" and Cornwall as "C").

5.3 Dual Lane at Norfolk – Future Proofed Option

A two-lane option at Norfolk Road as shown in Table 5.3 was modelled. The roundabout form is below:

- Circulating width: 5m-9.5m
- Island Diameter: 18m

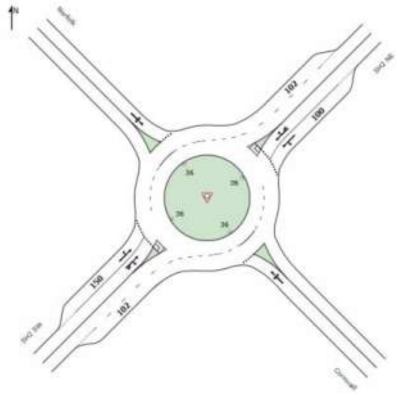


Figure 5.3 Two Lane Roundabout Option

The outcomes for the two-lane at Norfolk are shown in **Table 5.3**.

Table 5.3: Operation of a Dual Lane roundabout at Norfolk

Time Period	Traffic Volume Source	Max DoS[7]	Delay [sec] Average[8]	Delay [sec] Worst[9]	Max 95th Percentile Queue [m]	Intersection LOS
AM	2020	0.445	5	14 (N)	20 (SH2 SW)	LOS A (LOS B on worst approach - *Cornwall) Road*
	2030	0.615	5	18 (N)	35 (SH2 SW)	LOS A (LOS B on worst approach – *minor approaches*)
	2039	0.920	9	46 (N)	88 (N)	LOS A (LOS D on worst approach – *Norfolk Road*)
PM	2020	0.433	5	13 (SH2 SW)	22 (SH2 NE)	LOS A (LOS B on worst approach – *Cornwall Road*)
	2030	0.587	5	16 (N)	38 (SH2 NE)	LOS A (LOS B on worst approach – Cornwall Road)
	2040	0.890	8	32 (N)	74 (N)	LOS A (LOS C on worst approach – *Norfolk Road*)

From the SIDRA results it can be seen that the AM peak hour is most critical to the operation of the intersection when operating as a dual lane roundabout.

- A double lane roundabout will operate below practical capacity (DoS of 0.85) based on existing traffic flows.
- Based on forecasted 2030 traffic flows the roundabout will operate with a LOS A, with minor queues forming on the State Highway approaches and on Norfolk Road. These queues are minor and can only be expected to occur once or twice during the peak period
- In the long term, the queues are expected to begin to form on the Norfolk Road Approach resulting in queues of close to 100m and close to 50 second delays for vehicles on this approach, overall at this point the roundabout will still be operating at a reasonable level of service on the State Highway approaches.

[7] Maximum degree of saturation.

[8] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[9] Average delay per vehicle for the worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Norfolk is annotated as "N" and Cornwall as "C").

6 Summary of Paper

Based on the analysis completed above:

- The existing modelling results indicate that the intersection is currently operating over capacity, with significant queues and delays for right turners and through movements on the minor roads.
- Construction of a roundabout at the intersection will significantly improve the level of service for vehicles on the minor roads
- Based on the modelling, a one lane roundabout is expected operate efficiently and consistently up to approximately 2024. At which point queues are expected to start to form on the state highway approaches at peak times. Additional capacity will need to be provided on the state highway approaches to prevent significant queues and delays on the State Highway at peak times.
- Providing additional approach lanes for the roundabout's State Highway approaches will reduce queues and delays on the State Highway. With a two-lane arrangement, the intersection can be expected to operate below capacity on all legs up until approximately 2039, at which point the queues can be expected to form on the Norfolk Road approach.
- The traffic modelling supports the construction of a double lane roundabout with two lane entry and exit lanes for the State highway approaches.

A

Turn Around Movement Assumptions

Commercial Operator	Turning Information	Assessment
SH3 (SW) Leg		
Light Vehicles and Heavy Vehicles (Residential uses)		
Six residential uses, with no large-scale commercial uses	*Assume 1 vehicle movement per crossing during the peak*	▪ There are approximately 6 residential uses which in a worst case is expected to result in 6 additional movements at the roundabout in the peak hour. ▪ This also allows for some light vehicle traffic from the commercial uses. Thus, the assumption of 10-12 light vehicles for this leg can be considered conservative, but reasonable. ▪ Assume approximately 2 HV associated with farm use at this approach during the peak hour.
Total		▪ Based on the above – 6 LV movements associated with the residential uses – 2 HV turn around movements are expected in the peak ▪ And some light vehicle movements associated with the commercial uses. ▪ Noting the assumed number of 10-12 light vehicles movements these are considered reasonable

SNP – SH2/Wiltons Road/East Taratahi Road Intersection

Technical Assessment of a Roundabout Option

Date:	15 December 2020	**By:**	s 9(2)(a) [redacted]
Our Ref:	3234711	**Reviewed:**	s 9(2)(a) [redacted]

1 Background

Waka Kotahi and the Safe Network Programme are investigating the implementation of a roundabout to replace the existing staggered T intersections at:

- SH2/Wiltons Road/East Taratahi Road

The intersections are shown in the aerial in **Figure 1.1.**

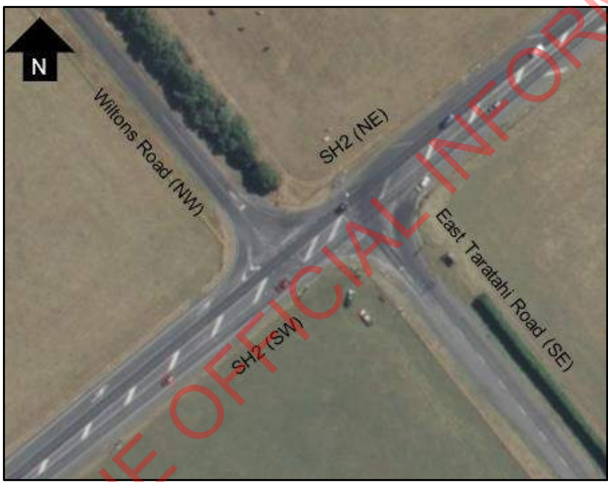


Figure 1.1 SH2/Wiltons Road/East Taratahi Road Intersection

These investigations also consider the placement of Median Barrier along the corridor from Masterton to Carterton, beginning approximately 475m southwest of the SH2/Ngaumutawa Road Intersection and ending just north of Chester Road in Carterton, which will increase the U-turn movements on the SH2 approaches.

The roundabout is being proposed primarily to facilitate the turnaround movements that will result from the placement of the Median Barrier, as well as improve the safety, and not to improve intersection performance. It is worth noting that the installation of a roundabout at this location may impact traffic and use of the existing bus stop on the north side of SH2 to the NE. The roundabout may also impact the ease of movement for any cyclists using the corridor.

This Technical Note draws on the modelling work previously undertaken as part of the single stage detailed business case in June 2019 by the Safe Roads Alliance . It is noted that this intersection was not modelled as part of that piece of work, however the growth used in that modelling has informed the modelling undertaken in this Technical Note.

2 Traffic Volumes and Growth

2.1 Traffic Volumes

The set of peak hour traffic volumes used for the previous modelling have been used and were derived from video surveys of the SH2/Wiltons Road/East Taratahi intersections undertaken on:

- Thursday, 25th October 2018; and
- Saturday 27th October 2018.

2.1.1 Additional turn around movements

Some additional U-turn movements have also been added to the following legs to account for the placement of the median barrier:

- SH2/Wiltons Road/East Taratahi Road Roundabout
  - SH2(SW) – U-turn movement catchment area up to SH2/Norfolk Rd/Cornwall Road intersection
  - SH2(NE) – U turn movement catchment area up to Hughes Line, where another roundabout is being proposed

This is assumed to be approximately 3% of the through movements on the opposing legs, with movements split 50% between heavy and light vehicles. Some modification has taken place to account for the lack of commercial uses to the northwest and to account for some light vehicle movements associated with the commercial uses to the south. This results in the following estimated movements as shown in **Table 2.1.**

Table 2.1 Additional U-turn Peak Movements

	Light Vehicles	Heavy Vehicles
SH2 (NE) Leg – Peak period movements	10-12 vehicles	2 vehicles
SH2 (SW) Leg – Peak period movements	7-11 vehicles	7-11 vehicles

The peak u-turn movement assumptions have been validated through considering the number of residential and commercial uses to the northeast and southwest of the roundabout and their likely peak hour movements. A summary of these validated assumptions is provided in Appendix A.

It is noted that placement of the roundabout at this location may alter the existing proportion of traffic on the minor approaches, with improved access for right turners from these minor roads. This could lead to a higher number of right turners from each of the minor roads. Any such change is likely to impact the operation of the State Highway approaches adversely. An increase in right turners from East Taratahi Road is considered to be the most likely and implication with the most significant potential impact. This will impact vehicles on the SH2 SW approach. The modelling presented does not consider this redistribution in the volumes used, but the potential impact has been commented on in Section 5.2.

2.1.2 Traffic Growth

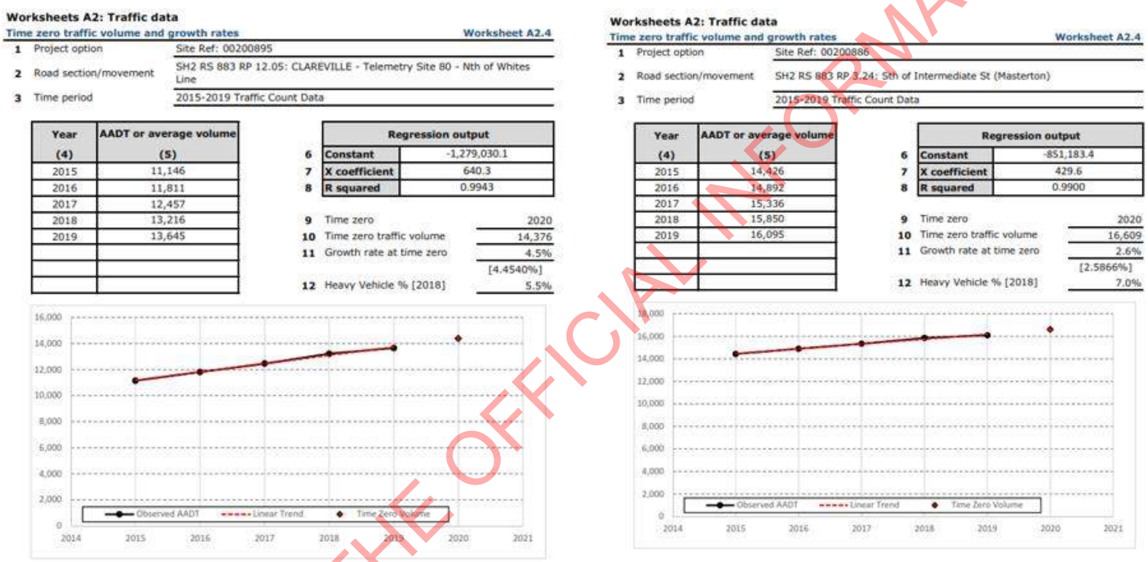
The main source of future year traffic growth is based on:

- Observed historical AADT volumes on SH2;
- Consideration to the level of growth applied in the modelling completed as part of the Single Stage Detailed Business Case

a. Historical AADT Growth

The current seven-year AADT volumes and growth is shown in Figure 2.1, covering the period 2013 to 2019. This shows an annual two-way traffic growth of 4.5% at the Clareville end of the State Highway and 2.6% at the Masterton end of the State Highway. For reference the intersection is located at the following RS/RPs:

- Norfolk: 002-0083-B/6.701



Worksheets A2: Traffic data
Time zero traffic volume and growth rates — Worksheet A2.4

1 Project option: Site Ref: 00200895
2 Road section/movement: SH2 RS 883 RP 12.05: CLAREVILLE - Telemetry Site 80 - Nth of Whites Line
3 Time period: 2015-2019 Traffic Count Data

Year (4)	AADT or average volume (5)
2015	11,146
2016	11,811
2017	12,457
2018	13,216
2019	13,645

	Regression output	
6	Constant	-1,279,030.1
7	X coefficient	640.3
8	R squared	0.9943

9 Time zero: 2020
10 Time zero traffic volume: 14,376
11 Growth rate at time zero: 4.5% [4.4540%]
12 Heavy Vehicle % [2018]: 5.5%

Worksheets A2: Traffic data
Time zero traffic volume and growth rates — Worksheet A2.4

1 Project option: Site Ref: 00200886
2 Road section/movement: SH2 RS 883 RP 3.24: Sth of Intermediate St (Masterton)
3 Time period: 2015-2019 Traffic Count Data

Year (4)	AADT or average volume (5)
2015	14,426
2016	14,892
2017	15,336
2018	15,850
2019	16,095

	Regression output	
6	Constant	-851,183.4
7	X coefficient	429.6
8	R squared	0.9900

9 Time zero: 2020
10 Time zero traffic volume: 16,609
11 Growth rate at time zero: 2.6% [2.5866%]
12 Heavy Vehicle % [2018]: 7.0%

Figure 2.1 Historic AADT growth south and north of SH2/Ngaumutawa and SH2/Norfolk intersections.

b. Consideration to the level of growth applied in the modelling completed as part of the Single Stage Business Case analysis

- The AADT of 13,216 was based on 2018 data from the counter in Clareville and annual growth is 3.5% based on seven years as this shows a consistent trend. A value of 20,000 has been used between Norfolk Road and Ngaumutawa Road based on traffic counts on the Waingawa Bridge.
  - ***The growth rate of 3.5% has been maintained within this model informed by the historic AADT growth.***

3 Assessing Intersection Operation

The operation of the proposed roundabouts has been assessed using the SIDRA transport modelling package.

The critical performance measures used in this assessment are:

- Practical Spare Capacity: measure of the increase possible in the modelled traffic volumes before the roundabout reaches the practical degree of saturation (specified by SIDRA as 0.85 for roundabouts).
- Degree of Saturation: measure of how much of the available capacity of the roundabout is being used with the modelled traffic volumes. Whilst a value of 1.0 indicates that the roundabout is "at capacity", it will not operate efficiently and is likely to experience significant delays and queues. A degree of saturation of 0.90 is commonly used as the maximum value at which a roundabout will operate efficiently and consistently.
- Maximum 95th Percentile Queue: maximum 95th percentile queue in any lane at roundabout. The 95th percentile queue length is the distance to the back of the longest queue that will form 95% of the time. It is likely that during an hour's operation of the roundabout, a queue length equal to the 95th percentile queue will form at least once.
- Level of Service (LOS): An index of the operational performance of traffic on a given roadway, traffic lane or approach which is based on amongst other things the delay, degree of saturation and density during a given flow period. LOS A represents the best operating conditions from the traveller's perspective and LOS F the worst.

4 Approach to Assessment

The approach taken for this assessment has been to test a one lane roundabout option developed by the design team and compare to the operation of the existing intersections that together will make up the crossroads.

The observed traffic volumes have been used with the additional U-turn traffic above applied. Uniform traffic growth of 3.5% is then applied to produce future expected traffic volumes for the current year (2020), which is 2 years on from the base year (2018) volumes and a future 10 year horizon (2030), which is 12 years on from the base year. An in-between or future year has also been modelled to represent the time at which a practical DoS is met (considered to be 0.9) and beyond which the roundabout is expected to stop operating efficiently and consistently.

Default SIDRA values for roundabout parameters have been retained except for the main ones affecting roundabout performance: central island diameter, circulating lane width and number of circulating lanes. The peak flow factor input for all scenarios has been calculated from the on-site surveys. Ongoing design work will refine other aspects of the roundabout, such as the alignment of the approach legs. These changes will have very little impact on the operation of the roundabout.

5 Current and Future Year Operation

5.1 Existing Intersection Operation

The existing give way arrangement at both the SH2/Wiltons Road and SH2/East Taratahi Road as shown in **Figure 5.1** were modelled. The two intersections have been modelled separately due to their staggered arrangement and the fact there are limited movements between the two minor roads. The intersection forms are below:

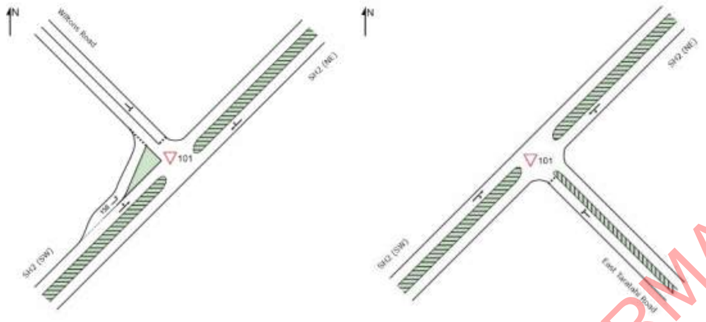


Figure 5.1: Existing Intersection Form at Wiltons Road (Left) and East Taratahi Road (Right)

The existing operation of the intersection has been modelled. This model has been tested to provide an indication of the expected performance of the intersection at present (2020).

The on-site survey video was analysed to calibrate the gap selection/headway for the SH2/East Taratahi Road intersection during the critical peak. Analysis of the video for the AM peak indicated the default SIDRA values represent the observable critical gaps on site. The SH2/Wiltons Road intersection was not calibrated, owing to the small number of right turn movements occurring from this intersection.

The modelling indicates the following existing level of service at the intersections as outlined in **Table 5.1** and **Table 5.2**

Table 5.1 Anticipated Existing Intersection Performance (Wiltons Road)

Time Period	Traffic Volume Source	Max DoS[1]	Delay [sec]		Max 95th Percentile Queue [m]	Intersection LOS
			Average[2]	Worst[3]		
AM	2020	0.508	0.5	27 (W)	2 (W)	LOS C on worst approach
	2030	0.675	1.9	91 (W)	11 (SH2 NE)	LOS E on worst approach
PM	2020	0.473	0.4	26 (W)	4 (SH2 NE)	LOS B on worst approach
	2030	0.646	1.2	81 (W)	14 (SH2 NE)	LOS D on worst approach

The existing modelling indicates that the intersection of State Highway Two and Wiltons Road is operating below capacity and will continue to do so into the future. Notwithstanding, right turn movements out of the minor road are subject to delays due to the volume of State Highway traffic, these delays will get worse into the future as the volume of traffic on the State Highway increases.

[1] Maximum degree of saturation.

[2] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[3] Average delay per vehicle for worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Wiltons is annotated as "W" and East Taratahi as "ET").

Table 5.2 Anticipated Existing Intersection Performance (East Taratahi Road)

Time Period	Traffic Volume Source	Max DoS[4]	Delay [sec]		Max 95th Percentile Queue [m]	Intersection LOS
			Average[5]	Worst[6]		
AM	2020	1.137	9.7	160 (ET)	68 (ET)	LOS F on worst approach
	2030	9.826	241	4062 (ET)	480 (ET)	LOS F on worst approach
PM	2020	0.808	4	81 (ET)	24 (ET)	LOS F on worst approach
	2030	5.937	104	2317 (ET)	320 (ET)	LOS F on worst approach

The existing modelling indicates that the intersection is SH2/East Taratahi Road intersection is over capacity, with significant queues and delays for right turners from the minor road. In the future, significant queues are expected on East Taratahi Road due to the demand for right turns into SH2. Right turns from the minor road will be made more difficult by the volume of traffic anticipated to be operating on the State Highway in the future.

Increasing delays for the right turn movement increases the safety risk associated with drivers picking smaller gaps to complete their turn, which in turn increases the risk of crossing/turning crashes. At high speeds such as those present on the State Highway crashes of this type can lead to a death or serious injury.

[4] Maximum degree of saturation.

[5] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[6] Average delay per vehicle for worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Wiltons is annotated as “W” and East Taratahi as “ET).

5.2 Single Lane at Wiltons Road/East Taratahi Road

A single lane option at SH2/Wiltons Road/East Taratahi as shown in **Figure 5.2** was modelled. The roundabout form is below:

- Circulating width: 7.2m
- Island Diameter: 28.0m

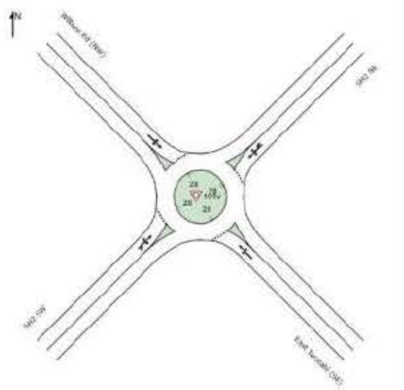


Figure 5.2 Single Lane Roundabout

The outcomes for the Single Lane at Wiltons Road/East Taratahi Road are shown in **Table 5.3**.

Table 5.3: Operation of a single lane roundabout at Wiltons Road/East Taratahi Road

Time Period	Traffic Volume Source	Max DoS[7]	Delay [sec]		Max 95th Percentile Queue [m]	Intersection LOS
			Average[8]	Worst[9]		
AM	2020	0.689	5	17 (W)	7 (SH2 SW)	LOS A (LOS B on worst approach)
	2029	0.917	7	29 (W)	156 (SH2 SW)	LOS A (LOS C on worst approach)
	2030	0.943	8	30 (W)	192 (SH2 SW)	LOS A (LOS C on worst approach)
PM	2020	0.589	5	14 (ET)	36 (SH2 NE)	LOS A (LOS B on worst approach)
	2030	0.785	5	17 (W)	88 (SH2 NE)	LOS A (LOS C on worst approach)
	2036	0.905	7	22 (W)	200 (SH2 NE)	LOS A (LOS D on worst approach)

[7] Maximum degree of saturation.

[8] Average delay for all vehicles on all approaches at roundabout – includes geometric delay for vehicles to negotiate the roundabout.

[9] Average delay per vehicle for worst movement at roundabout – includes geometric delay for vehicles to negotiate the roundabout. The approach predicted to experience the worst delay is noted in brackets after the delay time (Norfolk is annotated as "N" and Cornwall as "C").

From the SIDRA results it can be seen that the AM peak hour is most critical to the operation of the intersection when operating as a single lane roundabout.

- A single lane roundabout in place at present would be operating well below practical capacity (DoS of 0.85) and is expected to operate consistently and efficiently till 2029
- Compared to the existing intersection a single lane roundabout would significantly improve performance on both the minor approaches, with limited impact to the State Highway in the immediate term.
- By 2029 delays on the Wiltons Road approach would reach current levels and queues of more than 150m would be forming on the SH2 (SW) approach. Both State Highway legs would still be operating at a LOS A, with a maximum delay of 17 seconds for a u-turn movement on the SH2 (SW) approach.
- The construction of the roundabout may alter traffic patterns at the intersections, likely increasing the number of right turning vehicles onto the State Highway as the intersection becomes more accessible. This would likely result in additional delays for the through traffic and may shorten the life span of the single lane roundabout.

6 Summary of Paper

Based on the analysis completed above:

- The existing intersection model results indicate that the SH2/Wiltons Road intersection is currently operating below capacity and is expected to do so in the future, while the SH2/East Taratahi Road intersection is currently operating over capacity with significant queues and delays for right turners on East Taratahi Road modelled.
- Construction of a roundabout at the intersection will significantly improve the level of service for vehicles on the minor roads and the safety at the two intersections.

  Based on the modelling, a one lane roundabout is expected to operate efficiently and consistently up to approximately 2029. At which point queues are expected to start to form on the state highway's southwest approach in the AM peak. Notwithstanding, this approach would still be operating at a LOS A, with minimal delays (less than 20 seconds for any movement) and thus the degree to which additional 2 lane capacity is required on this leg could be beyond 10 years, noting that by 2040 queues of beyond 900m can be expected in the AM for the SH2 SW leg, with significant through moving traffic (1571 vehicles per hour).
- The construction of the roundabout may alter traffic patterns at the intersections, likely increasing the number of right turning vehicles onto the State Highway as the intersection becomes more accessible. This would likely result in additional delays for the through traffic and may shorten the life span of the single lane roundabout.

Sensitivity: General

A

Turn Around Movement Assumptions

Commercial Operator	Turning Information	Assessment
SH3 (NE) Leg		
Light Vehicles (Residential uses)		
Residential uses	*Assume 1 vehicle movement per residential crossing during the peak*	▪ There are 6 residential uses northeast of the crossing in a worst case is expected to result in 6 additional movements at the roundabout in the peak hour. ▪ Assume maybe 2 HV movements associated with farming activities (no commercial access to the north)
Total		▪ Based on the above 6 LV turn around movements are expected in the peak ▪ This is slightly less than the assumed 10-12 but, thus the assumption is conservative
SH3 (SW) Leg		
Light and Heavy Vehicles (Commercial and Residential uses)		
Ravensdown and two other commercial uses	*No truck numbers have been provided*	▪ Assume no more than 1 movement every 10 minutes associated with the commercial uses ▪ 6 HV sits below the lower bound of the range identified
Residential Uses	*Assume 1 vehicle movement per residential crossing during the peak*	▪ There are 5 residential uses northeast of the crossing in a worst case is expected to result in 5 additional movements at the roundabout in the peak hour. ▪ Assume maybe 2 HV movements associated with farming activities
Total		▪ Based on the above 5 LV turn around movements are expected in the peak ▪ Based on the above 8 HV turn around movements are expected in the peak ▪ And some light vehicle movements associated with the commercial uses. Though noting the assumed number these are considered reasonable