# RAISED SAFETY PLATFORM EVALUATION

## GORDONTON AND THOMAS ROAD INTERSECTION, HAMILTON

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# EXECUTIVE SUMMARY


## Background

Raised safety platforms (RSPs) were introduced at the signalised intersection of Gordonton and Thomas Roads, Hamilton, to improve alignment with Safe System principles and performance, particularly with respect to the severity of side-impact crashes. The treatment aims to ensure that intersection speeds do not exceed 50km/h, the upper speed at which side-impact forces are within human tolerances and therefore survivable.

Previously, the intersection was unsignalised and vehicles were passing through with 85% speeds of around 80 km/h. Various interim safety treatments have been introduced, and in more recent times signals have been introduced at the intersection, reflecting the development and growing road use in the area.

While the feasibility of RSPs has been established overseas, here in New Zealand, they are new. There is a need to monitor the performance of their use to establish whether they are performing as expected, and through objective evidence, understand if there are any issues ahead of further rollout.

## Raised safety platform evaluation

An evaluation was conducted to examine the performance of the RSPs as a Safe System solution for reducing DSI crashes. The evaluation also examined any potential associated safety risks with RSPs, and learnings obtained from delivery and operational performance.

The evaluation framework established dimensions of merit and performance standards under the criteria of *safety improvements, associated safety risks,* and *delivery and operation.* The standards defined the level of performance needed on each dimension. The evaluation findings were interpreted against the evaluation framework to derive conclusions about the overall effectiveness of the RSPs.

The measures, methods, and data sources used in the evaluation were as below.

- **Vehicle speed**[1] - measured using speed tubes (approximately 100 metres south, at the intersection, approximately 100 metres north) and also on the wider approach via fixed speed radars (speed threshold - north, 60km/h speed zone-south).
- **Road user behaviour** (braking behaviour on approach, red light running, stopping at the limit line, pedestrians and cyclists) - recorded by video camera positioned north of the intersection and at the intersection.
- **Perceived safety (community)** - measured through monitoring Hamilton City Council's online and telephone customer service channels for any safety related complaints or concerns about the RSPs.
- **Impact on traffic flow and throughput** - assessed by a Hamilton City Council Transport Systems Engineer.
- **Vertical acceleration** - measured travelling north and south over the RSPs in a light passenger vehicle at various speeds.


[1] Suitable baseline speed data was not available, limiting the confidence with which measured speeds after installation of the RSPs can be directly attributed to the RSPs alone. Also, while we are interested in the speed behaviour on the approaches to the RSP, only the intersection speeds were used as success criteria.

- **Development and delivery issues** – as reported by project staff and stakeholders at a post-delivery 'lessons learned' workshop and end of project report.
- **Council and community buy-in** - as identified through the monitoring of customer service channels and as reported by project staff (as above).

## Evaluation results

Following the installation and full operation of the RSPs, 85th percentile speeds through the intersection were well below 50km/h and comfortably met the performance target of not exceeding 50km/h. This is a significant improvement on the previous high intersection speeds of around 80 km/h. Radar measured speed at the southbound and northbound wider approaches exceeded the speed limit, and while these measures do not reflect the performance of the RSPs, they may warrant further attention. These relatively high speeds on approach further reinforce the effectiveness of the RSPs (and other intersection features) in supressing speed to safe system levels through the intersection.

Performance standards were met on five dimensions of *associated safety risks*, while there was insufficient data to conclude on a sixth (impact on behaviour and safety of vulnerable road users). Overall, it is concluded that crash risk resulting from the RSPs is low, and rather they are likely to significantly reduce crash risk.

Only five percent of southbound vehicles travelling through the intersection on a green light demonstrated late braking, a risk factor for rear end crashes. Only 0.7% of southbound vehicles (through and right turn lane) stopping at the intersection stopped on the RSP itself. No incidents of red-light running were observed. A relatively high proportion of vehicles stopped beyond the limit line which is likely to be captured by the intersection analysis system as red light running; a finding which supports the theory that this behaviour is contributing to the higher than expected incidence of red light running at the intersection (as reported by the Hamilton City Council).

Peak vertical acceleration travelling over the RSPs at appropriate speeds was well within the accepted range for safety and driver comfort and previously reported modelling suggests negligibly roll-over risk for trucks turning into Thomas Rd. Community feedback on perceived safety of the RSPs derived only one safety related submission, which did not indicate any serious safety concern.

The RSPs met the performance standard on all three dimensions of merit under *delivery and operations.* Expert assessment found no evidence the RSPs were having a negative impact on traffic efficiency. There was reported evidence of council buy-in and limited evidence to suggest community opposition.

## Evaluation conclusion

In synthesis, the RSPs met all performance standards across 10 measured dimensions of merit. From this result, it is concluded that RSPs are an effective Safe System solution for reducing DSI crashes at signalised intersections. The RSPs are associated with intersection speeds well under the Safe System target, there is low likelihood of associated safety risks, and the delivery and operation of the RSPs has progressed smoothly. Note, however, that reduced DSI crashes is the ultimate long-term measure of success and will be measured at an agreed time in the future.

Further strategies for improving the visibility of the RSP and raised platform are suggested as some have indicated that the raised nature of the RSP can be difficult to determine on approach. An appropriate response may be a colour treatment (e.g. Red) on the platform itself.

The RSP evaluation framework developed through this evaluation will be strengthened by ensuring appropriate baseline data collection at future trial installations, so that resulting changes on key performance measures can be more confidently attributed to the installation of RSPs alone.

# CONTENTS

# 1. INTRODUCTION

## 1.1. Hamilton raised safety platform trial

Raised Safety platforms at intersections are an emerging road safety countermeasure and have previously been trialled in the Netherlands and Australia[2]. Managing collision speed and energy to survivable levels is a key component of a Safe System approach, and rural and urban intersections are locations where deaths and serious injuries are common[3].

While the feasibility of RSPs has been established overseas, here in New Zealand, they are new. There is a need to monitor the performance of their use to establish whether they are performing as expected, and through objective evidence, understand if there are any issues ahead of further rollout.

Previously, the Thomas/Gordonton Rds intersection in Hamilton North was unsignalised and vehicles were typically passing through with 85% speeds of around 80 km/h. Various interim safety treatments have been introduced, and in more recent times signals have been introduced at the intersection, reflecting the development and growing road use in the area.

Raised safety platforms (RSPs) were introduced as part of the intersection signalisation. By installing raised tables on the north and south bound entry to the intersection on Gordonton Rd, the treatment seeks to reduce the incidence and severity of collisions at the intersection, particularly side-impact crashes. In line with Safe System theory, the goal is that vehicle speeds through the intersection do not exceed 50km/h, the upper speed limit at which side-impact forces are within human tolerances and are therefore survivable[4].

The Hamilton RSPs were fully operational from 1 May 2019 after a staged roll-out which involved temporary speed restrictions and VMS boards.

The northbound and southbound approaches to the intersection on Gordonton Rd have speed thresholds (60 km/h) and Speed Indicator Devices (SIDs). Approximately 250m north of the intersection, the speed limit reduces from 80 km/h to 60km/h as southbound traffic transitions from a rural to peri-urban environment. Features that reinforce this change of environment include kerb and channelling, housing, driveways, and street lighting.

Features of the RSPs are shown in Figure 1 and include:

- 2.5m approach ramp and 3.5m departure ramp.
- Profile - 1 in 25 up, 1 in 35 down.
- Platform 100mm high by 6m long constructed between island kerb, kerb and channel.
- White painted upward triangles on the approach only.
- Non-coloured platform - asphalt only, with no markings on the departure ramp.



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[2] Candappa, N., & Colobong, R. (2015). Effect of Safety Platforms on Speed and Driver Behaviour at a Trial Site in Belmont, Victoria. Intersection Study Task 9 Report. Monash University Accident Research Centre; Fortuijn, LGH, Carton, PJ & Feddes, BJ 2005, 'Safety impact of raised stop bars on distributor roads: draft', CROW, Ede, The Netherlands.

[3] New Zealand Transport Agency (2013). High risk intersections guide. New Zealand Transport Agency, Wellington.

[4] New Zealand Transport Agency (2013). High risk intersections guide. New Zealand Transport Agency, Wellington.

*Figure 1: Details of the Raised Safety Platform*

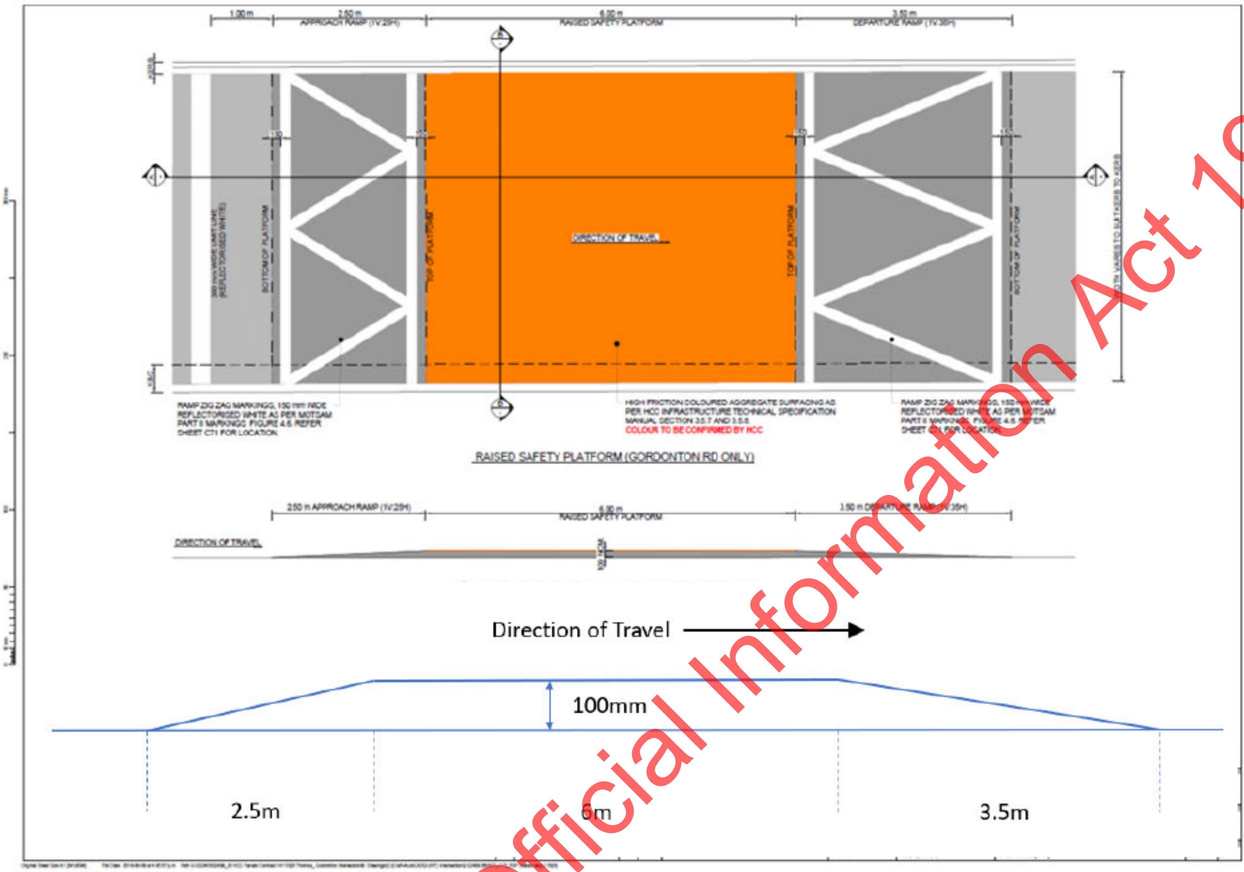



Figure 2 shows the RSP in the northbound lane and Figure 3 shows white upwards triangles (Shark's Teeth) on the approach ramp in the southbound lane.

*Figure 2*: Raised safety platform (northbound lane)

*Figure 3: Sharks' Teeth on approach ramp (southbound lane)*

The northbound (Figure 4) and southbound (Figure 5) approaches to the intersection on Gordonton Rd are shown below. Gated hump advanced warning signs (W14-4) are included with 50 km/h advisory supplementary signs.

*Figure 4: Gordonton Rd approaches (northbound)*

*Figure 5*: Gordonton Rd approach (southbound)


Figure 6 shows the northbound view exiting the intersection and the speed threshold transitioning from the 60km/h to 80km/h speed limit.

*Figure 6*: Northbound view exiting the RSP intersection

## 1.2. Evaluation of the raised safety platform

This report presents the results of a brief evaluation of the Gordonton/Thomas Roads intersection. The evaluation assesses the effectiveness of RSPs within New Zealand and was informed by recent evaluation in Victoria[5]. The evaluation was also conducted to inform the development of a more comprehensive evaluation framework and approach, should RSPs be implemented more widely in New Zealand in the future.

## 1.3. Overview of the evaluation report

Section 2 of this report details the RSP evaluation framework, while Section 3 describes the evaluation methods used. The evaluation findings are presented in Section 4 and all findings are synthesised in Section 4. Final conclusions and future directions are presented in Section 6.

## 1.4. Acknowledgements

The evaluation was a collaborative project with support and inputs from Mackie Research, WSP-OPUS, Hamilton City Council, and the New Zealand Transport Agency. Mackie Research would like to thank all those who contributed to the evaluation and who collectively made the evaluation possible.



[5] Candappa, N., & Colobong, R. (2015). Effect of Safety Platforms on Speed and Driver Behaviour at a Trial Site in Belmont, Victoria. Intersection Study Task 9 Report. Monash University Accident Research Centre.

# 2. EVALUATION FRAMEWORK

## 2.1. Evaluation purpose and criteria

The primary purpose of the RSPs are to achieve speeds through the intersection that are survivable in the event of a collision, particularly side-impact crashes. The primary purpose of the RSP evaluation therefore was to determine whether the RSPs provide an effective Safe System[6] solution for reducing DSI crashes at signalised intersections. As RSPs are new to New Zealand, a secondary purpose was to learn about implementation issues and wider performance characteristics.

Evaluation criteria specify the aspects of a project that will be considered when deciding whether or not, and in what ways, the project has been successful. The primary evaluation criteria used in the evaluation was *safety improvement.* Secondary criteria were *associated safety risks,* and *delivery and operation.*

## 2.2. Evaluation questions

The key (KEQ) and secondary evaluation questions (SEQ) aligned with the evaluation purpose and criteria.

The evaluation questions were as follow.

**KEQ 1: What is the effectiveness of the RSPs, in terms of providing a Safe System intersection solution?**

- **SEQ 1.1:** Are intersection speeds reduced to desired levels?

**KEQ 2: What observed safety risks are associated with implementation of the RSPs?**

- **SEQ 2.1:** Are the RSPs likely to lead to an increase in crashes? (e.g. rear-end and other crashes)
- **SEQ 2.2:** Are the RSPs likely to lead to any erratic or unsafe road user behaviour?
- **SEQ 2.3:** Are the RSPs likely to impact the behaviour of VRUs, particularly pedestrians?

**KEQ 3: What operational issues might be associated with the RSPs?**

- **SEQ 3.1:** What are the impacts of the RSPs on traffic efficiency through the intersection?
- **SEQ 3.2:** What are the impacts of the RSPs on council/community buy-in?
- **SEQ 3.3:** Are there any implementation or site-specific issues associated with installation of the RSPs?

## 2.3. Dimensions of merit

More specific 'dimensions of merit' were defined under the each of the evaluation criteria, and where possible, performance standards were established for each dimension. Each performance standard defined the level of performance the RSPs would need to achieve on its relevant dimension of merit if

[6] https://www.saferjourneys.govt.nz/about-safer-journeys/the-safe-system-approach/

the RSPs were to be judged as effective in achieving intended safety improvements, having low likelihood of associated safety risks, and having effective delivery and operation.

Defining dimensions of merit and performance standards allowed appropriate evaluation methods and data sources to be identified. The definitions also enabled transparent and defensible evaluative conclusions about the performance of the RSPs to be drawn from the evaluation findings.

Table 1, Table 2, and Table 3 over page summarise the dimensions of merit, performance measures, and standards established under each of the evaluation criteria. The final column in each table provides the rationale for the dimensions, measures, and standards established.

*Table 1: Dimensions of merit, performance measures, and performance standards (**Safety improvement criteria**)*

| SAFETY IMPROVEMENT | | | |
|---|---|---|---|
| **Dimension of merit** | **Performance measure** | **Performance standard** | **Rationale** |
| DSI crashes[7]. | Number of DSI crashes at the intersection. | Reduction in DSI intersection crashes from baseline. (Timing of measurement and performance standard to be established). | The primary purpose of the RSP is to reduce DSI crashes. |
| South and north bound vehicle speed through intersection[8]. | 85th percentile speed. | 85th percentile vehicle speed does not exceed 50 km/h. | Speeds not exceeding 50km/h are survivable speeds for side impact crashes. |

[7] Reduced DSI crashes is the long-term measure of effectiveness, and is not included in this evaluation.

*Table 2: Dimensions of merit, performance measures, and performance standards (**Associated safety risks criteria**)*

| ASSOCIATED SAFETY RISKS | | | |
|---|---|---|---|
| **Dimension of merit** | **Performance measure** | **Performance standard** | **Rationale** |
| Braking on approach (road user behaviour). | Proportion (%) of free-flowing southbound vehicles undertaking late braking on approach. | Proportion of late braking vehicles does not exceed five percent of all free-flowing southbound vehicles on approach. | Late braking may indicate driver confusion or late detection of the RSP which may have implications for safe travel through the intersection.<br>A more predictable/'self-explaining' road environment has safety benefits.<br>Human Factors theory posits that countermeasures should be designed for 90-95% of a user population. |
| Stopping at limit line (road user behaviour). | Proportion (%) of southbound vehicles stopping beyond the limit line (through and right turning lanes). | Proportion of vehicles stopping on the RSP does not exceed five percent of all southbound vehicles stopping at the intersection (through and right turning lanes). | Stopping on the RSP may indicate confusion about where they are supposed to stop<br>Human Factors theory as above. |
| Vertical acceleration. | Vertical acceleration force generated by the RSPs. | Vertical acceleration is within accepted parameters for safety and comfort. | Vertical acceleration may cause driver discomfort and at high levels and could potentially pose a safety risk through loss of control in extreme circumstances. |
| Red light running (road user behaviour). | Proportion (%) of southbound vehicles turning through a red light (through and right turning lanes). | Proportion of red-light running vehicles is comparable to other similar intersections. | Red light running increases the risk of DSI crashes at intersections. |
| Cyclist and pedestrian safety. | Number of observed risky events involving cyclists or pedestrians. | No observed risks for pedestrians or cyclists. | RSPs should not increase risks for any road user |
| Perceived safety. | Number of RSP related critical safety issues reported by the community via Hamilton City Council feedback channels. | No reported risks for pedestrians or cyclists. | Community perception that the RSPs is a safe treatment will support community acceptance and compliance with the RSPs. |

*Table 3: Dimensions of merit, performance measures, and performance standards (**Delivery and operation criteria**)*

| DELIVERY AND OPERATION | | | |
|---|---|---|---|
| **Dimension of merit** | **Performance measure** | **Performance standard** | **Rationale** |
| Traffic flow and throughput. | Impact on traffic flow and throughput (assessed by expert). | RSPs are assessed as not having a negative impact on traffic flow and throughput. | RSPs should ideally have minimal impact on traffic efficiency. |
| Council and community buy-in. | Reported level of Council buy-in.<br>Number of complaints or concerns raised by the community about the RSPs (via Hamilton City Council feedback and social media channels). | No opposition to RSPs raised by Council or the community. | The wider rollout of RSPs would benefit from Council and community buy-in. |
| Delivery and operation. | Delivery and operational issues reported by staff, contractors, and stakeholders. | Reported issues are not of a magnitude that would prevent wider roll-out[9]. | Delivery and operational issues associated with the RSPs should be within accepted tolerances for similar projects, and not specific to the treatment itself. |

[9] If RSPs are determined to be effective.

# 3. EVALUATION METHODS

The methods used to collect data under each of the evaluation criteria are detailed below.

## 3.1. Safety improvements

### 3.1.1. Traffic speed

#### Speed tubes (RSP intersection)

Speed tubes were placed just after the RSP departure ramps (north and southbound) to measure vehicle speed through the intersection and traffic volumes (see Appendix A for visual map).

Data over a 7-day period was analysed, beginning Wednesday 17 July and concluding on Tuesday 23 July 2019 (at midnight)[10]. The data was exported to Excel and scatter plots were used to check the data and remove anomalies. Various analyses were then carried out (i.e. speed distribution graphs, total vehicle counts, 85th and 95th percentile speeds, percentage of vehicles over the speed limit).

#### Speed tubes (RSP intersection approach)

Although not directly used as success criteria for the RSPs, surveys were also undertaken to understand the speed behaviour on approach to and departure from the intersection. Speed tubes were placed approximately 100 metres north and south of the intersection to measure southbound and northbound vehicle speed on approach (see Appendix A for visual map). Speeds as vehicles departed the intersection were also recorded. 7 days of data from 17 to 23 July 2019 were used in the analysis.

#### Speed radar (wider approach speed)

An existing speed radar (as part of a Speed Indicator Device) was located just after the southbound speed threshold (80km/h to 60km/h transition) to measure the speed of southbound vehicles at the threshold (see Appendix A for visual map). Another radar was located for northbound vehicles approaching the intersection within the 60 km/h zone.

Speed data collected by the radar were provided through the Opito platform as minimum, maximum, and 85th percentile speeds for every minute that vehicles were recorded. This data was exported to Excel to enable the data to be graphed.

For both datasets, data from a 7-day period from 17 to 23 July 2019 is reported. Data from the full period of data collection from 5 April to 29 July 2019 were graphed, with average 85th percentile speeds plotted for data between 20 May and 29 July 2019. Data collected before 20 May was excluded as this coincided with temporary speed restrictions on site.

[10] The RSPs were fully operational from 1 May 2019.

### Important note on method

Changes to the Gordonton/Thomas Road intersection occurred through a series of stages and included a number of subsidiary interventions such as temporary speed limits. Because of this, it was not possible within the timeframe of the evaluation to collect baseline speed data that would not have been contaminated in some way. This lack of baseline speed data reduces the confidence with which speeds measured after the installation of the RSPs can be directly attributed to the RSP treatment itself. However, the most important consideration is that the intersection is operating with speeds that are inherently safe, which is the focus of this evaluation.

## 3.2. Associated safety risks

### 3.2.1. Road user behaviour

Two cameras were positioned to capture road user behaviour on approach to, and travel through, the intersection. The camera location, field of view, and road user behaviour recorded by each camera is shown in Table 4 (see Appendix A for visual map).

Camera A recorded road user behaviour data between 24 and 26 June 2019 while Camera B recorded data between 28 and 30 June 2019.

*Table 4: Detail of cameras used in RSP evaluation*

| | Position | Field of view | Road user behaviour recorded |
|---|---|---|---|
| **Camera A** | 45 metres north of the intersection. | Rear view of southbound vehicles on approach; through and right turning vehicles. | Braking behaviour on approach.<br>Red light running.<br>Cyclists and pedestrians. |
| **Camera B** | At the intersection (on signal pole). | Front view of southbound vehicles on approach; through and right turning vehicles.<br>Rear view of northbound vehicles exiting the intersection. | Stopping at limit line.<br>Cyclists and pedestrians. |

A coding framework and protocol (see Appendix B for full detail) was developed to code selected samples of the video data. Table 5 details for each road user behaviour the eligibility criteria for inclusion in the analysis, the behaviour codes used, and the video data coded.

*Table 5: Summary of RSP evaluation road user behaviour video analysis*

| Road user behaviour | Eligibility criteria | Behaviour codes | Video data coded |
|---|---|---|---|
| Braking on approach. | Southbound through vehicle on green light on approach to intersection. | • Braking for whole frame (Quadrant 1+2).<br>• Braking in Quadrant 1 only. | Eight hours of data coded in 30-minute time period blocks spaced over three days (24 – 26 |

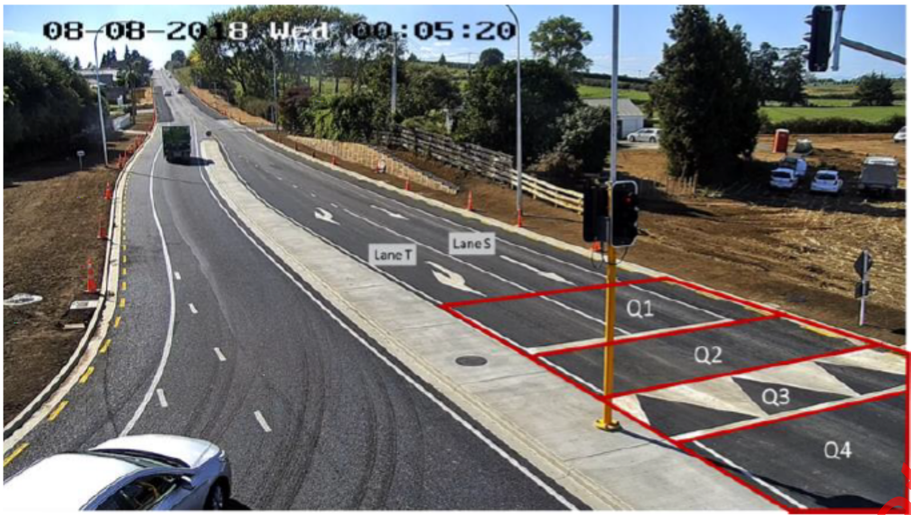
| | | | |
|---|---|---|---|
| | No head-way vehicle in close proximity[11].<br>Through lane only. | • Braking Quadrant 2 only (i.e. indicator of late braking).<br>• No braking.<br>• Can't tell.<br>• Excluded (head-way rule). | June 2019). Early morning, dusk, and night conditions coded only[12]. |
| Stopping at limit line. | Southbound vehicle stopped at the RSP intersection[13].<br>Front car in queued traffic only coded.<br>Through and right turn lane. | • Behind/on limit line.<br>• Between limit line and start of Shark's Teeth.<br>• On Shark's Teeth.<br>• On RSP. | 24 hours of data coded in five-minute time period blocks spaced over two days (28-29 June 2019). |
| Red light running | Southbound vehicle, through or right turning on red light. | Incident details recorded. | As for braking on approach. |
| Cyclist and pedestrian safety | All cyclists and pedestrians experiencing a critical safety event. | Incident details recorded. | As for braking on approach. |

Figure 7 shows the two quadrants defined for the braking video analysis while Figure 8 shows the four quadrants defined for the stopping at the intersection analysis (i.e. Q1=Behind/on limit line, Q2=Between limit line and start of Shark's Teeth, Q3=On Shark's Teeth, Q4=On RSP).

*Figure 7: Quadrants 1 and 2 for braking video analysis*


[11] Excluded as braking behaviour may be influenced by the front vehicle rather than the RSP; vehicle still included in the total vehicle count.
[12] The acuity of the video data did not allow braking to be reliably coded during daylight hours.
[13] The camera field of vision did not enable it to be accurately determined whether stopped vehicles were on a red light, however, it could be assumed that most stopped vehicles were under this condition.

*Figure 8: Quadrants 1, 2, 3 and 4 for stopping at intersection video analysis*




## 3.2.2. Vertical acceleration

Vertical acceleration was measured to estimate likely driver comfort and potential risk for loss of control. The accelerometer function of the Samsung A5 mobile phone was used to measure vertical acceleration while travelling over the RSPs in a light passenger vehicle. The phone was placed on the front edge of the front passenger seat facing upwards and the top of the phone orientated towards the front of the vehicle (hence vertical acceleration was measured in the "Z" axis). A total of 16 passes were made, at various speeds, north and south bound (Table 6). The data was collected 7 July 2019, between 3.15pm and 4.02pm.

*Table 6: Number, direction and speed of RSP passes to measure vertical acceleration*

| Pass | Direction | Speed over RSP (km/h) |
|---|---|---|
| 1 | Northbound | 57 |
| 2 | Northbound | 59 |
| 3 | Northbound | 19 |
| 4 | Northbound | 45 |
| 5 | Northbound | 61 |
| 6 | Northbound | 23 |
| 7 | Northbound | 47 |
| 8 | Southbound | 65 |
| 9 | Southbound | 60 |
| 10 | Southbound | 62 |
| 11 | Southbound | 57 |
| 12 | Southbound | 54 |
| 13 | Southbound | 53 |
| 14 | Southbound | 55 |
| 15 | Southbound | 52 |
| 16 | Southbound | 17 |

### 3.2.3. Cyclist and pedestrian safety

Information was collated on any critical safety events involving cyclists or pedestrians identified through the road user behaviour video analysis and coding process previously described.

### 3.2.4. Safety perception (community)

The Hamilton City Council's online and telephone customer service channels were monitored by Hamilton City Council following the full operation of the RSPs to identify any safety related complaints or concerns from the public.

## 3.3. Delivery and operation

### 3.3.1. Traffic flow and throughput

Assessment of whether the RSPs were having any impact on intersection traffic flow and throughput (traffic efficiency) was provided by a Hamilton City Council Transport Systems Engineer.

### 3.3.2. Council and community buy-in

The level of Council and community buy-in to the RSPs was assessed through the monitoring of the Hamilton City Council online and telephone customer service channels conducted for safety perception (community) and through review of the 'lessons learned' workshop and end of project report (see below).

### 3.3.3. Development and delivery

Development and delivery issues were identified through a 'lessons learned' workshop at the completion of the project. The workshop, held in Hamilton on 7 June 2019, involved project staff and stakeholders. The findings have been previously reported[14], and key themes are synthesised in this report.



[14] Hamilton City Council (2019). Project Closedown Report. Thomas/Gordonton Intersection Improvement. Trim document number: D-3015913. Hamilton City Council.

# 4. EVALUATION RESULTS

## 4.1. Safety improvements

### 4.1.1. Intersection speeds (tube data)

North and southbound vehicle speeds through the intersection are shown in Table 7 and speed distributions are shown in Figures 9-12. Results are shown for all vehicles and separately for when following vehicles with a headway less than three seconds are removed from the analysis[15].

All 85th percentile speeds (41 and 44 km/h for northbound and southbound respectively when <3 sec headways removed) are well within the performance target of speed not exceeding 50km/h. Given that all of the 95% speeds were very close to the target of 50 km/h, this suggests excellent Safe System performance.

While the unavailability of baseline speed data reduces the confidence with which the speed result can be attributed fully to the RSPs, it is concluded that the RSPs are associated with speeds through the intersection well within the performance standard of not exceeding 50km/h.

*Table 7: RSP intersection speeds (approx. 10m from centre of intersection; 7-day data from 17-23 July 2019)*

| | Northbound | | Southbound | |
|---|---|---|---|---|
| | *All data* | *<3 second head way removed* | *All data* | *<3 second head way removed* |
| Total vehicle count | 18423 | **12083** | 25623 | **15639** |
| 85th percentile speed (km/h) | 41 | **43** | 44 | **46** |
| 95th percentile speed (km/h) | 49 | 52 | 52 | 54 |
| Vehicles over speed limit | 0.7% | **1.0%** | 1.1% | **1.6%** |

Speed distribution graphs (Figures 9-12) enable further interpretation of vehicle speed behaviour. Very low speed vehicles (e.g. <30km/h) are likely to have been influenced by the traffic lights, for example, accelerating again after having been stopped on red. Higher speed vehicles (e.g. >35km/h) are more likely to have been free flowing through the intersection on a green light and therefore show more clearly the effect of the RSPs on speed. This can be seen in the bi-modal distribution of both graphs when vehicles with three second headway are removed. Both graphs show a secondary peak of vehicles at around 35-45km/h; more likely free flowing on green and travelling over the RSPs at speeds within the desired 50km/h.

[15] To account for the possibility that road user behaviour is influenced by the vehicle in front and not the RSP.

*Figure 9: Distribution of RSP intersection speed - northbound (all data)*

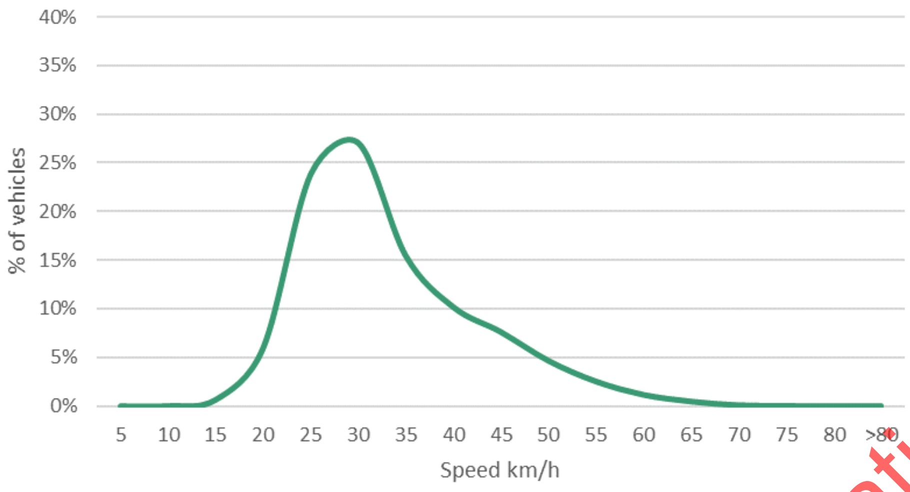



*Figure 10: Distribution of RSP intersection speed - northbound (<3 second head way removed)*

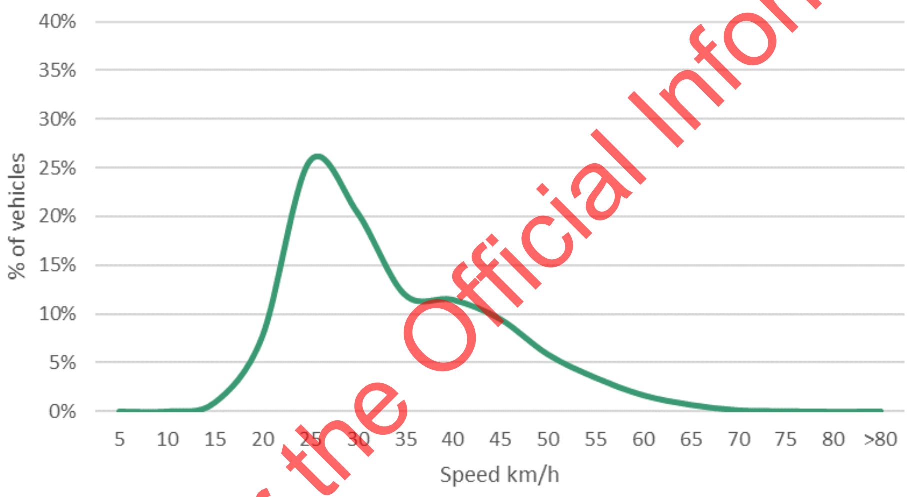



*Figure 11: Distribution of RSP intersection speed - southbound (All data)*

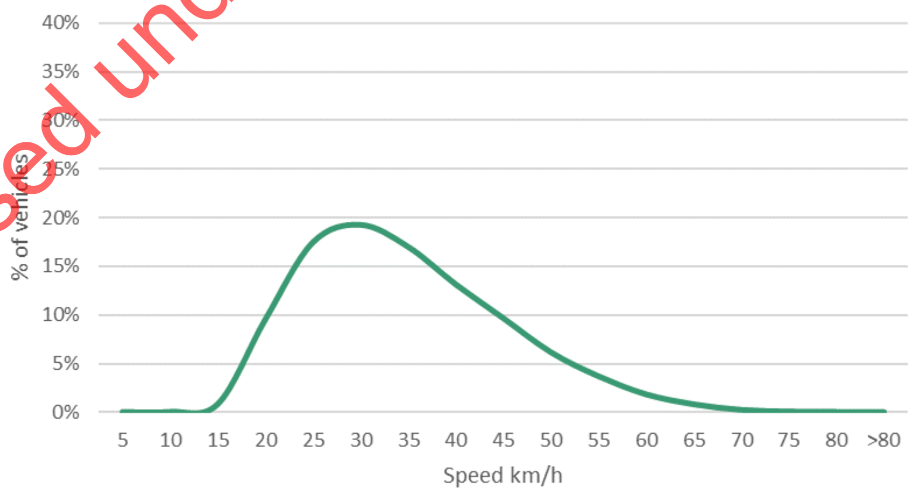
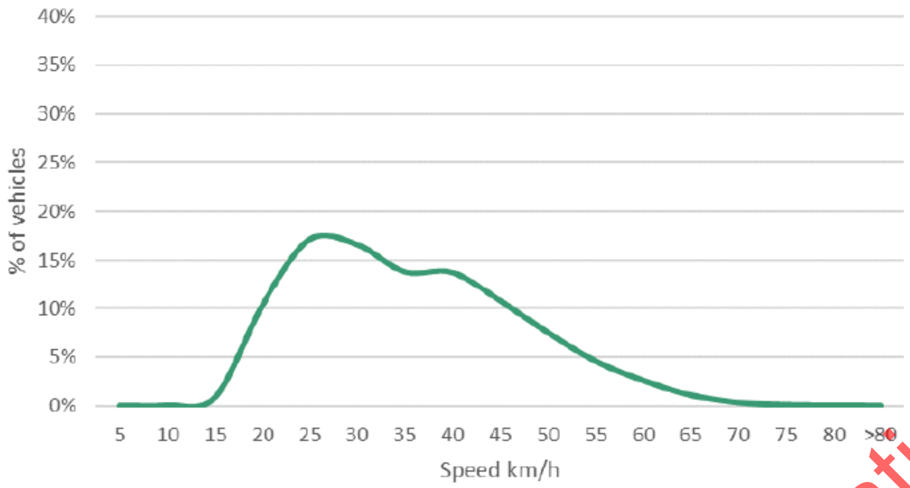


Figure 12: Distribution of RSP intersection speed - southbound (<3 second head way removed)




### 4.1.2. Approach speeds (tube data)

North and southbound vehicle speeds on approach to the RSPs are shown in Table 8, both including and excluding vehicles recorded following others with less than a 3-second headway.

The 85th percentile speeds of **59km/h** northbound and **60km/h** southbound are at or below the speed limit of 60km/h in these locations. They are also substantially higher than those recorded as vehicles drive off the RSPs at the intersection, which suggests that the RSPs are very effective in lowering speeds to Safe System levels at the intersection.

Table 8: Approach speeds (approx. distances from centre of intersection; 7-day data from 17-23 July 2019)

| | Northbound (100m south) | | Southbound (90m north) | |
|---|---|---|---|---|
| | *All data* | *<3 second head way removed* | *All data* | *<3 second head way removed* |
| Total vehicle count | 43040 | 26537 | 27164 | 18566 |
| 85th percentile speed (km/h) | 58 | **59** | 59 | **60** |
| 95th percentile speed (km/h) | 62 | 63 | 64 | 65 |
| Vehicles over speed limit | 8.1% | **10.9%** | 11.9% | **14.4%** |

### 4.1.3. Wider approach speeds (radar data)

Data from the fixed radars located north and south of the intersection collected data on 85th percentile speeds each minute[16] as vehicles approached the intersection over several months following treatment installation. This provides an understanding both of vehicle speeds on the approach further away from the intersection, and how these speeds have changed over time.

#### 7-day data

Radar data from the same 7-day period as used for the tube data (17-23 July 2019) were used to calculate 85th percentile vehicle speeds[17].

At the southern radar 120m south of the intersection, northbound vehicles were captured travelling within the 60km/h speed limit area. They would therefore be expected to be travelling at or around the speed limit, however the weighted 85th percentile speed of **66km/h** (Table 9) suggests many vehicles travelled above the speed limit in this direction.

The northern radar was located 250m north of the intersection and captured southbound vehicles immediately after having crossed the speed threshold, where the speed limit changes from 80km/h to 60km/h. To some extent, vehicles would therefore be expected to be travelling above the speed limit, as they decelerate over the threshold. This is reflected in the **71km/h** weighted 85th percentile speed observed at this location (Table 9).

*Table 9: Approach speeds at radars (approx. distances from centre of intersection; 7-day data from 17-23 July 2019)*

| | Northbound (120m south) | Southbound (250m north) |
|---|---|---|
| Total vehicle count | 38281 | 21562 |
| 85th percentile speed (km/h) | **66** | **71** |
| Mean maximum speed (km/h)[18] | 71 | 75 |

#### Speed trends since treatments installed

The radar data show that speeds in both directions near the intersection increased in the month immediately following installation until around 1 May 2019 when all traffic management measures were removed (Figure 13 and Figure 14). They have since remained stable, with weighted average 85th percentiles of **66km/h** northbound and **70km/h** southbound for the period from 20 May – 29 July 2019.

[16] 85th percentiles per minute were calculated by Opito software. For minutes where only one vehicle was recorded, 85th percentiles were equal to the speed of that one vehicle; for minutes where only two vehicles were recorded, 85th percentiles were equal to the speed of the slower vehicle.

[17] Mean weighted 85th percentile speeds were calculated by multiplying per minute 85th percentile calculations (produced by Opito software) by the number of vehicles recorded each minute, divided by the total number of vehicles recorded over the entire period.

[18] The Opito data also provided maximum vehicle speeds for each minute where a vehicle was recorded. A mean maximum speed value was calculated from these.

*Figure 13: 85th percentile speeds each minute at 65m (within 60km/h speed limit zone; all northbound vehicles)*

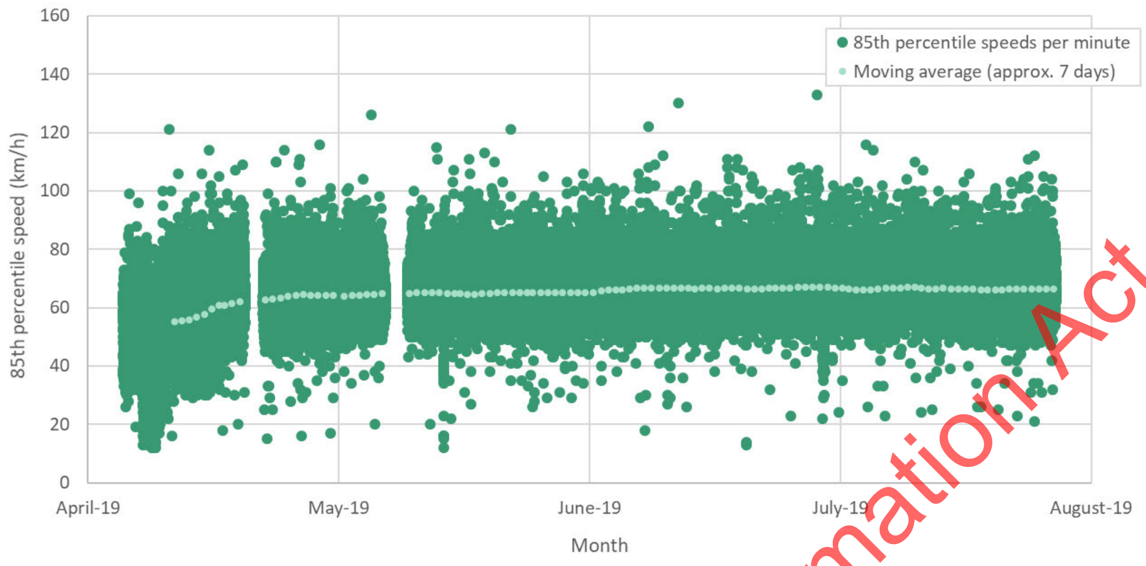
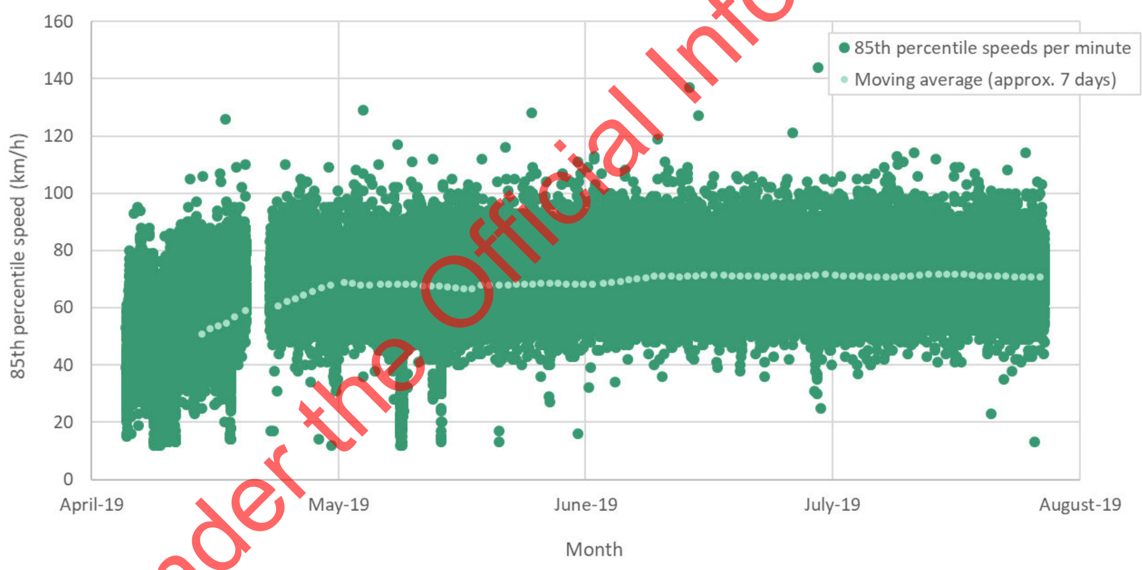



*Figure 14: 85th percentile speeds each minute at northern speed threshold (all southbound vehicles)*




*Note: All vehicle data collected is shown. Each dot represents an 85th percentile calculation of vehicles per minute. The moving average is calculated as the mean of the previous 7000 data points (roughly equivalent to 7 days of data). Data prior to 1 May 2019 is before the full implementation of the RSPs and includes periods of temporary speed restrictions at site.*

### 4.1.4. Speed profile through the intersection

The 85th percentile speed results from the 7-day data at each point of measurement in the study are shown in Figure 15 and Figure 16. Each figure shows the speed profile of vehicles as they approach, travel through, and then exit the intersection.

Both figures show the reduction in speed on approach, minimum speed at the end of the RSP, and steady acceleration upon exiting the intersection.

*Figure 15*: 85th percentile speeds northbound (mix of radar and tube measurements; 7-day data from 17-23 July)

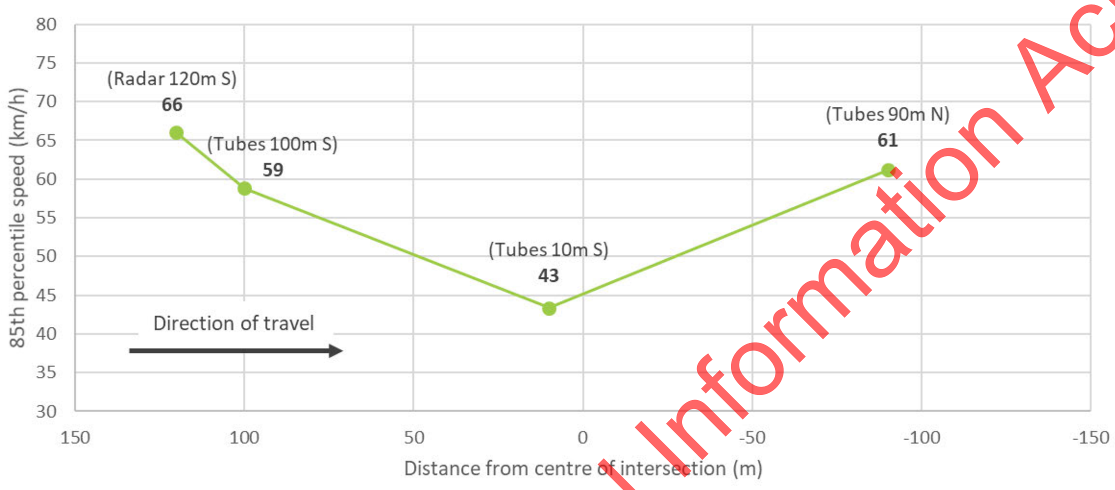
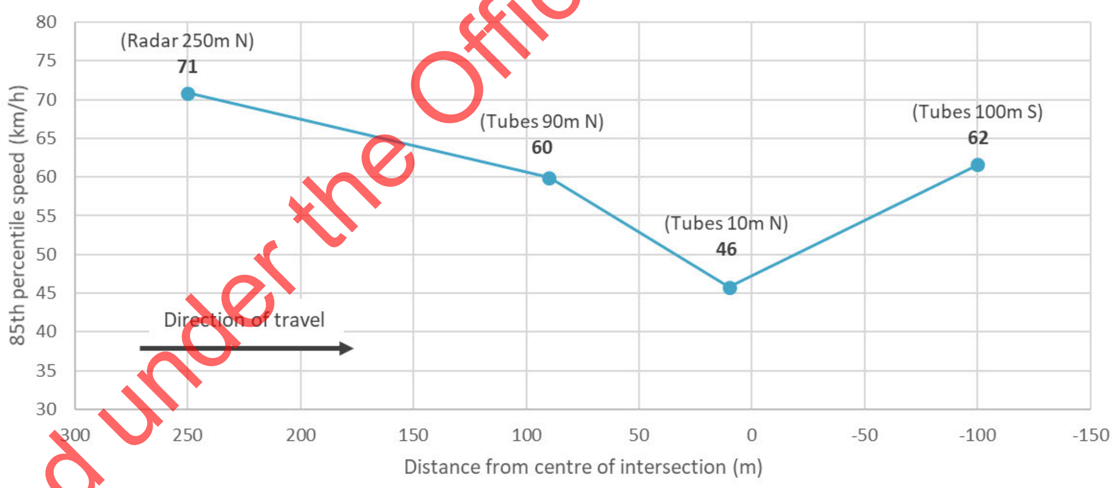



*Figure 16*: 85th percentile speeds southbound (mix of radar and tube measurements; 7-day data from 17-23 July)




*Note: Radar speed measurements are weighted 85th percentiles. Tube speed measurements are excluding vehicles recorded following others with less than a 3 second headway. Intersection departure speeds are summarised in Appendix C. Positive distances are on the approach to the intersection, negative distances are as vehicles drive away from the intersection.*

The effects of the intersection on traffic speed is clear, and although it can't be separated out, it is likely that a substantial component of this speed reduction is likely to be from the RSPs.

## 4.2. Associated safety risks

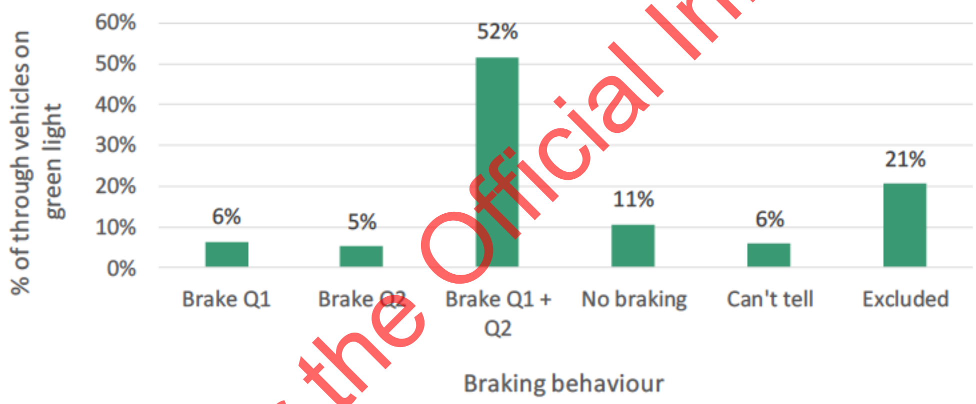
### 4.2.1. Road user behaviour - braking on approach

A total of 799 southbound vehicles travelled through the intersection on a green light during the time periods examined in the video analysis[19]. Five percent of these vehicles braked in Quadrant 2 only, the indicator of late braking used (Figure 17). This result is right on the threshold of the performance standard[20] established for this dimension of merit and indicates that a small minority of drivers may experience some uncertainty as they approach the RSP.

The greatest proportion of vehicles (52%) braked through both Quadrant's 1 and 2, indicating sustained braking during the immediate approach. About 1 in 10 vehicles (11%) did not break at all during the approach captured in the video. This result should be interpreted in the context of the low speeds through the intersection previously reported. For example, non-braking vehicles may be travelling at a speed prior to the RSPs where braking is neither required and where no braking does not constitute a safety risk.

There were no clear examples of driver confusion resulting from the RSP, which may have been indicated by very obvious hard braking ahead of the RSP.

*Figure 17: Braking behaviour on approach to the Gordon/Thomas Road intersection*




*n=799*

### 4.2.2. Road user behaviour - stopping at limit line

In the period of video data analysed, a total of 482 southbound vehicles in the through lane were coded as having stopped prior to the RSP intersection. During this same period, a total of 579 southbound vehicles in the right turn lane were coded as having stopped.

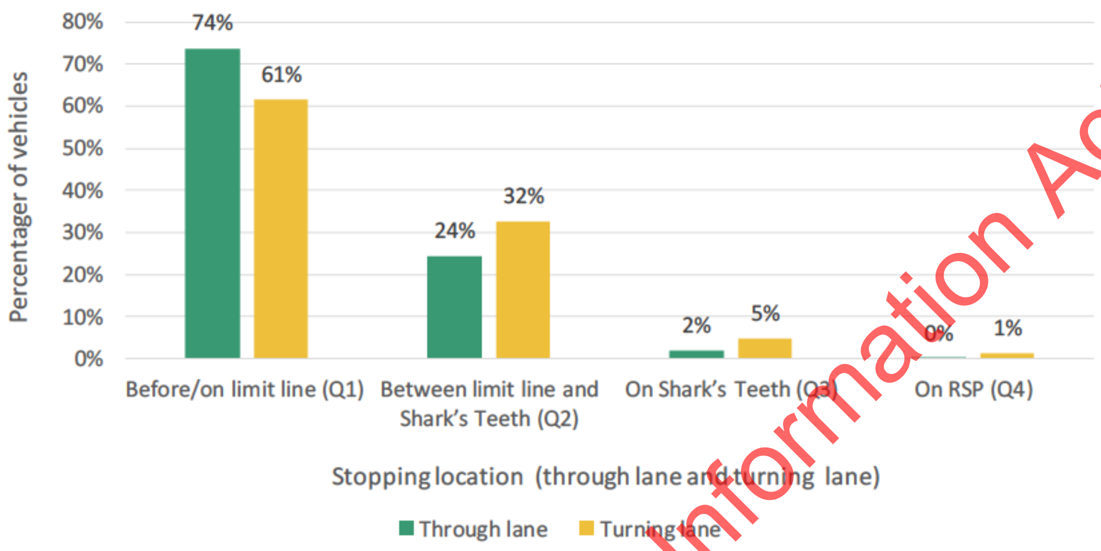
Figure 18 shows that for both lanes, the greatest proportion of vehicles stopped on or before the limit line. About a quarter (24%) of vehicles in the through lane and about a third (32%) in the right turn lane, stopped in the space between the limit line and the Shark's Teeth. A smaller proportion of vehicles stopped on the Shark's Teeth themselves (two percent in through lane, five percent in turning lane). One percent (n=7) of turning vehicles stopped on the RSP itself, while no through vehicles stopped in this position. Therefore 0.7% of all stopping vehicles in the

[19] Eight hours in 30-minute time periods (early morning, dusk, night) between 24 and 26 June 2019.

[20] i.e. Proportion of late braking vehicles does not exceed five percent of all free-flowing southbound vehicles on approach.

analysis stopped on the RSP, a result well within the performance standard established for this dimension of merit[21]. This suggests that most driver are likely to understand the layout with regards to where to stop, with a minority of drivers not complying precisely with the yield line – but at a level that is not likely to present any safety risk.

*Figure 18: Stopping behaviour at the RSP intersection*




*n=482 (through lane); n=579 (right hand turn lane)*

### 4.2.3. Road user behaviour - Red light running

No incidents of red-light running were observed during the time periods examined in the video analysis.

The Hamilton City Council has reported SCATS evidence of a slightly higher percentage of apparent red light running at the RSP intersection compared to what is typical for similar (non-RSP) intersections[22]. The Council has theorised this result may be a false 'over-count', caused when vehicles are positioned stationary forward of the limit line detector used to record a red-light violation, yet not having travelled through the intersection. It was predicted this phenomenon may be particularly evident at the RSP intersection with the limit lines set some distance back from the RSP (i.e. increasing the proportion of vehicles in a stationary position forward of the limit line and nearer to or on the RSP itself).

The stopping behaviour results from the evaluation support the Council's theory, given the proportion of vehicles stopping beyond the limit line.



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[21] i.e. Proportion of vehicles stopping on the RSP does not exceed five percent of all southbound vehicles stopping at the intersection (through and right turning lanes).

[22] For week 24-30th June 2019, the percentage of vehicles entering during red were: Eastbound right turn: 1.6%; Northbound through: 2.6%; Southbound through: 1.1%; Southbound right turn: 10.5%

### 4.2.4. Vertical acceleration

A Typical acceleration profile is shown in Figure 19, including the positive and negative changes in acceleration as the vehicle moves over the table. Table 10 shows the peak vertical acceleration measured for each of the north and southbound passes made over the RSPs (expressed as $m/s^2$ and g).

*Figure 19. Typical acceleration profile from acceleration measurements.*

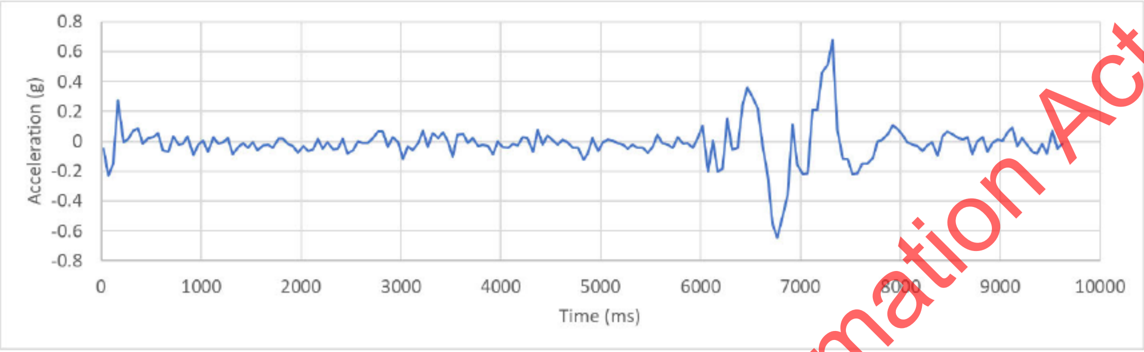
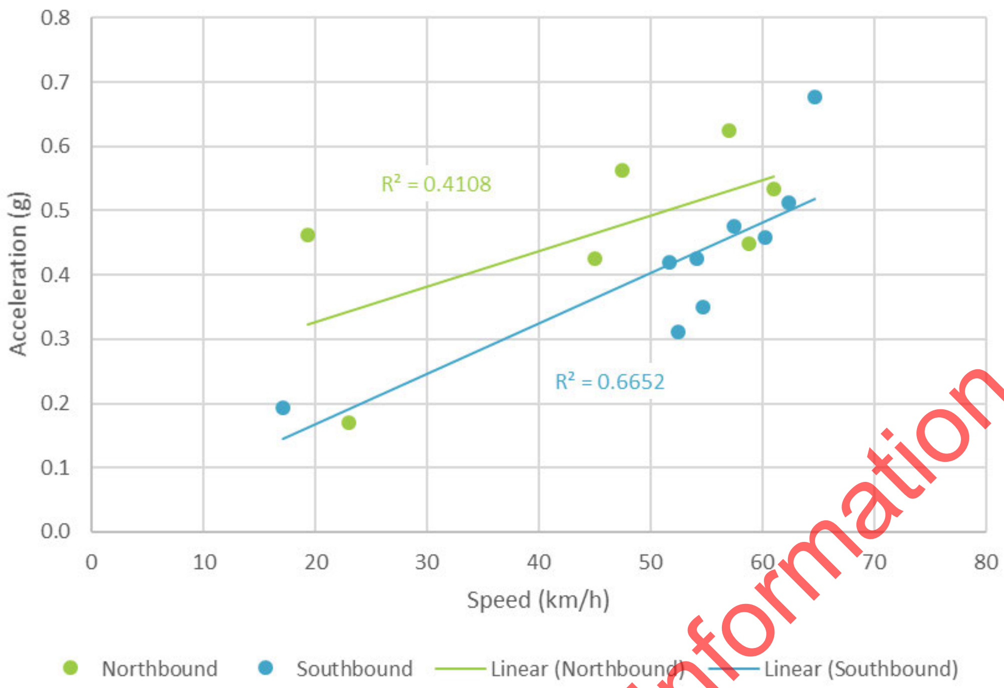



*Table 10: Peak vertical acceleration crossing the RSPs at different speeds*

| Time | Direction | Speed (km/h) | Peak acceleration (m/s) | Peak acceleration (g) |
|---|---|---|---|---|
| 3:15 PM | Northbound | 57 | 15.94 | 0.62 |
| 3:29 PM | Northbound | 59 | 14.21 | *0.45* |
| 3:33 PM | Northbound | 19 | 14.34 | 0.46 |
| 3:46 PM | Northbound | 45 | 13.99 | 0.43 |
| 3:50 PM | Northbound | 61 | 15.05 | *0.53* |
| 3:54 PM | Northbound | 23 | 11.48 | 0.17 |
| 3:59 PM | Northbound | 47 | 15.34 | 0.56 |
| 3:18 PM | Southbound | 65 | 16.45 | *0.68* |
| 3:26 PM | Southbound | 60 | 14.30 | *0.46* |
| 3:31 PM | Southbound | 62 | 14.84 | *0.51* |
| 3:38 PM | Southbound | 57 | 14.48 | 0.48 |
| 3:43 PM | Southbound | 54 | 13.99 | 0.43 |
| 3:48 PM | Southbound | 53 | 12.86 | 0.31 |
| 3:52 PM | Southbound | 55 | 13.24 | 0.35 |
| 3:58 PM | Southbound | 52 | 13.93 | 0.42 |
| 4:02 PM | Southbound | 17 | 11.70 | 0.19 |

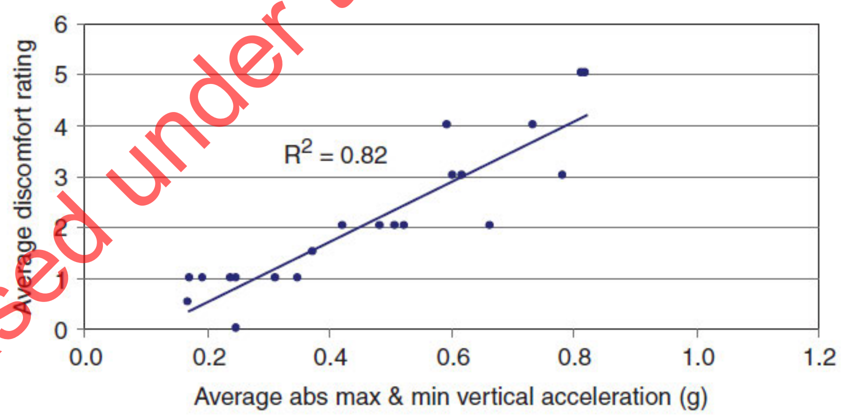
Figure 20 plots peak vertical acceleration and speed. As would be expected, a positive linear relationship is shown. Ideally, more data would be collected to confirm the relationship, however, the analysis shows that speeds of 50-60 km/h are associated with accelerations of approximately 0.4g.

*Figure 20: Peak vertical acceleration crossing the RSPs at different speeds*




A 2004 study[23] of the impact of road humps on driver comfort is used to assist with the interpretation of the vertical acceleration results in this study. The earlier study reported that vehicle occupants are generally unwilling to accept a peak vertical acceleration of greater than 0.7 g. Further, accelerations of approximately 0.4g, the 'g' force of appropriate speeds (50-60 km/h) over the RSPs found in this study, were equated with average driver discomfort ratings of 2[24], where a rating of 2-3 = Slightly uncomfortable (Figure 21). Therefore, taking the 2004 study as a reference point, it can be concluded that the peak vertical acceleration of appropriate speeds over the RSPs is within acceptable ranges for driver comfort.

*Figure 21*: Correlation between driver discomfort rating and vertical acceleration




*Source: Kennedy, J., et al (2004).*

[23] Kennedy, J., et al (2004). Impact of road humps on vehicles and their occupants. Prepared for Charging and local Transport Division, Department of Transport. TRL Report TRL 614.

[24] Where 0-1 = Comfortable, 2-3 = Slightly uncomfortable, 4-5 = Uncomfortable, and 6 = Very uncomfortable.

Earlier simulation work was also carried out by WSP-OPUS to investigate whether the proposed inclusion of an RSP on the right-hand turn (into Thomas Rd) would have a significant effect on the stability of turning trucks[25]. The RSP was modelled to have negligible effects on changing the critical roll-over speed, compared with the same turn without the RSP, for both constant speed and constant acceleration.

### 4.2.5. Cyclist and pedestrian safety

No cyclists or pedestrians used the intersection in the periods coded for the braking analysis, while one cyclist was recorded during the stopping behaviour analysis. There was nothing about this example of cyclist use of the intersection that suggested unsafe use for the cyclist.

### 4.2.6. Safety perception (community)

One potential safety related concern about the RSP was received by Hamilton City Council during the period monitored (see below). The submission raises concern about the visibility of the RSP and suggests the need for improved signage.

> *"Just a question, who is in control of the section of Gordonton Road near Thomas Road? The raised table near the traffic lights is particularly difficult to see at night in bad weather. There is very little depth perception to see that the cross hatching indicates a height change in the road surface. If the light is green for traffic coming down hill that don't know about it, hitting the table could cause an accident. The signage needs to be clearer or a speed bump sign needs to be clearly visible."*

It is understood that the RSP project team are also aware of the visibility concern raised by the submission. Independently, other individuals have commented that the visibility of the vertical nature of the RSP could be made more obvious. These perceptions do not report a critical safety event and the performance standard established for the perceived safety dimension of merit is therefore achieved. However, the comments about this do suggest that consideration of how the vertical component of the RSP could be made more obvious, is warranted.

## 4.3. Delivery and operation

### 4.3.1. Traffic flow and throughput

Assessment of the impact of the RSPs on traffic flow and throughput undertaken by the Hamilton City Council Transport Systems Engineer concludes that there is currently little evidence that the RSPs are significantly impacting intersection capacity. It is observed the RSPs may actually replicate the effect of how limiting motorway speed during times of high volume can increase throughput (i.e. reducing the operating speed somewhat at the intersection may not necessarily have any effect on throughput during times of high volumes).

The assessment also concluded:

- Driver behaviour at the intersection when accelerating from stopped (i.e. from green) appears similar to non-RSP sites in terms of acceleration rate and headway.
- Since fully operational, there has been no requirement to alter 'normal' traffic signal timing settings (e.g. inter-green times) as a result of the RSPs.

[25] Jamieson, N. (2018). Investigation of proposed road safety platform at Gordonton Rd using simulation modelling. Opus Research Report 18-232499.26

- The heavy vehicle acceleration rate appears more of a factor, for both RSP and non-RSP sites, compared to whether there is a raised platform (e.g. in the situation when light vehicles are 'stuck' behind a heavy vehicle that is accelerating slowly away from the intersection).
- Higher-speed platform profiles, as used in the Hamilton RSPs, are likely to help with avoiding effects on intersection delay, compared to more abrupt platforms that seek a more significant speed reduction (e.g. 25-30km/h).

The observation that RSPs may actually increase traffic throughput during peak volumes concurs with earlier Dutch research[26] cited by Corben & Candappa (2014)[27]. The Dutch study reported that raised stop bars at very busy intersections not only improved safety but also enhanced intersection capacity and the ability to negotiate intersections.

### 4.3.2. Noise

During the development of the evaluation plan, noise measurement was considered. However, on inspection of the intersection in operation, including articulated trucks driving over the RSPs, it was determined that the noise impacts are likely to be negligible, and probably undetectable compared with the other noises caused by vehicles moving through the intersection. Earlier consultation with a noise measurement expert also suggested difficulty in objectively measuring the noise impacts of the RSPs without clean baseline data. Therefore, on balance it was decided that the effort required to collect noise data was not justified by the marginal value it would provide.

There have not been resident reports of noise caused by the RSPs, and this will continue to be monitored by Hamilton City Council in Future.

### 4.3.3. Council and community buy-in

As reported, only one safety related concern about the RSP was received by Hamilton City Council during the period monitored. The Hamilton City Council project close down report and summary of findings from the lessons learnt workshop (see below) reports high Councillor engagement and support, high stakeholder satisfaction overall, high level of partner trust, commitment, and confidence, and no major project related complaints from the community during the design and implementation stages.

### 4.3.4. Project delivery

Project delivery issues identified during the 'lessons learned' workshop were reported by Hamilton City Council[28].

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[26] Fortuijn, LGH, Carton, PJ & Feddes, BJ (2005). Veiligheidseffect van kruispuntplateaus in gebiedsontsluitingswegen. In CROW (Ed.), Bijdragen Verkeerskundige Werkdagen 2005 (pp. 1-19). Ede: CROW.

[27] Corben, B., & Candappa, N. (2014) Proposed trial of elevated stop lines at Surfcoast Highway and Kidman Avenue, Belmont. Final Project Report. Corben Consulting and Monash University Accident Research Centre.

[28] Hamilton City Council (2019). Project Closedown Report. Thomas/Gordonton Intersection Improvement. Trim document number: D-3015913. Hamilton City Council.

The Council report concludes that the project was completed satisfactorily, was of high quality, had high councillor engagement and support, and overall high stakeholder satisfaction, and had achieved intended outcome. Factors contributing to the success of the project were identified to include:

- effective working relationships
- collaboration between project staff and contractors
- good communication
- quality and fit for purpose methods and solutions
- innovative practice,
- partner trust, commitment, and confidence.

There was timeframe pressure throughout the project and the end date changed on a number of occasions. Pressure to complete the project was exacerbated by a fatal crash during the design stage. A degree of flexibility during the design and implementation stage was considered appropriate and inevitable given that the project was the first of its kind in New Zealand. Management of vehicle speeds through the worksite during construction was challenging, however, was managed satisfactorily. No major complaints about the project were received from the community during the project design and implementation stages.

A range of delivery and operation issues were identified in the Council report. In synthesis, these issues reinforced the importance or need in such projects for:

- clearly defined project processes, systems, concepts, roles and responsibilities, timing, and roll out (at the outset and early in the planning stage)
- project ownership and leadership within Council
- effective project management, including on-going monitoring of actions and milestones, and risk management
- necessary pre-construction information, testing, design, and other preparations (e.g. service locations, pavement testing)
- defined communication channels, integration of different communication channels, and the maintenance of communication through all stages
- identify, engage, and work with key stakeholders early in planning and throughout as required
- engage community early in the planning process and maintain communication throughout the project
- effectively manage community expectations (e.g. timing, completion).

The synthesis above indicates that delivery issues associated with the RSP project were largely consistent with those that might be expected in other similar projects. Further, there is little evidence that the project generated delivery issues specific or unique to the RSP treatment itself.

# 5. EVALUATION SYNTHESIS

This section synthesises the evaluation results and concludes on the performance of the RSPs on each dimension of merit established in the evaluation.

## 5.1. Performance conclusion – **Safety improvement**

**"What is the effectiveness of the RSPs, in terms of providing a Safe System intersection solution?"**

Under the Safe System, the most important measure of effectiveness is speed through the intersection not exceeding 50km/h. 85% percentile speeds easily met the standard and 95% percentile speeds (northbound) also met the standard (Table 11)[29].

*Table 11: Evaluation synthesis and conclusion – **Safety improvement***

| Evaluation question | Dimension of merit | Evaluation result | Perf std met? | Evaluation conclusion |
|---|---|---|---|---|
| *Are intersection and approach speeds reduced to desired levels?* | Vehicle speed through the intersection. | 85th percentile speed well under 50km/h. | Yes | RSPs are associated with desired intersection speed[30]. |

## 5.2. Performance conclusion – **Associated safety risks**

**"What observed safety risks are associated with implementation of the RSPs?"**

It is concluded from the results for late braking, red light running, and peak acceleration that there is a **low risk** of the RSPs increasing crash risk (Table 12). The method used to monitor community feedback also provided little evidence the RSPs are perceived as unsafe by the community, although it is acknowledged that this method involved checking Council public feedback channels for related comments, as opposed to actively surveying motorists The results for stopping at the limit line suggest that a higher recorded incidence of red light running at the intersection is likely being contributed to by stopping behaviour and which is behaviour that does not constitute actual red-light violations in most cases.

It is concluded from the results of stopping on the RSP itself, that the RSPs are associated with a low risk of erratic or unsafe driver behaviour. Less than one percent (0.7%) of all stopping

[29] The ability to confidently attribute the result to the RSP is compromised in this study by the absence of baseline speed data prior to the installation of the treatment.

[30] Notwithstanding the uncertainty about attribution.

vehicles in the analysis stopped on the RSP, a result well within the performance standard established for this dimension of merit[31].

The relatively high proportion of vehicles stopping somewhere beyond the limit line and up to the end of Shark's Teeth (26% of through lane vehicles, 38% of right turn lane vehicles), may be occurring because the limit line is set some distance back from the Shark's Teeth. While this behaviour would appear to be relatively low risk, the Hamilton City Council may wish to examine this finding further.

There was insufficient data collected to conclude on the likelihood of the RSPs impacting the behaviour of VRUs using the intersection.

*Table 12: Evaluation synthesis and conclusion – **Associated safety risks***

| Evaluation question | Dimension of merit | Result | Perf std met? | Conclusion |
|---|---|---|---|---|
| *Likelihood of RSPs increasing other crash types, particularly rear end.* | Braking on approach. | Late braking by 5% of vehicles. | Yes. | Low risk of increasing crash risk |
| *Likelihood of erratic or unsafe road user behaviour?* | Stopping at limit line | .66% of stopping vehicles stopped on the RSP. | Yes. | Low risk of erratic or unsafe behaviour. |
| | Red light running. | No incidents observed. | Yes | Stopping behaviour is likely to contribute to the recorded incidence of red light running. |
| | Vertical acceleration | Peak vertical acceleration at appropriate speeds over the RSPs is within an acceptable range for driver comfort. | Yes | Impact of vertical acceleration on safety risk and driver comfort is within an acceptable range. Previous truck roll-over analysis showed negligible effects. |
| | Perceived safety (community) | One safety related submission (but not a critical safety event). | Yes | Community feedback method provides little evidence that RSPs are perceived as unsafe. |

[31] i.e. Proportion of vehicles stopping on the RSP does not exceed five percent of all southbound vehicles stopping at the intersection (through and right turning lanes).

| | | |
|---|---|---|
| *Likelihood of impact on the behaviour of VRUs?* | Cyclist/pedestrian safety | Insufficient data to conclude |

## 5.3. Performance conclusion – **Delivery and operation**

"What operational issues might be associated with the RSPs?"

It is concluded that the RSPs have performed as intended and should be considered for further roll out (Table 13). Expert assessment finds no current evidence of a negative impact on traffic efficiency. There is reported evidence of council buy in and limited evidence to suggest community opposition. Observations and experience during the delivery and operation of the site would support wider roll-out of this measure as a Safe System solution.

*Table 13: Evaluation synthesis and conclusion – **Delivery and operation***

| Evaluation question | Dimension of merit | Evaluation result | Perf Std met? | Conclusion |
|---|---|---|---|---|
| Impact on traffic efficiency through the intersection. | Traffic flow and throughput. | RSPs assessed by expert as not negatively impacting traffic flow and throughput. | Yes | No current evidence of a negative on traffic efficiency. |
| Impact on council and community buy in. | Issues reported by staff, contractors, and stakeholders. | High councillor engagement and support; high level of partner trust, commitment, and confidence, no major project related complaints from the community; only one recorded public submission about the RSPs. | Yes | Evidence of positive council and community buy in. |
| Delivery and operational issues. | Issues reported by staff, contractors, and stakeholders. | Reported issues are typical for similar projects and not treatment specific. | Yes | Reported issues do not indicate any safety or operational issues. |

# 6. EVALUATION CONCLUSION

This section concludes on the overall effectiveness of the RSPs and gives direction to the further development of RSPs and the RSP evaluation framework.

## 6.1. RSP effectiveness

The primary purpose of this evaluation was to determine whether the Gordonton/Thomas Road RSPs provide an effective Safe System solution for reducing DSI crashes at signalised intersections. A secondary purpose was to learn about implementation issues and wider performance characteristics.

The RSPs met all 10 of the measured performance standards established. From this result, it is concluded that the RSPs are an effective Safe System solution. Note, however, that reduced DSI crashes is the ultimate long-term measure of success and this will be measured at an agreed time in the future.

The most important measure of effectiveness within the scope of this evaluation is intersection speed, and while the absence of clean baseline data reduces the confidence with which measured speeds after installation can be attributed fully to the RSPs, the evaluation shows speeds well under the target of not exceeding 50km/h. When the earlier performance of the intersection is considered – with 85% speeds typically at approximately 80 km/h, it is clear that the new intersection configuration, including the RSPs, is now operating in line with Safe System performance levels.

The effectiveness of the RSPs are also noteworthy given that the approach speeds are relatively high with variable compliance with the 60 km/h speed limit. The high (>60km/h) approach speeds, while not specifically part of the RSP performance standards are areas for future attention with regard to the effectiveness of other supporting speed management measures such as lowered speed limits and speed limit threshold treatments.

The RSPs met the performance standard on five dimensions of merit under the potential for associated safety risks. There was insufficient data to concluded on the sixth dimension (likelihood of impact on the behaviour of VRUs). Overall, it is concluded there is a low risk of associated safety risks from the RSPs, including other crash types.

The RSPs met the performance standard established on all four dimensions of merits under delivery and operation indicating good performance in this regard

Overall, RSPs are likely to be an effective road safety countermeasure moving forwards.

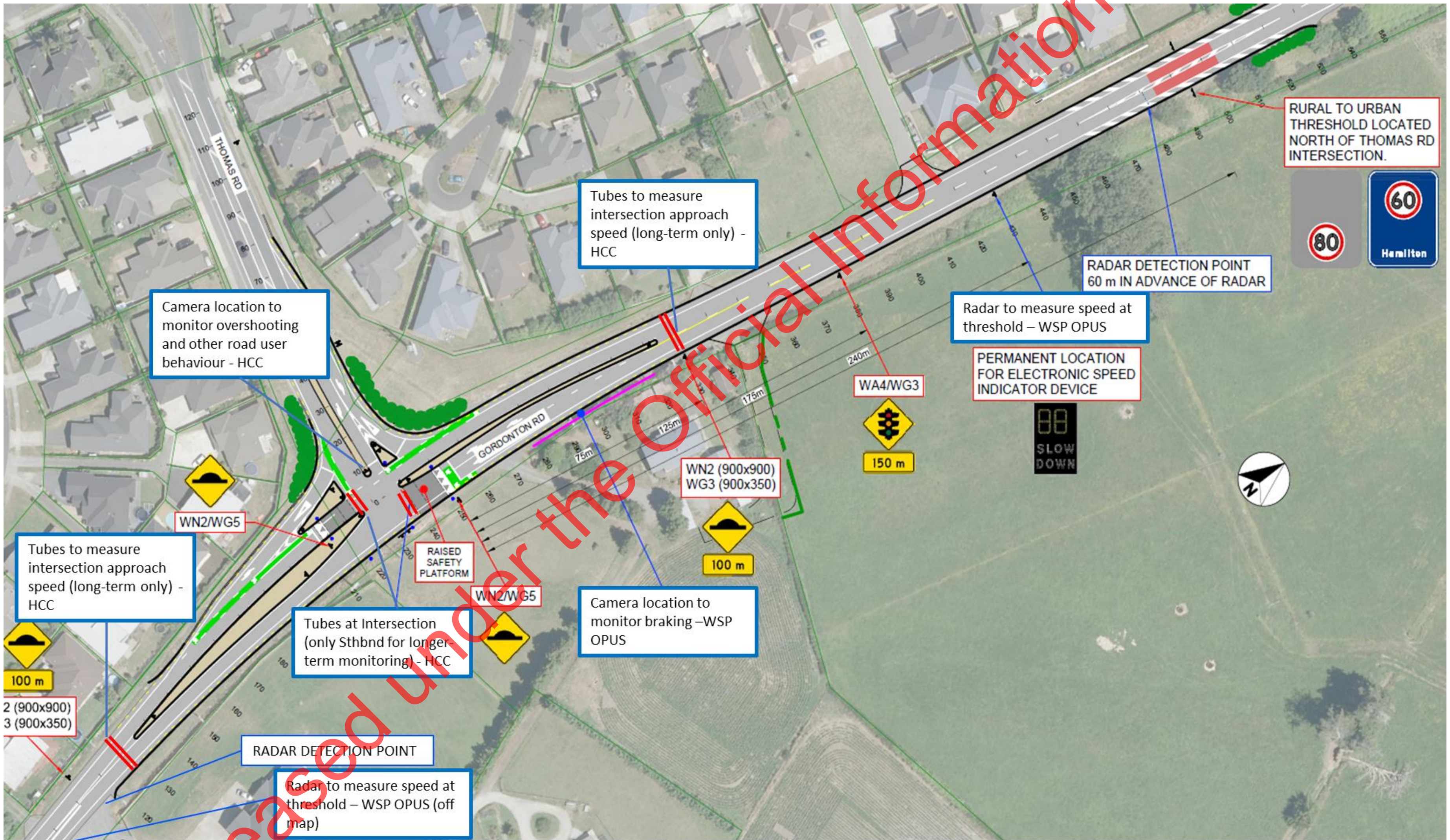
## 6.2. Further developments

Feedback on the RSP treatment suggests that the Hamilton City Council may wish to investigate strategies for improving the visibility of the RSP and particularly the change in height. Possible measures could include a colour treatment (e.g. Red) on the platform itself.

The RSP evaluation framework developed through this evaluation will be strengthened by ensuring appropriate baseline data collection, so that resulting changes on key performance indicators for future projects can be more confidently attributed to the installation of RSPs.

# 7. APPENDICES

## Appendix A: Layout for data collection (Background plan courtesy of WSP OPUS)



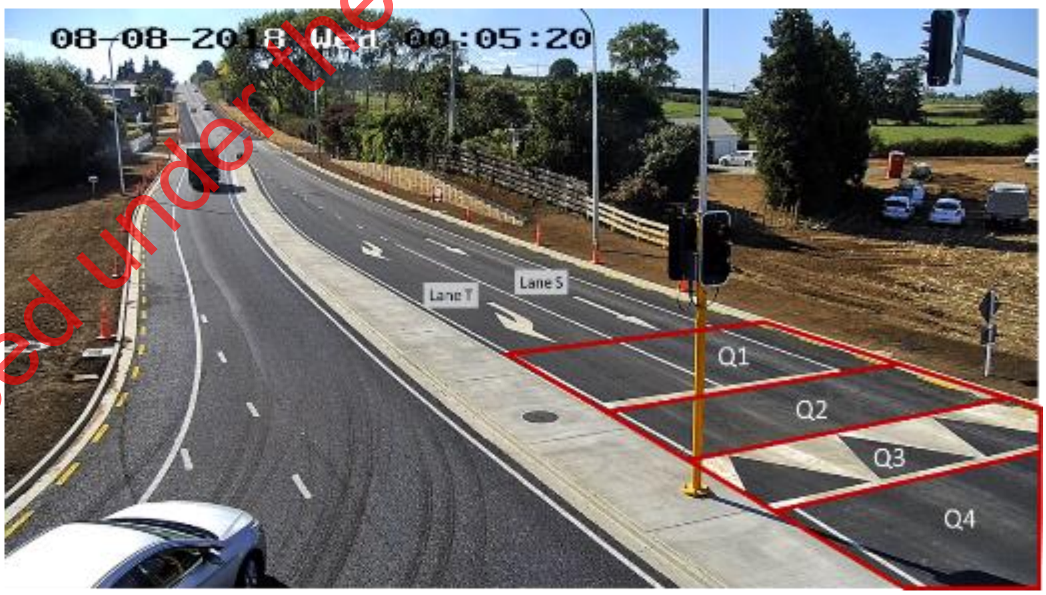
# Appendix B: Video analysis framework and protocol

This analysis involves two protocols from two different cameras:

- Hamilton City Council Camera
    - CCTV footage
    - High-resolution
    - View of approaching vehicles
    - Cannot determine signal phasing
- Opus Camera
    - Poor quality footage, sometimes blurred
    - Rear view of vehicles approaching intersection
    - Can determine signal phasing
    - Good understand braking behaviour. However, only clear at night/dusk/dawn

| Hamilton City Council Camera | Opus Camera |
|---|---|
|  |  |

## Hamilton City Council Camera



## Aim

This field of view gives us an indication of **vehicle's limit line compliance when stopping**. Behaviour in each lane is recorded separately (T=turning lane; S=straight ahead). The field of view has been divided into four quadrants:

- Q1 – Behind or on the limit line
- Q2 – Between the limit line and the start of the Shark's Teeth
- Q3 – On the Shark's Teeth
- Q4 – On the table

A vehicle's location is determined by the placement of their front wheels. Some examples are shown below.

| | |
|---|---|
| Q1 |   |
| Q2 |    |
| Q3 |  |
| Q4 |   |

Because the camera angle does not show the traffic light, we cannot determine red light running from this field of view. However, we can determine the location past the limit line that they stop.

This camera angle does not show the signal phasing. Therefore, we won't be able to detect people running a red light. But this will potentially help to explain the slightly high levels of red light running mentioned by John Kinghorn from the Hamilton City Council.

## Coder notes

- Only code vehicles who have stopped and who are at the front of a group
- Watch in 4x speed
- Set a timer for every 5 minutes. At every 5-minute interval, add in a code under the date and time column. This will break the coding up into 20-minute video blocks
- Code 24 hours of footage across one day.
- If a pedestrian or cyclist is present in the intersection, give them a new row, put in a timestamp and highlight it

## WSP Opus camera


### Aim

The coding protocol for this camera view will look at **vehicle's braking behaviour on approach to the intersection under green light conditions**.

- Examine braking behaviour for both lanes of traffic
  - B = Is the vehicle braking for the whole frame (Q1+2)
  - O = Braking in Q1 only
  - L = Do they brake quite late (Q2)
  - N = No braking
  - U = Can't tell
  - E = Excluded because someone is in front of them (less than two arrows), or they started from stopped (i.e. red light), or were in a queue (i.e. red light)

In addition, **vehicles that are non-compliant with the red signal (go through the entire intersection)** will be coded:

- Date, time, lane
- Number of seconds between the light turning red and the entry into the intersection
- Other traffic present? Any incidents?
- Any braking, slowing behaviour?
- Open-ended description

### Coder notes

- The signal phasing differs for through vs right-turn vehicles. Important to be alert to this during coding
- Code 8 hours of footage at x1 speed
- Code only during low-light conditions
- If a pedestrian or cyclist is present in the intersection, give them a new row, put in a timestamp and highlight it.

# Appendix C: Intersection departure speeds

*Table 14: Departure speeds (approx. distances from centre of intersection; 7-day data from 17-23 July 2019)*

| | Northbound (90m north) | | Southbound (100m south) | |
|---|---|---|---|---|
| | *All data* | *<3 second head way removed* | *All data* | *<3 second head way removed* |
| Total vehicle count | **25178** | **17753** | **43910** | **25071** |
| $85^{th}$ percentile speed (km/h) | **61** | **61** | **60** | **62** |
| $95^{th}$ percentile speed (km/h) | **65** | **66** | **65** | **66** |
| Vehicles over speed limit | **16.5%** | **19.4%** | **16.3%** | **21.7%** |