# Road Safety Study – Candia Road – 'Before' and 'After' Crash Monitoring

Bruno Royce

Traffic Engineering Solutions Ltd

## Abstract

In 2009 a crash study determined that a substantial rural road loss-of-control crash problem exihsted along Candia Road (Auckland, New Zealand).

In 2010, substantial crash remedial works were recommended, designed and installed along the study cordon.

In 2017, reported crash statistics were studied along the study cordon for a 7 year period 'before' and 'after' the crash remedial works were installed. It was determined that the combined package of constructed works reduced crashes significantly. Prior to works, 45 crashes were reported along the study cordon over 7 years, including 1 fatality and 9 serious injury crashes. After works, only 6 crashes were reported over 7 years, with zero death/serious injury crashes, and no evidence of crash migration. Reported crashes reduced by a substantial 87%, with $24 million in lifetime crash cost savings, very high Benefit Cost Ratio (19), and an average of 1.4 Death/serious injury crashes saved per year.

## Background

A crash reduction study in 2009 of Candia Road (Henderson, Auckland, New Zealand) established that a substantial rural road loss-of-control crash problem existed between Henderson Valley Road and Sturges Road. The outcome of the study was a package of crash remedial works which were constructed in early 2010. The majority of the works were implemented at two bends within the study cordon. In order to determine the effectiveness of the works, a 'before' and 'after' study was undertaken in 2017. Reported crashes were compared for a seven-year period 'before' the works were implemented (2003 – 2009, inclusive), and a seven-year period 'after' the improvements were installed (2010 – 2016, inclusive). A 7 year analysis period was selected rather than the typical 5 year period because the data was available, and a longer period of analysis was considered likely to improve the significance of the analysis.

## Study Cordon

Candia Road is a rural road located in Henderson, West Auckland, with a posted speed of 70km/h. The area is predominantly farmland and rural lifestyle blocks. The study cordon was a 1km section of Candia Road located between Henderson Valley Road and Sturges Road. This section was selected because it had a high number of reported crashes prior to the crash study, over a five-year period (2004-2008). The junctions of Henderson Valley Road and Sturges Road were excluded from the study due to crash patterns at these junctions being minor and not related to the main crash pattern (loss-of-control crashes). Candia Road carried around 2,500 vehicles per day (vpd) in 2010, and 3,500 vpd in 2016, representing a 40% increase in traffic over this time period.


*Figure 1: Location of Study Cordon*

## Method

During the initial crash study, The New Zealand Transport Agency (NZTA) Crash Analysis System (CAS) crash plots indicated that reported crashes were predominantly loss-of-control, and these were distributed along the entire study cordon route. However, a detailed review of individual Traffic Crash Reports revealed that most of the loss-of-control crashes on the crash plots directly related to two major, sharper bends (to the north and south of Vineyard Road), with a relatively minor number of crashes related to a third more moderate bend (at Vineyard Road). Many of the crashes were not plotted correctly at the actual location of the bends, and there are two main reasons considered likely to explain this:

- Rural road crashes may be plotted in accordance with the final resting place of the errant vehicle, rather than at the location where the loss-of-control problem begins. In the case of loss-of-control crashes the difference can be significant, as vehicles gradually losing control can traverse a sizeable distance before coming to rest. It is important to track loss-of-control crashes back to the original location of the problem; and

- Rural roads often have few indicators to help identify an exact geographic location, and the approximate location of a crash may be estimated based on a rough distance from the nearest side road. Detailed examination of Traffic Crash Reports can provide clues to help identify the causal factor and its precise location.

Crashes are often a result of a combination of contributory factors acting simultaneously. Along the subject route the loss-of-control crash problem was considered to be aggravated by a combination of the following key factors:

- Excessive vehicle speeds for the road environment, with two relatively sharp bends and one moderate bend on a road with a posted speed of 70km/h;
- Lack of conspicuity of curve warning signage, with the existing curve warning signage being technically correct but limited in terms of visibility (number, location, size, and obstructed by vegetation);
- Narrow and unforgiving road shoulders, reducing the space available for motorists to correct an errant vehicle;
- Ineffective road-marking delineation (faded edgeline and centreline);
- Irregular road surface condition (patch seal repairs and evidence of seal failure);
- Inconsistent super-elevation (undulating road surface);
- Insufficient road surface skid resistance (visual evidence of longitudinal cracking and flushing of seal surface).

The crash severity was considered to be exacerbated by the road's narrow width, increasing the likelihood of head-on collisions. Also, a steep embankment existed on the outside of two bends, with no guardrails, increasing the risk of Run-off and Roll-over (R&R) crashes.
A package of crash remedial measures was proposed (TES 2009), with reference to general recommendations in technical guidelines (Austroads, 2009a; Austroads, 2009b; Transit New Zealand, 2009). The works were focussed mainly at the two sharper bends, and the following works were considered (illustrated in Figures 2 and 3):

- **Curve warning signage and chevrons**: Upgrade quantity, size, visibility and double-gate;
- **Embankment:** Cut-back embankment to improve forward visibility on the inside of one bend;
- **Road shoulders**: Widen and seal road shoulders, to provide a more forgiving roadside and more opportunities for errant motorists to correct their vehicle if starting to lose control;
- **Shape correction**: To provide a smooth road surface and consistent super-elevation around the bends;
- **Skid resistant surface**: A highly skid-resistant road surface (Polished Stone Value > 70) at two bends, reducing likelihood of loss-of-control at the bends;
- **Water-cutting**: Water-cut the road surface on the approaches to the bends, to reduce the likelihood of loss-of-control crashes on the approaches to the bends, but with reduced expenditure (as opposed to skid resistant surfacing);
- **Guardrail**: Install guardrail, to prevent errant vehicles from R&R down an embankment on the outside of two bends;
- **No Overtaking**: Install thermoplastic double yellow 'No-Overtaking' lines, to discourage

overtaking and speeding, and to reduce the visual appearance of the road's width;

- **Thermoplastic road-marking**: Install thermoplastic road-marking for durability;
- **Reflective Raised Pavement Markers (RRPM's)**: Upgrade RRPM's, with red and amber reflective faces for edgeline and double yellow 'No-Overtaking', respectively;
- **Edge marker posts**: Maintain posts and install additional posts, for improved delineation, particularly at night;
- **Vegetation trimming**: To improve forward visibility of existing and proposed signage;
- **Street-lighting**: Being a rural road, only flag-lighting of junctions was required. The junction at Vineyard Road had no crash problem and adequate flag-lighting;
- **Raised profile road-marking**: This was recommended for edgelines and centrelines, for enhanced visibility and audible warning should a motorist start to deviate. However, it is understood that this recommendation was deleted from the final plans due to concerns about the possible effect of associated noise on local residents.

The proposed crash remedial works did not include special provisions for pedestrians and cyclists, since vulnerable road users weren't significant in the reported crash statistics, and pedestrian / cyclist volumes were observed to be low. Figures 2 and 3 illustrate the proposed works as photographed after implementation.

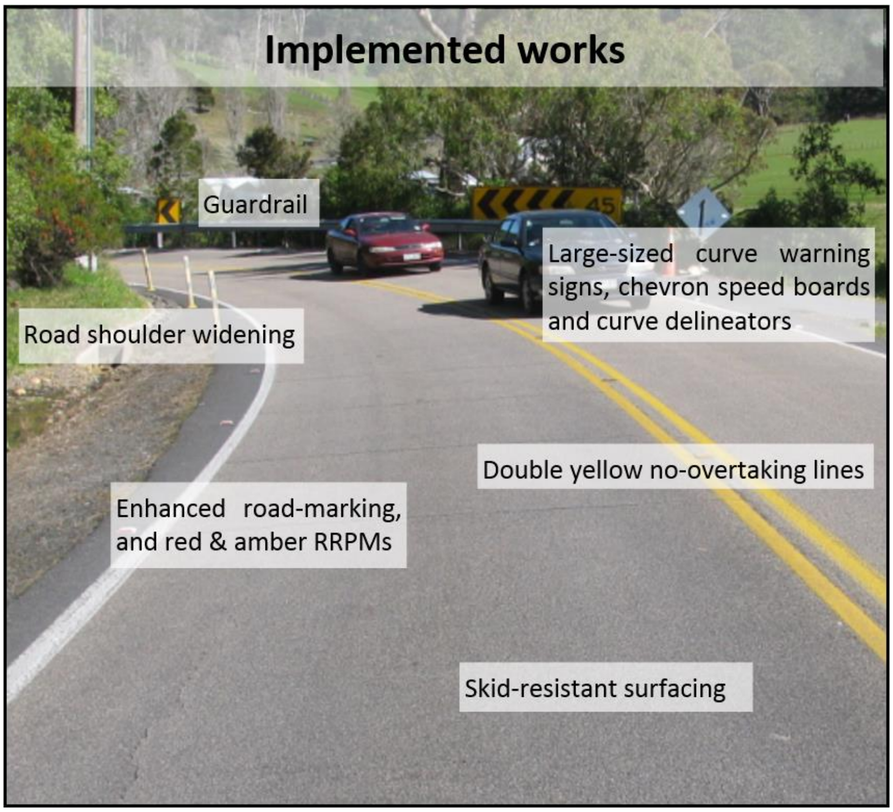



***Figure 2: Constructed works on the northern approach to the bend north of Vineyard Road. Similar works were implemented on the southern approach to this bend***

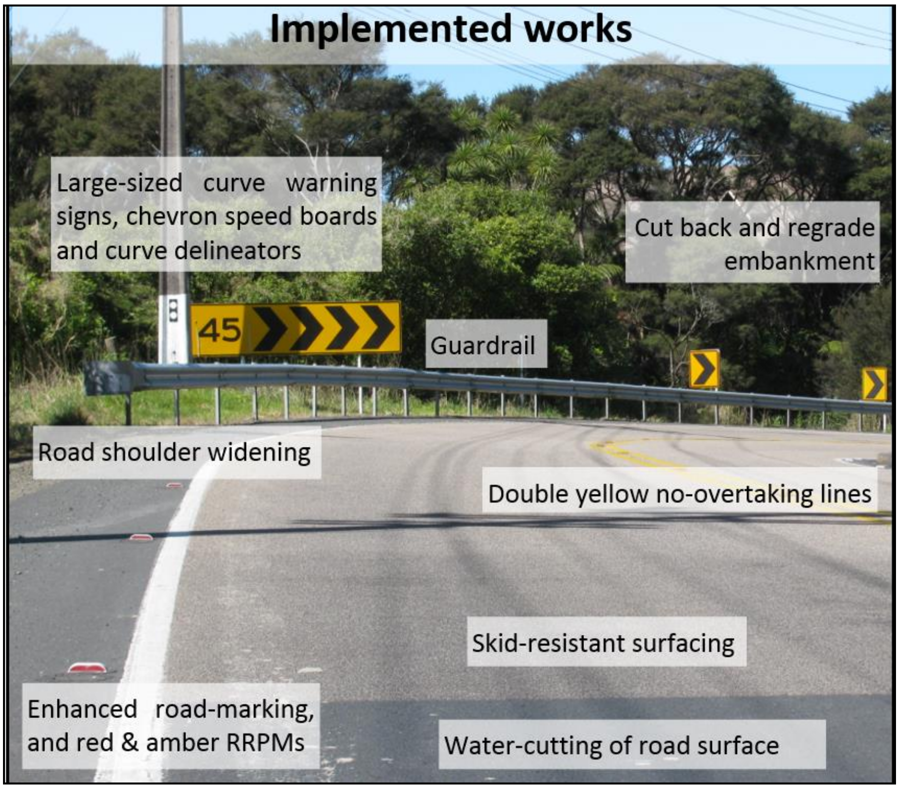



***Figure 3: Constructed works on the northern approach to the bend south of Vineyard Road. Similar works were implemented on the southern approach to this bend***

**Results**

Figure 4 illustrates a crash plot of reported crash statistics 'before' the crash remedial measures were installed. The position of most crashes has not been edited, and the crashes appear to be distributed along the entire route.

Figure 5 illustrates the same crashes as Figure 4, but Traffic Crash Reports have been analysed in detail and the exact nature, position and direction of each crash re-plotted. Correct interpretation of Traffic Crash Reports can require significant experience and technical expertise. This further analysis results in crash patterns being much stronger and more evident. This enables the causal factors to be identified more accurately, and any proposed remedial works to be focussed on the main issues.

Figure 6 illustrates a crash plot of reported crash statistics 'after' the crash remedial measures were installed. In this case the Traffic Crash Reports were not analysed for accuracy of the crashes' positions and directions, as it is evident that there have been significant crash savings achieved, and the exact nature of the crash patterns are less relevant at this stage of the analysis.

The works were installed in early 2010. Hence, for the crash monitoring, the 'before' analysis encompassed a seven-year period from 2003 to 2009 (inclusive), and the 'after' analysis encompassed a seven-year period from 2010 to 2016 (inclusive).

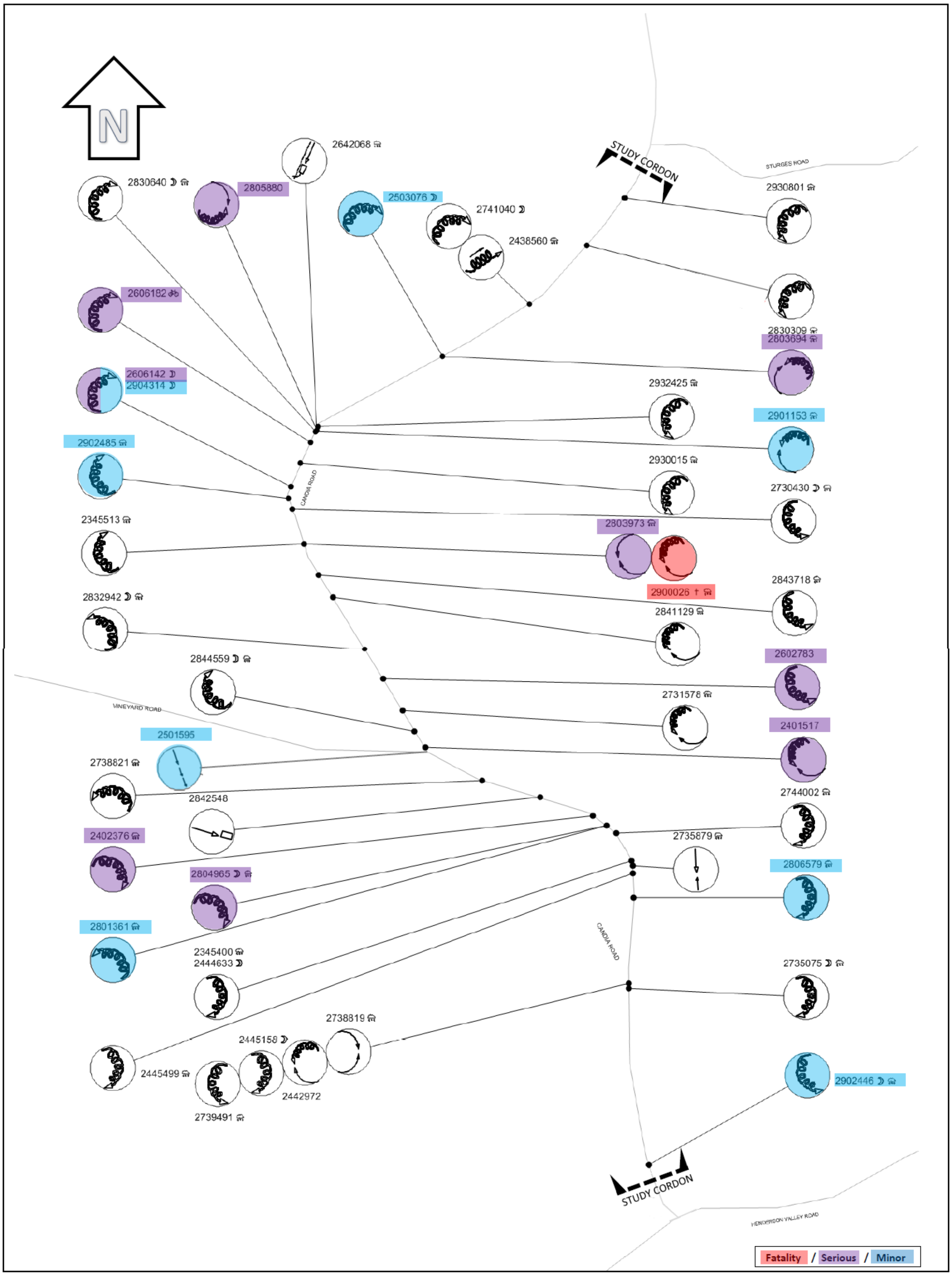
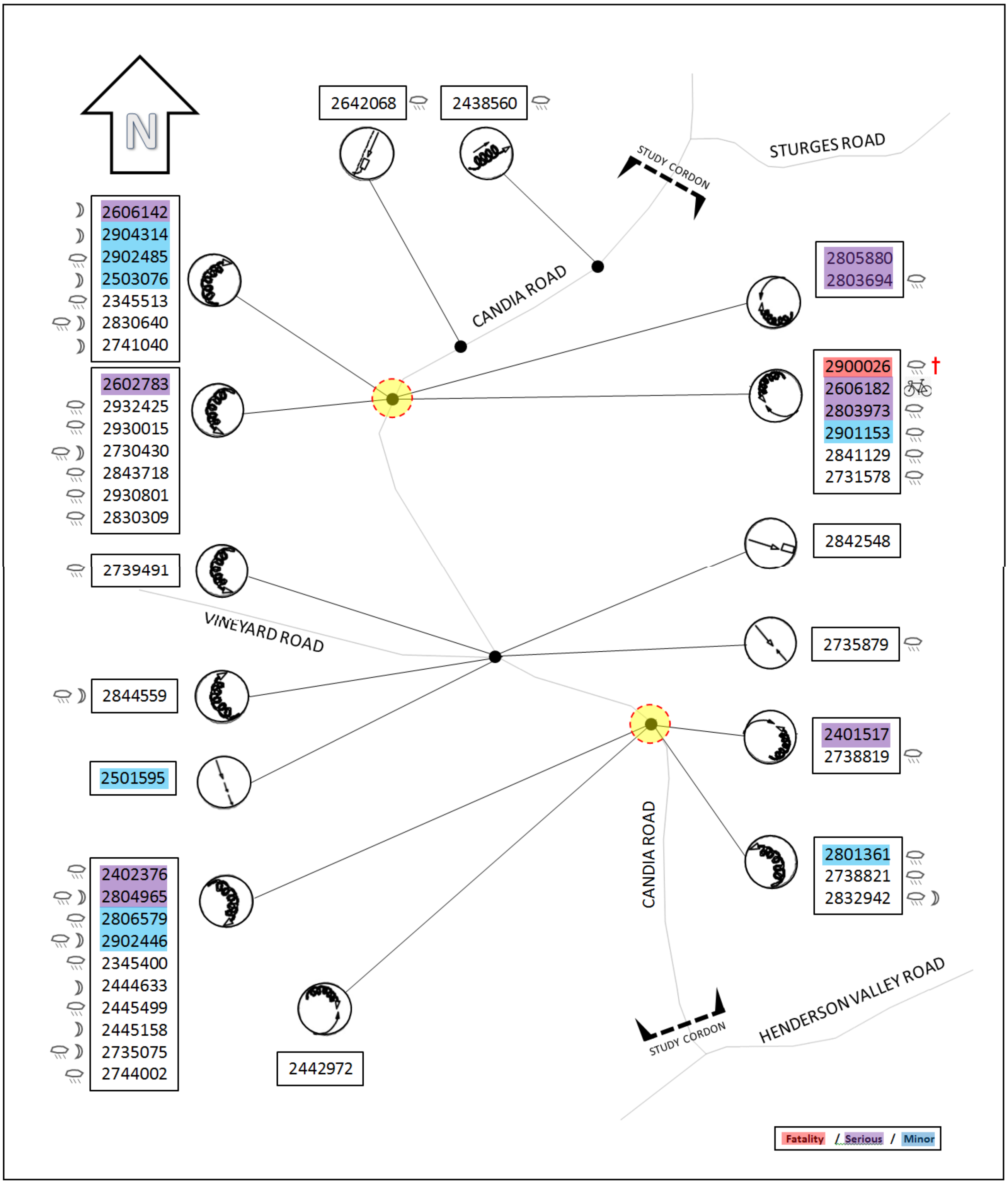



***Figure 4: NZTA CAS Plot (edited) for Candia Road – All Reported Crashes 2003 – 2009. In total, 45 reported crashes over seven years, including 1 fatality, 9 serious injury, and 8 minor injury crashes. Crashes plotted along the route, similar to the original crash plot***




**Summary:**

- 45 reported crashes over 7 years, including 1 fatality, 9 serious, and 8 minor injury
- 32 crashes in wet conditions (71%)
- 13 crashes at night (29%)
- 1 vulnerable road user crash

*Figure 5: NZTA CAS Plot (edited) for Candia Road – All Reported Crashes 2003 – 2009. In total, 45 reported crashes over seven years, including 1 fatality, 9 serious injury, and 8 minor injury crashes. Traffic Crash Reports analysed and crashes re-plotted and grouped accurately*

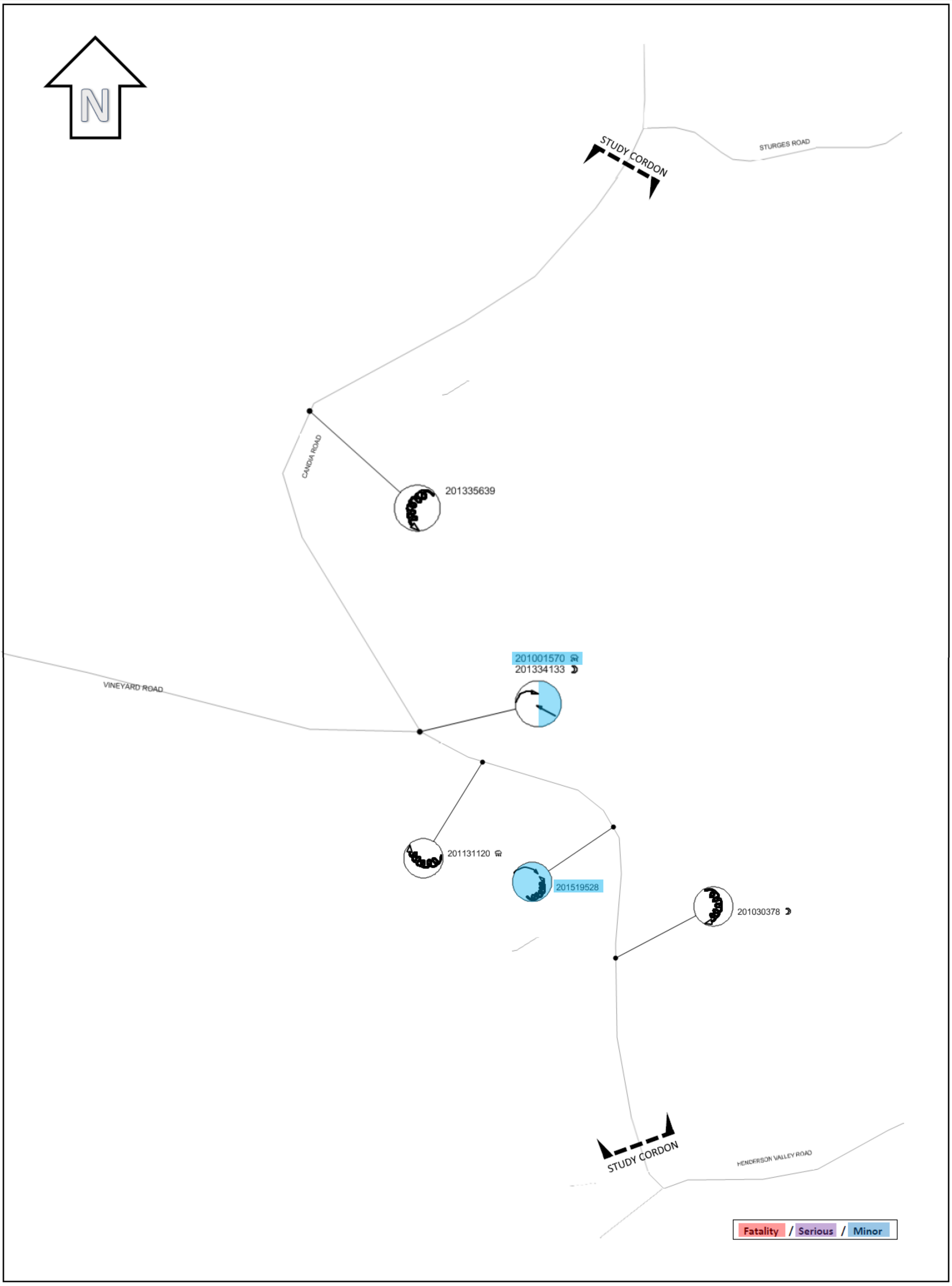



***Figure 6: NZTA CAS Plot (edited) for Candia Road – All Reported Crashes 2010 – 2016. In total, 6 reported crashes over seven years, including 2 minor injury crashes. These crashes are in the locations provided by the NZTA Crash Analysis System.***

Overall, the crash savings achieved along the route for the combined package of constructed works were substantial, and far exceeded expectations and crash reduction savings typically expected and generated. The results are summarized as follows:

- From 2003 to 2009, 45 crashes were reported within the study cordon. Only 6 crashes were reported from 2010 to 2016. Thus, reported crashes along the study cordon have reduced 87%. This result achieves statistical chi-squared significance greater than 99.9%. Also, over the intervening time periods, traffic volumes on Candia Road were estimated to have increased by around 40%;

- Analysis of all reported loss-of-control crashes on roads in the Auckland area over the same time periods shows a 22% reduction in loss-of-control crashes. Thus, over the same time periods, the reduction in reported crashes within the study cordon has far exceeded the control group crash trend. The percentage crashes saved taking into account the crash trend is 83%;

- Reported crashes were reviewed on nearby rural roads over the same time periods, and this established that reported crashes had decreased in the surrounding area by a margin greater than the crash trend. Hence, there was no evidence of crash migration, and addressing crashes along the study cordon did not result in crashes relocating elsewhere;

- The 45 reported crashes before works included 1 fatality, 9 serious injury and 8 minor injury crashes. The 6 crashes after works included only 2 minor injury crashes. The average number of death/serious injury crashes saved per year is 1.4; and

- The estimated cost of construction of all the works was around $1 million, and reverse discounted to present value would be around $1.3 million. Based on economic analysis (NZTA, 2016), Present value life-time crash cost savings were around $24 million (including the 22% downward crash trend), resulting in a Benefit Cost Ratio (BCR) of approximately 19.

It is noted that regression to the mean analysis of the crash statistics was considered unnecessary due to the long period of crash analysis (7 years), and due to the results being highly significant.
Also, it is acknowledged that land-use patterns are more likely to change over a longer period of analysis. However, over the analysis period the only identified variable was vehicle volumes, which increased by around 40% over the analysis period, thus enhancing the merit of the results. Other variables such as nearby road geometrics, driver behaviour, posted speed limits, or police enforcement (speed/alcohol) were not identified to have changed.
The crash remedial works were **innovative** for the following reasons:

- The key causal factors relating to the crash patterns (excessive speed and loss of control at the two main bends) were precisely identified by reading all the available Traffic Crash Reports, with most of the reported crashes re-positioned and re-plotted (Figure 5). The initial crash plot (Figure 4) indicated crashes distributed relatively evenly along the route, which was misleading, and necessitated preparation of Figure 5. Also, non-injury crashes were considered important to help identify crash patterns/locations;

- A large number of complementary crash remedial measures were implemented simultaneously at specific sites, focusing on the key issues, while achieving a route-long Safe System crash saving;

- The package of works that were implemented exceeded crash remedial works generally recommended in technical guidelines to address similar issues, but were justified by the results, showing that significantly better outcomes can be achieved by doing more than the required minimum improvements.

The package of remedial works was **cost effective**, as evidenced by the substantial benefit-cost ratio achieved by the crash savings.
The package of remedial works **stands out beyond traditional activities** in terms of the extremely high percentage of crash savings (87%), proven to have been achieved over a long period of time (7 years), with no evidence of crash migration.
Consideration was given to the possibility of asymmetrical cross-section carriageway design being more cost effective at addressing loss-of-control crashes. For example, shoulder widening may be more cost effective on the inside rather than the outside of bends, in order to address loss-of-control crashes. However, a significant result was considered unlikely to be achieved from such analysis at this location because:

- In this study, shoulder widening was only one out of thirteen crash remedial measures installed, and its contribution to crash savings may only represent around 10% of the overall crash saving result;
- If it were to be assumed that a narrow shoulder was a factor in each loss-of-control crash, then at the two bends the number of loss-of-control crashes occurring on the outside of a left hand bend (18) and right hand bend (20) are fairly evenly matched, which wouldn't indicate any preference for shoulder widening on the inside or outside of a bend within this study cordon;
- In this study shoulder widening was limited and mainly undertaken on the outside of bends, due to steep embankments on the inside of bends.

## Conclusions

In summary, crash studies can achieve substantial crash savings with very high BCR far exceeding typical expectations by using several techniques, such as:

- Precisely locating and plotting crashes by analysing all available Traffic Crash Reports. This is particularly important for rural roads, as geographical references are often unavailable, or distant;
- Using all available crash data (including non-injury and minor injury crashes), in order to establish stronger crash patterns, identify causal factors, and determine correct locations of crashes. Examining only severe injury and fatal crashes can lead to weaker crash patterns and less evidence of specific causal factors;
- Focusing the crash remedial works at the locations where most crashes have been reported, while applying the 'Safe Systems' approach to the remainder of the route; and
- Designing a large package of complementary remedial works, focussed at key locations along routes, as determined by the in-depth crash analysis. Incorporating additional complementary countermeasures can result in crash savings far greater than that typically predicted or achieved.

## Acknowledgements

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