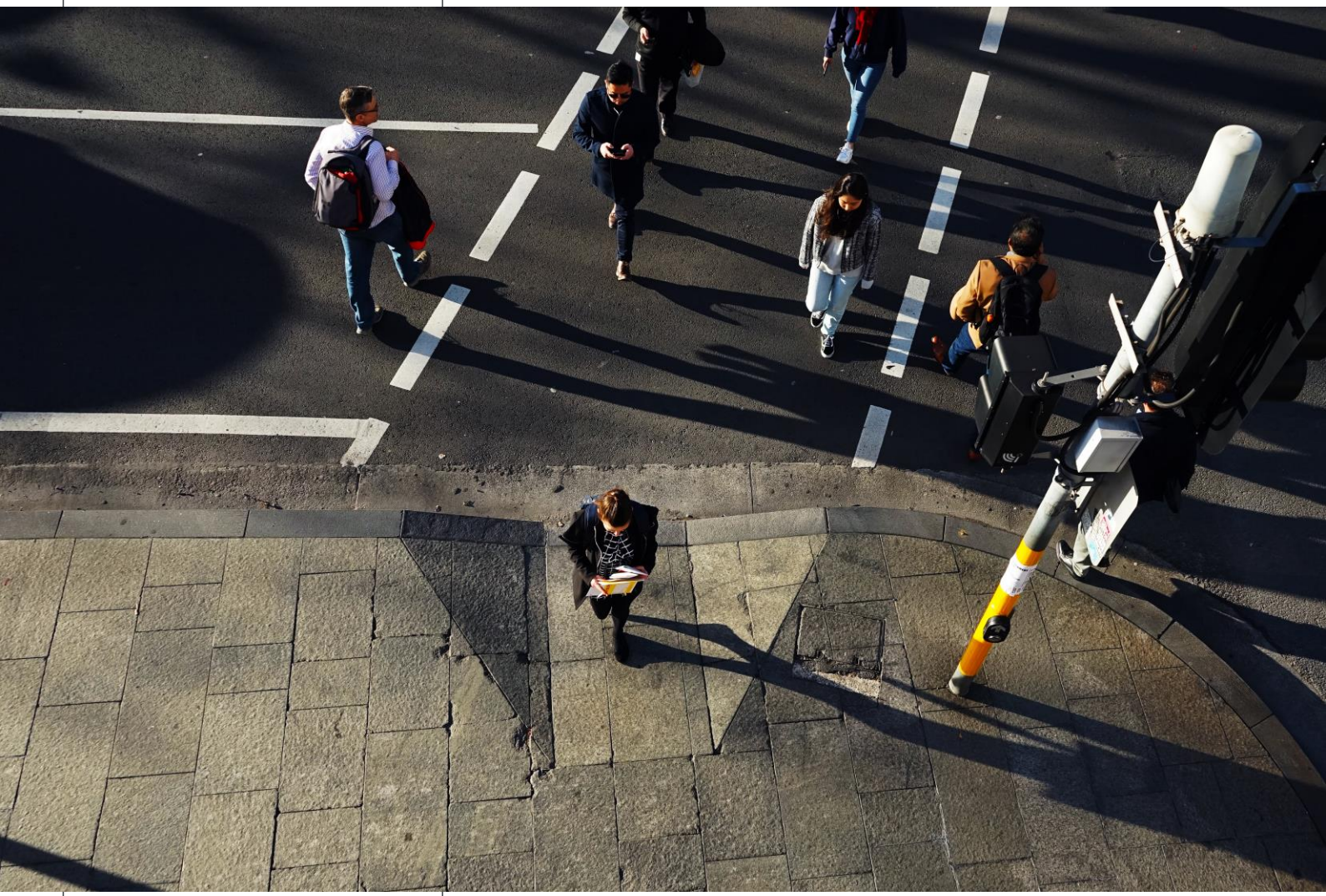
Transport for NSW

Evaluation of the NSW Pedestrian Protection Program

Summary Report

September 2023



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Acknowledgement of Country

Transport for NSW acknowledges the traditional custodians of the land on which we work and live.

We pay our respects to Elders past and present and celebrate the diversity of Aboriginal people and their ongoing cultures and connections to the lands and waters of NSW.

Many of the transport routes we use today – from rail lines, to roads, to water crossings – follow the traditional Songlines, trade routes and ceremonial paths in Country that our nation's First Peoples followed for tens of thousands of years.

Transport for NSW is committed to honouring Aboriginal peoples' cultural and spiritual connections to the lands, waters and seas and their rich contribution to society.

1 Executive Summary

The NSW Pedestrian Protection Program (PPP) is a mass action program launched in NSW in August 2015, which aimed to upgrade up to 560 two-phase signalised intersections with timed pedestrian protection (TPP). TPP is a method of traffic and pedestrian control whereby a red turn arrow or a delayed start are used to hold turning vehicular traffic for a period while the green pedestrian signal is displayed, allowing pedestrian movements to occur first.

An outcome evaluation of the PPP was conducted in October 2021 – December 2022 to identify whether the program resulted in reduced pedestrian crash rates, fewer opportunities for pedestrian-vehicle conflicts, and increased visibility of pedestrians whilst crossing. It also explored whether the program had been delivered as intended.

The evaluation found that PPP resulted in a significant reduction in Fatal and Serious Injury (FSI) pedestrian-involved crashes (between 43% to 47%), as well as a reduction of between 20% (not statistically significant) to 38% (statistically significant) in overall pedestrian-involved crashes. The effectiveness of the intervention was also mediated by the protection type provided (arrow and/or delay treatment).

The evaluation also found that, following the introduction of the PPP, there were substantially fewer opportunities for pedestrian-vehicle conflicts, with an overall increase in the number of pedestrian legs protected, and an increase in the amount of time protection was provided. Specifically, 98% of the sample of intersections had the same level or an increased number of legs protected. Results also revealed that 93% of intersections assessed had the same or greater amount of time protection post-treatment (on average, an increase of 22 seconds per intersection).

The evaluation was also able to determine that PPP improved the visibility of pedestrians by identifying that fewer people were in the ‘poor visibility’ zone (first and last quarter of the crossing) and more people were in the ‘improved visibility’ zone (middle half of the crossing) when pedestrian protection was lifted. Specifically, results revealed that 97% of intersection legs reviewed had adequate protection for the average speed pedestrian to enter the ‘increased visibility’ zone. Further, the study revealed that 94% of these intersections provided adequate protection for slower, more vulnerable pedestrians - supporting road users of all ages and abilities.

A series of stakeholder interviews were conducted to determine whether the program was implemented as intended and how the program could be improved for future rollouts of PPP. Stakeholders identified that there was a significant culture change as a direct result of the program – where PPP is implemented as a standard practice at all intersection upgrades. Stakeholders also identified that despite initial reservations by some that the implementation of PPP may lead to greater vehicular congestion, there was no strong evidence from stakeholders to suggest this occurred.

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Definitions

Term	Definition
CRS	Centre for Road Safety
FSI	Fatal and Serious Injury
HPAA	High Pedestrian Activity Area
MUARC	Monash University Accident Research Centre
Net Ops	Network Operations Branch
PPP	Pedestrian Protection Program
RUM	Road User Movement
SCATS	Sydney Coordinated Adaptive Traffic System
TCS	Traffic Control Signal
TfNSW	Transport for New South Wales (NSW)
TMC	Traffic Management Centre
TPP	Timed Pedestrian Protection

2 Background

On 5 August 2015, the then Minister for Roads announced the roll out of the NSW Pedestrian Protection Program. The program included the treatment of two-phase intersections across NSW that were identified as in need of update to better protect pedestrians and reduce the risk of a crash. The program originally aimed to treat up to 560 signalised intersections over 3 years, at a cost of $5 million.

The announcement followed the coronial inquests of two pedestrian fatalities at signalised intersections in Waterloo in July 2007 (Inquest: 16 July 2009) and Beecroft in May 2012 (Inquest: 5 November 2014). In both of these crashes, the green roundel signal for a turning driver commenced at the same time as a green walk signal on a parallel pedestrian movement (as illustrated in Figure 1).

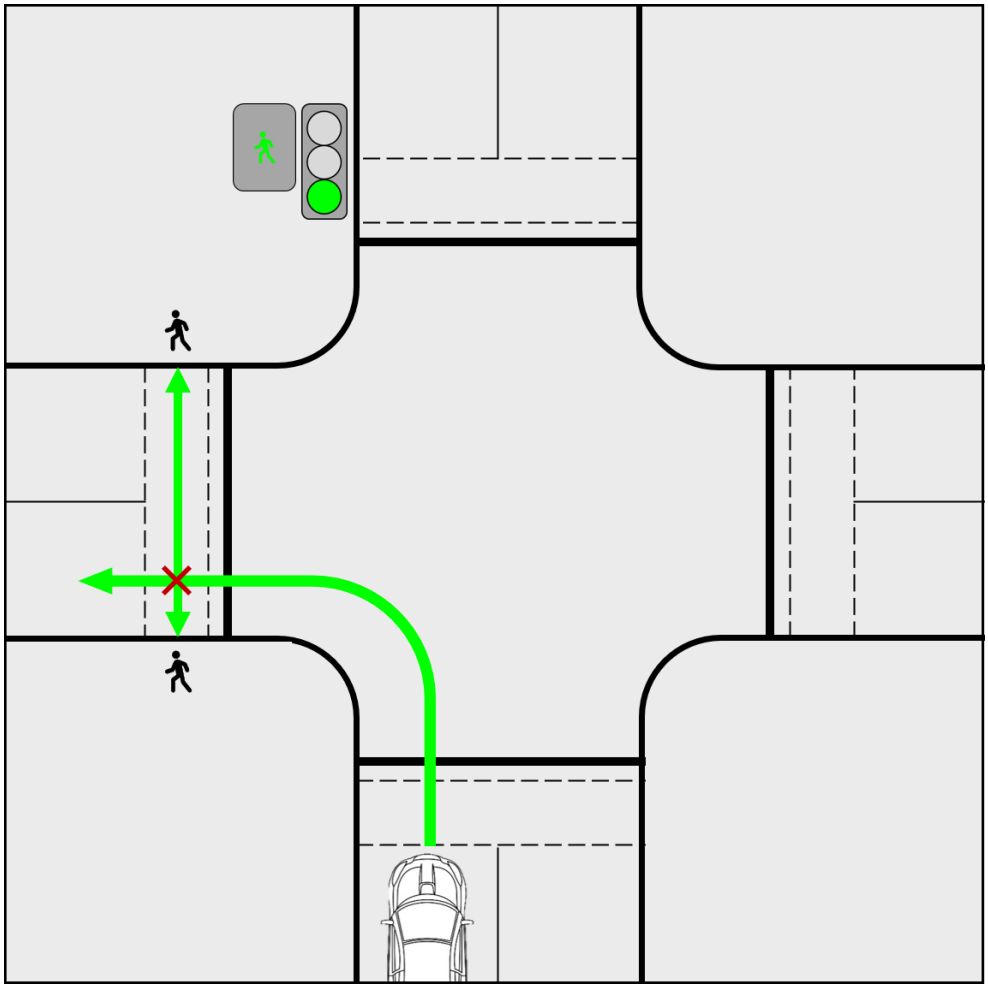

Figure 1: Parallel green signal for both vehicle and pedestrian operation at a signalised intersection. Red 'x' indicates a potential conflict point.

In this type of operation, the pedestrian movement is not provided protection in Walk (green pedestrian) or Clearance phases (flashing red pedestrian), from filtering vehicle movements (see Figure 2), and as such, pedestrians and vehicles cross through the intersection at the same time. Whilst in NSW, a driver turning at an intersection must give way to any pedestrians at or near the intersection who is crossing the roads (Rule 62(1) of the Road Rules 2014, NSW), we know that people make mistakes which can lead to this conflicting crash type.

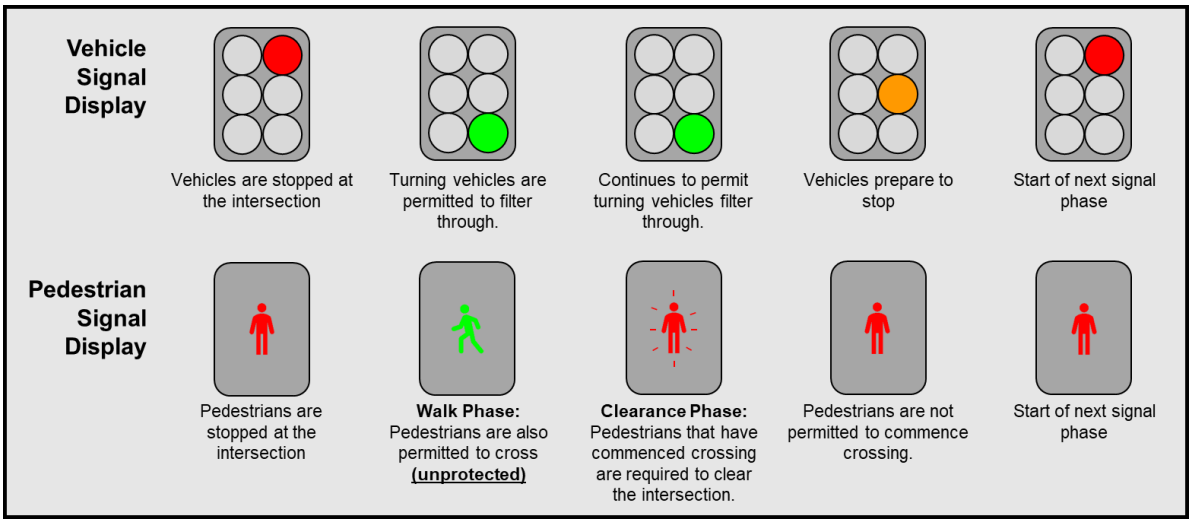

Figure 2: Vehicle and Pedestrian Signals when no pedestrian protection is provided. As can be seen, during the walk and clearance phases of the pedestrian movement, turning vehicles are allowed to filter through.

In both crashes, the Coroner identified that better pedestrian protection may have prevented these crashes and recommended *"...introducing a change to phasing of traffic lights so as to provide pedestrians with a 10-15 second head start at intersections..." and "...carrying out a review and assessment of all 2-phase intersections on State roads to prioritise and implement the installation of traffic signal delay phasing so that vehicle traffic be held on a red light while a green walk sign permits pedestrians to leave the footpath unimpeded for a period of time"* (NSW Coroner 2014, 2022).

2.1 Crash analysis

Between 2010 and 2015 (inclusive), crash analysis revealed that there were 5,050 crashes involving pedestrians at intersections. These crashes resulted in 96 pedestrians who were killed, 1,921 who were seriously injured and 3,676 who sustained other injuries.

2.2 Review of Literature

The NSW Centre for Road Safety (CRS) conducted a literature review in May 2015, which examined pedestrian safety at signalised intersections, and explored the use of Timed Pedestrian Protection (TPP) at signalised intersections to provide temporal separation of pedestrian and vehicle movements. TPP is a method of traffic and pedestrian control whereby a red turn arrow or a delayed start are used to hold conflicting turning vehicular traffic for a period of time, while the green pedestrian signal is displayed allowing pedestrian movement to occur. This type of treatment is more consistent with the Safe System approach to road safety.

The CRS review identified research evidence which suggests the introduction of TPP (also known as Leading Pedestrian Interval; LPI) can result in direct and indirect safety benefits to pedestrians including:

- Reduced pedestrian-vehicle crashes (Van Houten et al., 2000; King, 2000; Fayish & Gross, 2010).

- Fewer pedestrian-vehicle conflicts (Van Houten et al., 2000).
- Increased visibility of pedestrians whilst crossing (Van Houten et al., 2000; Saneinjad & Lo, 2015).
- Fewer drivers violating pedestrian right of way (Pecheux et al., 2009).
- Fewer drivers rushing into intersections before pedestrian arrival (Van Houten et al., 2000).

Combined, these findings suggested that replacing parallel green signals for both vehicle and pedestrians traffic signal phasing with TPPs would significantly contribute towards reducing pedestrian-vehicle crashes at signalised intersection crossings.

2.3 NSW Pedestrian Protection Program

The NSW Pedestrian Protection Program (PPP) aimed to upgrade all two-phase signalised intersections in NSW with TPP. In preparation for the program, a total of 760 two-phase intersection locations were identified by Network Operations throughout NSW. Of these sites, approximately 200 were excluded from the program because they were identified as either having no pedestrian crossings, having adequate existing pedestrian protection, or having more than two-phases. As such, the total program consisted of review and upgrade of up to 560 two-phase intersections.

Depending on the configuration of the existing site, the program included infrastructure and software changes (also known as controller personality changes) and upgrades to existing lanterns with left-turn red hold arrows, where required. As part of this program, ‘Left Turn on Red’ (LTOR) practice was also reviewed and removed, where it conflicted with a PPP upgrade.

3 Evaluation Approach

The overarching aim of the program was to deliver improved pedestrian protection at two-phase, signalised intersections, through signal phasing and infrastructure changes. The evaluation was intended to assess whether implementation of the program contributed to improving pedestrian safety and to support decisions about future roll out of the program to larger signalised intersections (three-phase and larger).

3.1 Key Evaluation Questions

The evaluation focussed on four key evaluation questions to understand implementation and impact of the program. The first three questions were derived from some of the expected outcomes of successful implementation identified in the review (See 2.2 Review of Literature), and where data and information sources were readily available. Some expected outcomes, such as reductions in drivers violating pedestrian right of way and decreased rushing into intersections could not be directly measured and were therefore out of scope.

The key evaluation questions were:

1. Did the implementation of the Pedestrian Protection Program result in **reduced pedestrian crashes** at treated intersections?
2. Did the implementation of the Pedestrian Protection Program result in **fewer opportunities for pedestrian-vehicle conflicts** at treated intersections?
3. Did the implementation of the Pedestrian Protection Program result in **increased visibility of pedestrians whilst crossing** at treated intersections?
4. Was the Pedestrian Protection Program implemented as intended?

Each evaluation question was addressed in one of four distinct stages designed to assess the impact of PPP on pedestrian safety in several ways. An outline of the evaluation stages and methodological approach for each appears in Table 1 below. The converging evidence across the different stages helped to synthesise the overall findings and address some of the limitations of individual stages.

Table 1: Stages of the PPP Evaluation

Stage	Evaluation Question	Approach
1	Did the implementation of the Pedestrian Protection Program result in **reduced pedestrian crashes** at treated intersections?	At a program level, a comparison between pre- and post-implementation pedestrian involved crashes at treated signalised intersections, compared to control intersections.

2	Did the implementation of the Pedestrian Protection Program result in **fewer opportunities for pedestrian-vehicle conflicts** at treated intersections?	For each treated intersection:
		• Measured change in degree of protection provided (before and after) at treated intersections, based on:
		  ○ pedestrian protection level
		  ○ reduction in conflict time (seconds)

3	Did the implementation of the Pedestrian Protection Program result in **increased visibility of pedestrians whilst crossing** at treated intersections?	For each pedestrian leg: • Estimating how far into the intersection the pedestrian is likely to be along a crossing, when protection is lifted to determine whether a range of pedestrians are likely to be in a 'poor visibility zone' or 'improved visibility zone', for drivers to be able to see them.
4	Was the Pedestrian Protection Program delivered as intended?	Interviews with stakeholders addressing the following: • Have the program activities been implemented as intended? • What were the enablers and barriers to program implementation? • Was the program implemented within the expected timeframe and budgets? • What factors impacted program's implementation timeframes and costs?

A short summary of the methodological approach for each stage is provided in the findings sections.

4 Treatment Sites and Types

4.1 Treatment Sites

A total of 760 two-phase TCS sites were preliminarily identified by Network Operations (NetOps) branch. Of these, it was determined that 201 did not need PPP treatment for the following reasons:

- 49 sites had adequate existing pedestrian protection (as determined by NetOps)
- 90 sites did not have any pedestrian/vehicle conflict
- 58 sites had no pedestrian crossings
- 4 sites were larger than two-phase intersections.

Of the remaining 559 sites that were eligible for PPP treatment, 43 were removed from the program:

- 37 sites were no longer two-phase sites
- 4 sites were affected by light rail works
- 2 sites were decommissioned.

In this evaluation, a total of 516 sites were assessed in detail. Data for these 516 sites were used for evaluation stages 1 to 4.

4.2 Treatment Types

Three broad treatment category types were used for throughout the analysis, depending on how TPP was implemented. As seen in Figure 3, the Delay treatment was when vehicles were held with a red roundel on all approaches, preventing not only turning movements but through movements as well. The Arrow treatments (Figure 4) on the other hand, only held turning movements that conflicted with the demanded pedestrian movements, allowing non-conflicting through movements to pass. In some cases, there was a combination of Delay and Arrow treatments at an intersection, where both treatment types were used (Figure 5).

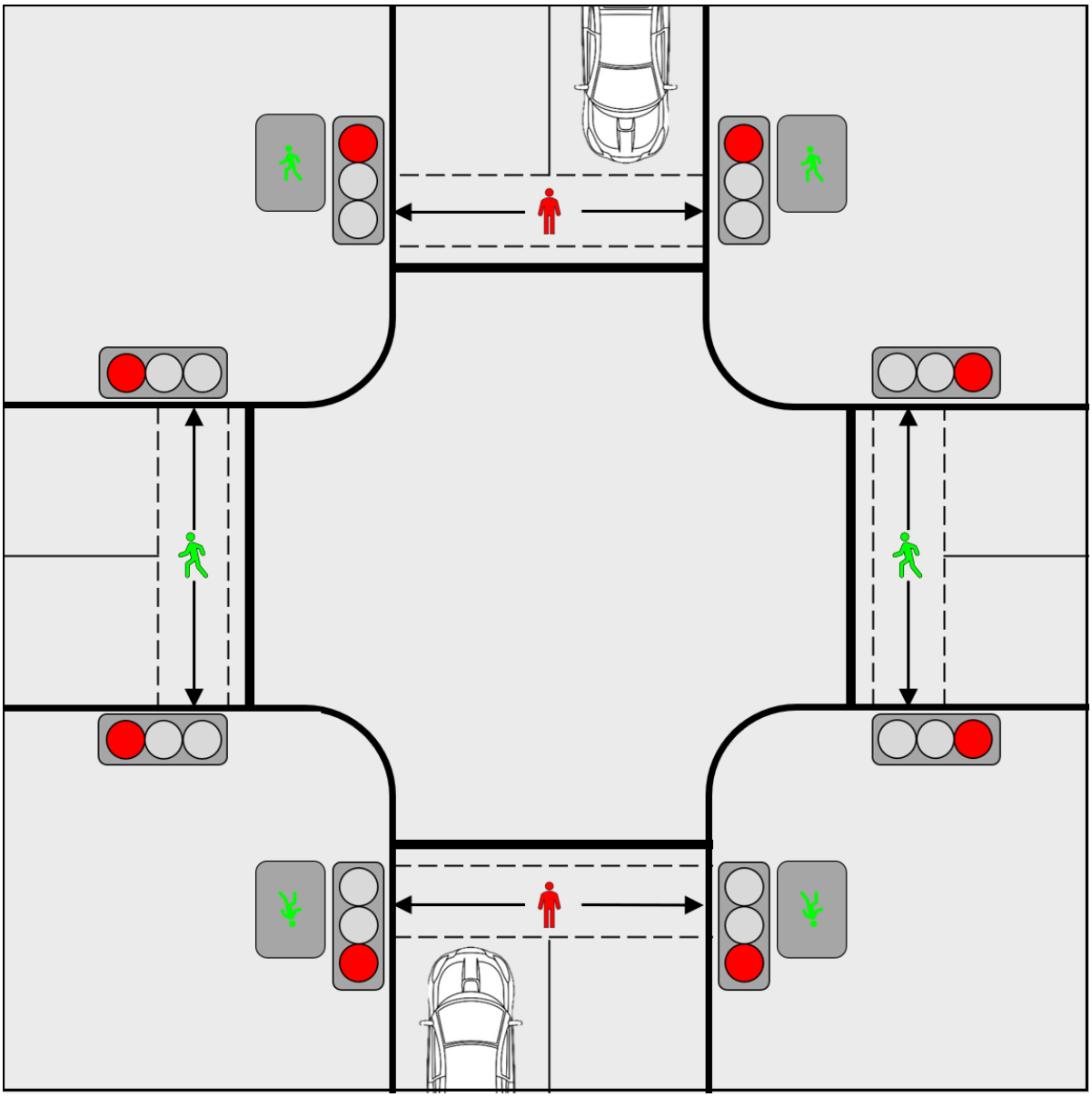

Figure 3: Delay treatment type for a two-phase arrangement – Pedestrians walking north/south are given a green pedestrian light whilst the conflicting north/south facing turning vehicles as well as the non-conflicting parallel through movements (i.e., vehicles going straight) are held at the intersection with a red roundel. Pedestrian east/west movements are protected in the same way.

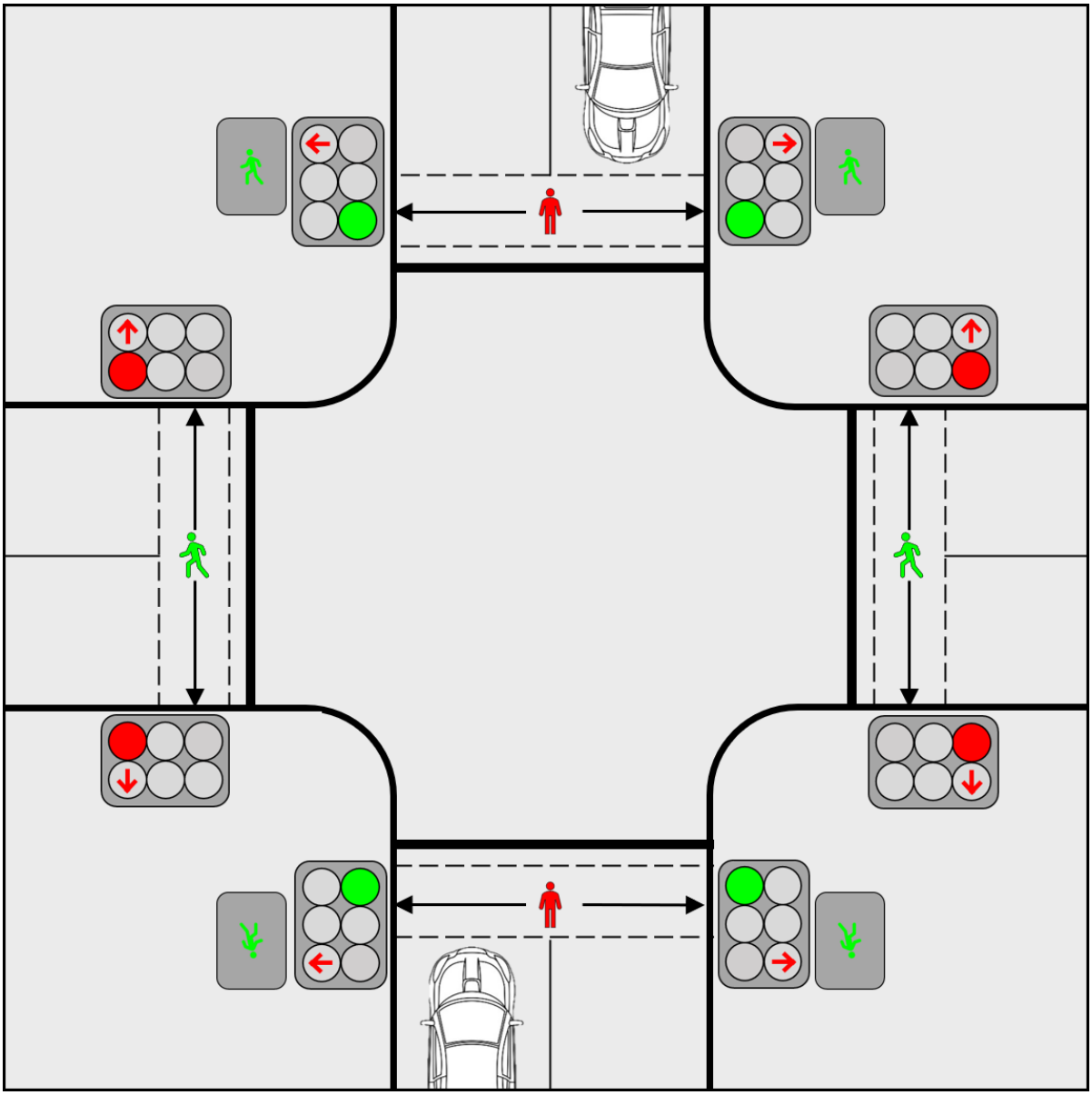

Figure 4: Arrow treatment type for a two-phase arrangement – Pedestrians walking north/south are given a green pedestrian light whilst conflicting north/south facing turning vehicles are held at the intersection with a red arrow. North/south non-conflicting through movements for vehicles (i.e., vehicles going straight) are given a green light. Pedestrian east/west movements are protected in the same way.

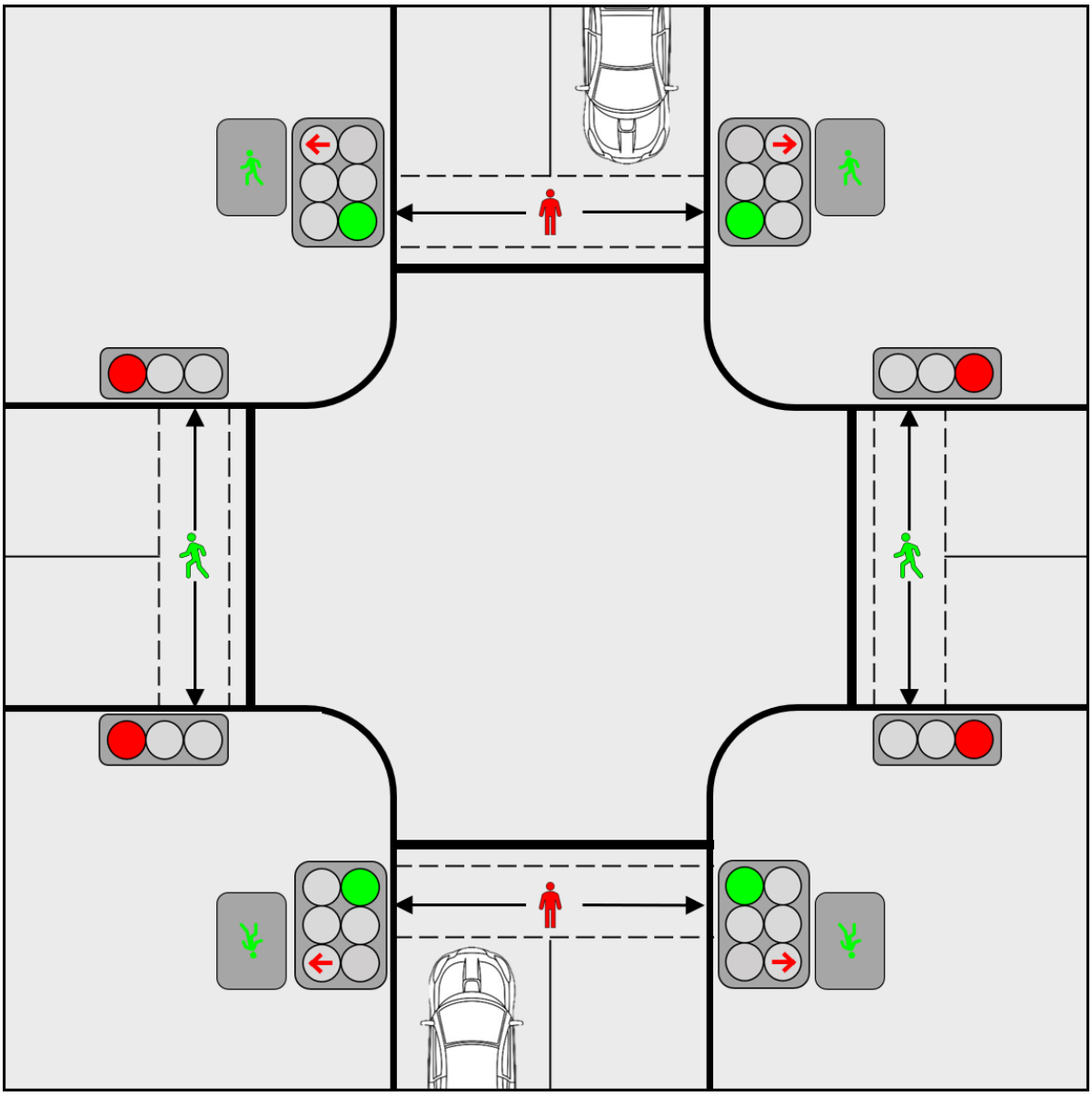

Figure 5: Arrow and Delay treatment type for a two-phase arrangement – Pedestrians walking north/south are given a green pedestrian light whilst conflicting north/south facing turning vehicles are held at the intersection with a red arrow. North/south non-conflicting through movements for vehicles (i.e., vehicles going straight) are given a green light. Pedestrian east/west movements are protected with a delay treatment.

5 Stage 1: Did PPP result in reduced pedestrian crashes?

KEY FINDINGS

- PPP resulted in a reduction of between 20% (non-significant) to 38% (significant) in overall pedestrian-involved crashes.
- There was also a significant reduction in the FSI pedestrian-involved crashes (between 43% to 47%).
- Delay only treatments reduced in pedestrian-involved crashes by 32% to 49%, and FSI pedestrian-involved crashes 56% to 61%.
- Arrows treatments only did not appear to demonstrate either a statistically significant, nor a practically important, change in the crash rate.
- Delay and arrows treatments fell somewhere between those for the delay only and arrows only treatments; a significant FSI crash rate reduction of 49% in only one analysis.

The impact of the Pedestrian Protection Program on pedestrian crashes was explored through a statistical crash analysis undertaken by Monash University Accident Research Centre (MUARC) on behalf of TfNSW. This section summarises the findings of the full report.

5.1 Brief Method

A quasi-experimental design with controls was used to measure the change in pedestrian crash rates at treated sites from a period of time before to a period of time after implementation of the treatment, adjusted for changes in crash rate over the same time period at suitably chosen control sites.

Two different controls were used.

1. An internal control: This approach compared the change in pedestrian-involved crashes at the treatment site to the change in vehicle-only crashes (control crashes) at the same intersection.
2. An area-based (external) control: This approach compared the change in the rate of pedestrian-involved crashes at treated signalised intersections to signalised intersection that were not treated in the same LGA, over the applicable before and after period.

The primary outcome of interest (that is, the measure of effectiveness) was a reduction in the rate of crashes involving pedestrians, and the subset of FSI crashes.

The impact of the COVID-19 pandemic has had a major impact on the delivery of the remaining sites but also on pedestrian and vehicle movement patterns. However, the use of both internal and external control analysis and the use of a quasi-experimental design accommodated for this limitation in Stage 1.

5.2 Summary of Results

5.2.1 Effectiveness in reducing all crashes and FSI crashes

As seen in Table 2, between the two control approaches, at a program level, the PPP was found to result in a significant reduction in overall pedestrian-involved crashes of between 20% to 38%. Table 3 also highlights the significant benefits of the program in reducing FSI pedestrian-involved crashes, with between a 43% to 47% reduction, across both control approaches.

Table 2: Effectiveness of the PPP at reducing pedestrian-involved crashes, across the two control approaches.

Program level: All crashes (pedestrian involved)	Incidence rate ratio	95% confidence interval	p-value
Internal control	0.80 (20% reduction)	0.62-1.03	0.08
External control	0.62 (38% reduction)	0.48-0.80	<0.0005*

Table 3: Effectiveness of the PPP at reducing fatal and serious injury pedestrian-involved crashes, across the two control approaches.

Program level: FSI crashes (pedestrian involved)	Incidence rate ratio	95% confidence interval	p-value
Internal control	0.53 (47% reduction)	0.36-0.78	0.001*
External control	0.57 (43% reduction)	0.40-0.79	0.001*

5.2.2 Effectiveness by treatment type

The study explored the impact of the PPP by the three different treatment type options: delay only, arrow only or arrow and delay.

Delay only treatment

As seen in Table 4, for intersections that were treated with delay protection only, analysis revealed that there was a significant reduction of between 32% to 49% in the rate of all pedestrian-involved crashes after TPP treatment. There was also a significant reduction in the rate of FSI pedestrian-involved crashes, of between 56% to 61%.

Table 4: Effectiveness of the delay only treatments at reducing pedestrian-involved crashes (all crashes and FSI), across the two control approaches.

Delay only treatment	Incidence rate ratio	95% confidence interval	p-value
All crashes (internal control)	0.68 (32% reduction)	0.48-0.96	0.03*

Delay only treatment	Incidence rate ratio	95% confidence interval	p-value
All crashes (external control)	0.51 (49% reduction)	0.35-0.74	<0.0005*
FSI (internal control)	0.39 (61% reduction)	0.23-0.65	<0.0005*
FSI (external control)	0.44 (56% reduction)	0.27-0.71	0.001*

Arrow Only Treatment

Table 5 highlights that there was no significant change in the rate of pedestrian-involved crash or FSI pedestrian-involved crashes, for sites that were treated with arrows only, with either of the two control approaches.

Table 5: Effectiveness of the arrow only treatments at reducing pedestrian-involved crashes (all crashes and FSI), across the two control approaches.

Arrows Only Treatment	Incidence rate ratio	95% confidence interval	p-value
All crashes (internal control)	0.98	0.59-1.66	0.95
All crashes (external control)	0.74	0.44-1.24	0.25
FSI (internal control)	1.1	0.52-2.35	0.8
FSI (external control)	0.99	0.52-1.89	0.97

Arrow and Delay Treatment

As seen in Table 6, intersections where the treatment involved a combination of both arrows and delay protection, there was no significant change in the overall pedestrian-involved crash rate using either of the two control approaches. The rate or FSI pedestrian-involved crashes only appeared to significantly reduce in one of the two control approaches; there was a 49% reduction in FSI crashes using the external control approach.

Table 6: Effectiveness of the arrow and delay only treatments at reducing pedestrian-involved crashes (all crashes and FSI), across the two control approaches.

Arrows and Delay Treatment	Incidence rate ratio	95% confidence interval	p-value
All crashes (internal control)	0.88	0.55-1.40	0.59

Arrows and Delay Treatment	Incidence rate ratio	95% confidence interval	p-value
All crashes (external control)	0.75	0.48-1.12	0.2
FSI (internal control)	0.6	0.27-1.36	0.22
FSI (external control)	0.51 (49% reduction)	0.28-0.96	0.04*

5.3 Limitations

This stage of the evaluation had some limitations. Given many of the installations occurred relatively recently, 40 (8.3%) of the 484 treated intersections had to be excluded from both analyses due to the time period after installation which was too short to obtain a reliable count of crashes, while two (0.4%) intersections were first signalised either at the same time, or just prior to the treatment and had to be excluded. Another 65 intersections (13.4%) were excluded from the externally controlled analysis because there were no intersections in the same LGA with the same speed limit profile and other important characteristics profile to serve as matched intersections.

Despite this, the results pertaining to delay only treatments are convincing. A longer follow-up may provide more statistical power to detect a significant reduction in crashes for sites with arrows only. However, the point estimates of effectiveness measured in this study suggest this treatment is far less effective than delay only (at two-phase sites). Further data would likely only serve to narrow the confidence intervals, not change the estimate of effectiveness by a large margin.

5.4 Conclusion

This stage of the evaluation identified a novel finding – that the relatively simple treatment of adding a delay only treatment was an effective solution to significantly reduce pedestrian crashes and FSIs at two-phase intersections. Further, it was revealed that delay treatments are more effective than adding arrows to control traffic movements. This is a positive finding given that changing the signal phasing to provide a timed delay for pedestrians to cross is easier to implement and less costly than changing the infrastructure to add turn arrows. Whilst it may mean that TPP treatments may be appropriate for a broader range of intersections than previously thought, its application should be on a case-by-case basis. This is particularly the case for intersections which are larger than two-phase.

6 Stage 2: Did the PPP result in fewer opportunities for pedestrian-vehicle conflicts?

KEY FINDINGS

- The PPP overall increased both the number of pedestrians legs protected, and the amount of protection provided at treated sites.
- 98% of intersections had the same level or an increased number of pedestrian legs protected.
- 93% of intersections assessed had the same or a greater amount of time protection post-treatment (on average, an increase of 22 seconds per intersection).
- The increased protection led to fewer opportunities for pedestrian-vehicle conflicts due to the temporal separation of road users.

6.1 Brief method

This stage of the evaluation assessed the degree of pedestrian protection change at intersections before and after treatment interventions. The rationale for this approach was that as the degree of protection increases, there will be a reduction in the number of opportunities for potential pedestrian-vehicle conflicts and conflict time. Given the manual data extraction required for this stage to determine timings of each site before and after the implementation of PPP, a representative subset of sites was selected for further analysis.

6.2 Summary of Results

As seen in Table 7, of the representative sample of PPP treated sites assessed, 47% of sites which previously had no protection, now had some form of pedestrian protection at all pedestrian legs.

Table 7: Type of pedestrian protection at the sample of intersections, pre-PPP vs post-PPP.

	Post: Delay only	Post: Arrows + Delay	Post: Arrows only	TOTAL	TOTAL %
Pre: No Protection	31	6	19	56	47%
Pre: Delay only	15	3	3	21	18%
Pre: Arrows + Delay	0	8	2	10	8%
Pre: Arrows only	2	6	24	32	27%

	Post: Delay only	Post: Arrows + Delay	Post: Arrows only	TOTAL	TOTAL %
TOTAL	48	23	48	119	100%

6.2.1 Number of pedestrian legs protected (pre vs post)

Figure 6 illustrates that 98% of the 119 intersections assessed had the same level or an increased number of legs with pedestrian protection. The two intersections with a reduced number of legs protected were determined to have construction occurring nearby and pedestrian legs were removed. Thus, there was no vehicle-pedestrian conflict at these locations.

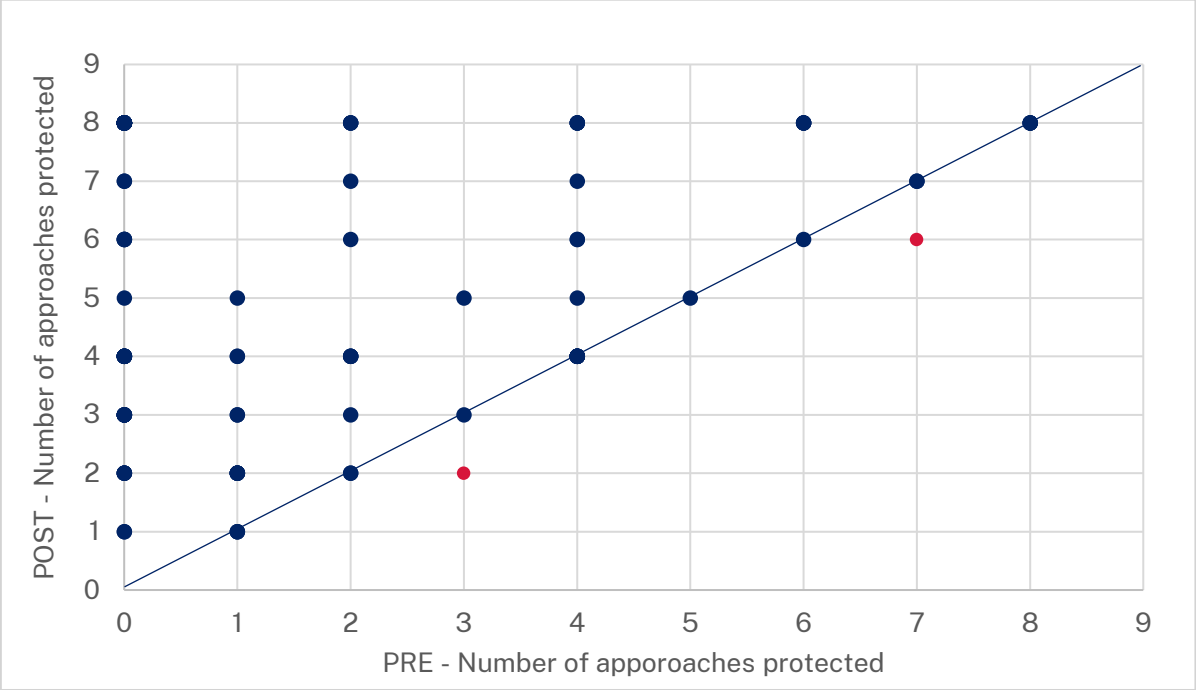

Figure 6: Number of approaches protected pre-vs post-PPP.

6.2.2 Amount of pedestrian protection (pre vs post)

Given that most intersections had a stable or increased number of legs that were protected, Figure 7 illustrates the sum of the amount of protection that was provided pre-compared to post-PPP. It indicates that 93% of 119 intersections assessed had the same or greater total amount of protection post-treatment, compared to pre-treatment. Specifically, amount of intersection protection increased by, on average, 22 seconds (11 seconds compared to 33 seconds). Whilst eight intersections had a lower amount of total protection time than prior to the program (see red dots in Figure 7), given how close the times are compared to prior to PPP, it is assumed that these represent carefully considered tweaks to timings to improve intersection performance, without compromising pedestrian safety. However, this assumption needs to be further explored to determine if this the case.

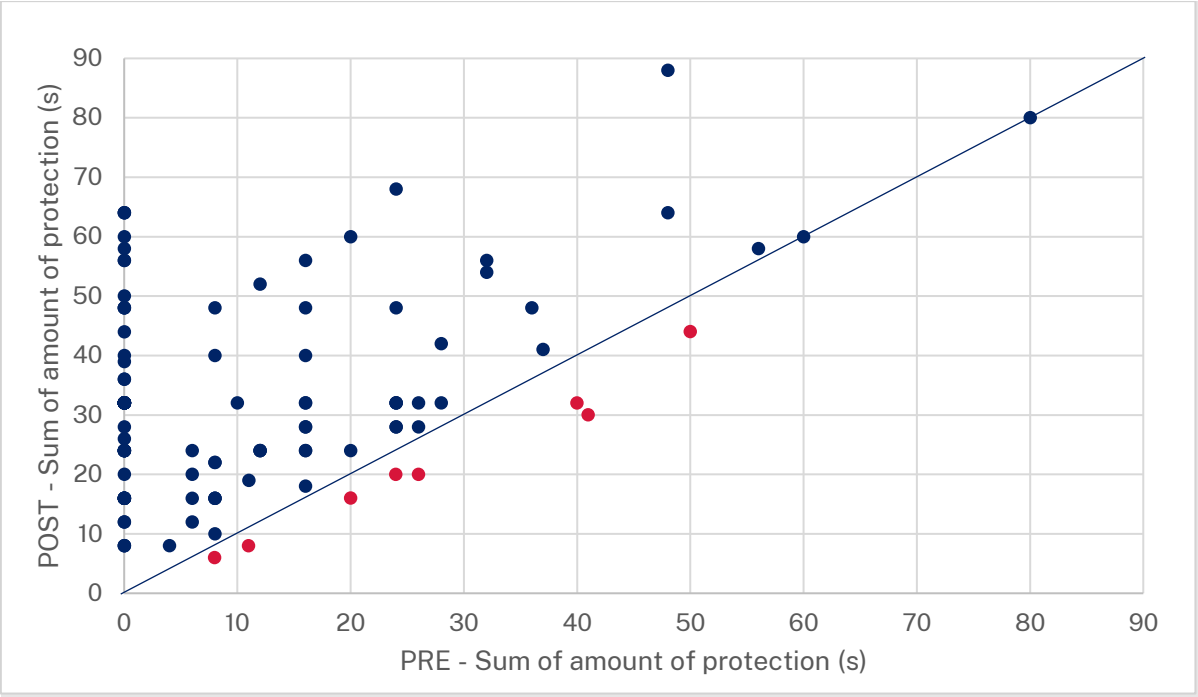

Figure 7: Sum amount of protection provided pre- vs post-PPP (seconds)

6.3 Conclusions

The findings of this stage support that the PPP overall increased both the number of sites with pedestrian protection and the amount of protection provided at treated sites. This would foreseeably result in fewer opportunities for vehicle and pedestrian interactions indicating the program was successful in achieving this objective.

7 Stage 3: Did the PPP increase the visibility of pedestrians?

KEY FINDINGS

- The visibility of pedestrians at PPP treated sites was significantly enhanced.
- The proportion of sites where pedestrians end up in the 'improved visibility zone' when vehicles get a green light significantly increased for both the average speed pedestrian (from 38% before to 97% after) as well as for vulnerable pedestrians (from 35% before to 94% after).
- Of the sites sampled, further increases of pedestrian protection of 1-2 seconds to 23 pedestrian legs would result in 100% of all pedestrians entering the safer 'increased visibility zone' before vehicles get a green light.

7.1 Brief Method

A pre-post assessment was used to answer this evaluation question. Specifically, the analysis assumed that the pedestrian crossing lengths at each intersection remained constant in the before and after period. It was also assumed that walking speed of pedestrian groups was not likely to change. As such, the only difference between sites pre-and post-implementation was the amount of pedestrian protection provided. By calculating the distance of each pedestrian leg and looking at average walking speeds of different pedestrian groups, it is possible to estimate the amount of time needed for pedestrians to be in the middle of the crossing.

The approach allowed us to identify how far into the intersection road users will be, when protection is lifted. It is expected that the closer they are to the middle of the crossing, the greater their visibility will be to drivers. Further, two pedestrian groups were assessed: average walking speed pedestrians and slower walking 'vulnerable pedestrians' including older people, those with vision or mobility impairment, and those under 12 years of age.

7.2 Analysis

A literature review determined pedestrians walking speeds: 1.2m/s for the average pedestrian and 1m/s for vulnerable pedestrians. Crossing distances were also estimated using design drawings of the intersections.

In order to determine whether pedestrians would be more visible following the treatment, two critical spaces within each leg of a crossing were defined:

- 'poor visibility zones' (the first and last quarter of a pedestrian crossing)
- 'improved visibility zones' (the middle half of a pedestrian crossing)

These spaces were defined in consultation with the Safer Roads team, within the Centre for Road Safety, TfNSW. The rationale for these zones is illustrated by Figure 8 below. Specifically, 'poor visibility zones' as defined as those areas where pedestrians on a

kerb may be visually occluded to the drivers by the vehicle's 'A' pillar (see Figure 9 for vehicle pillars). This poor visibility may cause pedestrians to unexpectedly 'appear' as both vehicles and pedestrians start moving in a green-on-green configuration. It was expected that following the implementation of the PPP, there would be a significant increase in the number of pedestrians that could, at least, get into the 'improved visibility zones', when the pedestrian protection is lifted.

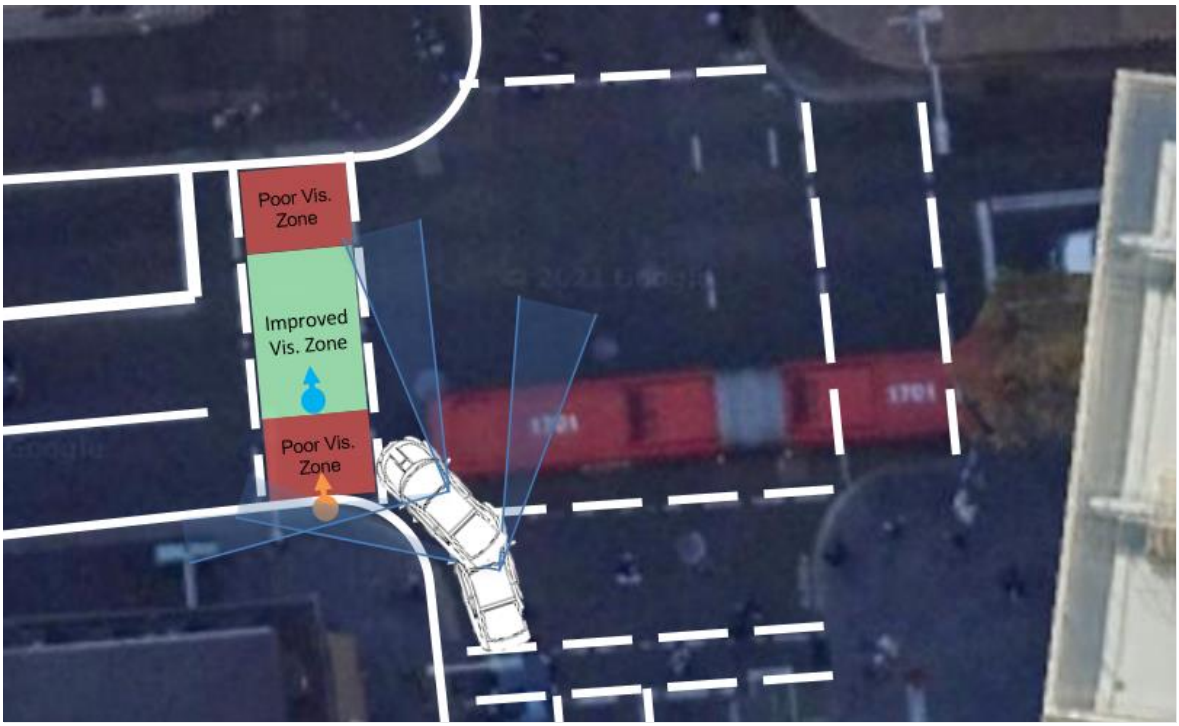

Figure 8: Birds eye view of a signalised intersection. The vehicle's blind spots created by an 'A' pillar occlusion are illustrated. Orange icon represents a pedestrian movement from the kerb; blue icon represents a pedestrian continuing their movement from the middle of the intersection in the 'improved visibility zones'. As seen, the orange icon is occluded by the vehicles 'A' pillar as they enter the poor visibility zone, whereas the blue icon is visible from throughout the vehicle movement.

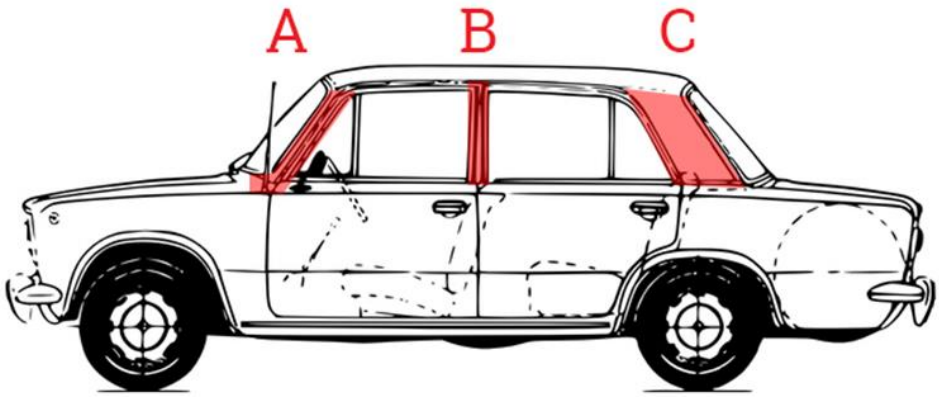

Figure 9: An example of vehicle's A, B and C pillars. Source: https://autoexpertus.com/pillars-automotive.

The analysis quantified and collated the total number (and proportion) of pedestrian legs, where pedestrians moved from being in the 'poor visibility zones' (pre-treatment) to the 'improved visibility zones' (post-treatment).

7.3 Summary of Results

Results were explored across a range of walking speeds up to 1.5m/s. Figure 10 illustrates the proportion of pedestrians that are likely to be in the 'increased visibility' zone at various walking speeds, pre- and post-implementation of PPP.

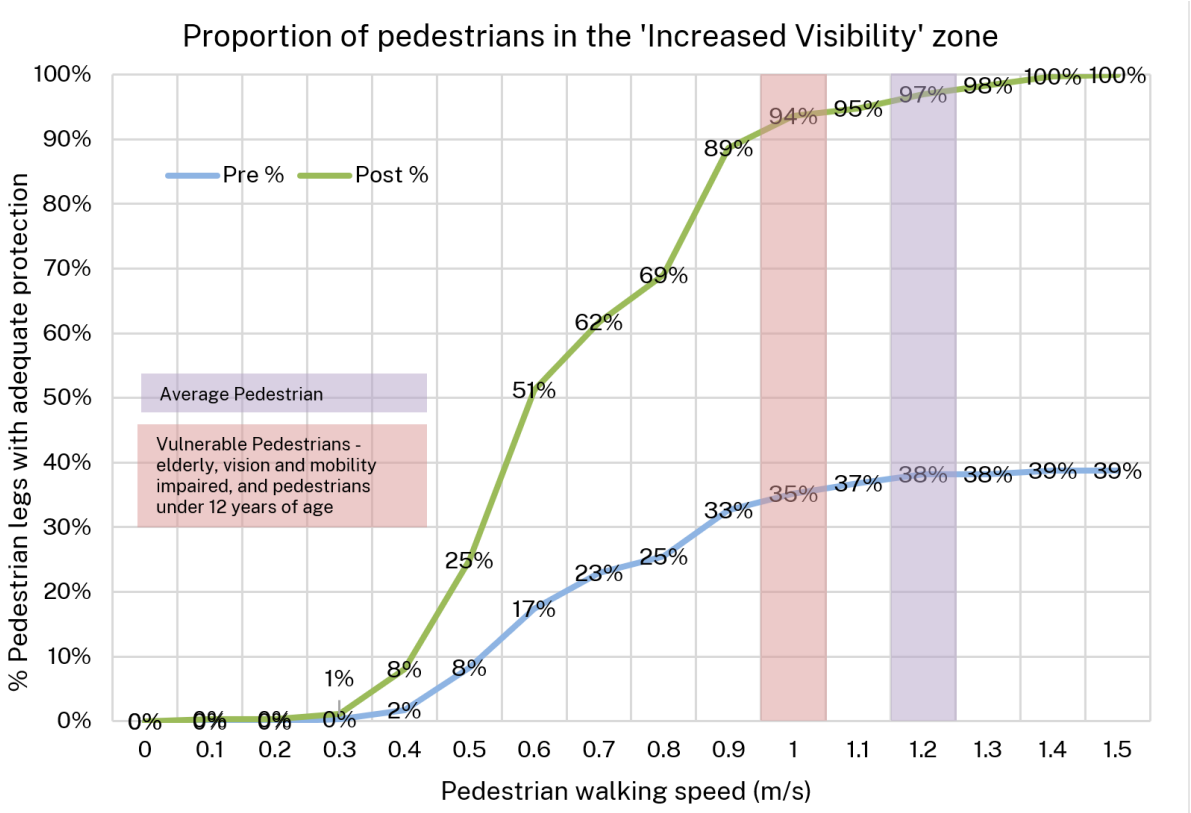

Figure 10: Proportion of pedestrians in the increased visibility zone (pre and post) when pedestrian protection is lifted.

7.3.1 Increases in visibility for the Average and Vulnerable pedestrians

Pre-implementation, only 38% of pedestrian legs provided enough protection for the average pedestrian to enter the 'increased visibility' zone. In contrast, post-PPP, 97% of intersection legs reviewed had adequate protection for the average pedestrians to be able to enter the 'increased visibility' zone.

Similar results were revealed for vulnerable pedestrians. Specifically, whilst pre-implementation only 35% of pedestrian legs allowed vulnerable pedestrians to enter the 'increased visibility' zone, this increased to 94% of intersections which provided adequate protection. Further, even at walking speeds of 0.8m/s, 69% of pedestrian legs had adequate protection for vulnerable pedestrians to enter the 'increased visibility' zone.

7.3.2 Assumptions

The analysis has two key assumptions that were necessary for the analysis. Firstly, it assumes that pedestrians would commence walking as soon as the pedestrian light turns green. In reality, there is likely to be some start loss; the time taken to process the

light change and commence walking. Further, this start loss may be longer for vulnerable pedestrians more than average pedestrians.

Secondly, there was an assumption that pedestrians have an unimpeded access to the pedestrian crossing. However, it is possible that in some cases, where there are heavy pedestrian volumes, pedestrians will be queued behind one another, meaning that they would enter the roadway well after the crossing had commenced. In these situations, it is common practice to increase the green pedestrian signal timing in SCATS, which also means an increased delayed start to vehicles.

However, these assumptions are unlikely to significantly have impacted the safety benefits observed in this stage of the program.

7.4 Conclusion

Stage 3 of the evaluation found that pedestrian protection, at a representative sample of treated sites, was significantly enhanced. Specifically, the proportion of sites where pedestrians end up in the 'improved visibility zone' when vehicles are given a green light to proceed, was significantly increased for both the average pedestrian (from 38% before to 97% after) as well as for vulnerable pedestrians (from 35% before to 94% after). For the pedestrian legs that could have been afforded more protection to allow vulnerable pedestrians to enter the 'increased visibility zone', minor increases in protection by 1 to 2 seconds would result in 100% compliance. Further roll out of PPP should consider utilising 'improved visibility' method, in determining whether protection is adequate.

8 Stage 4: Was the PPP implemented as intended?

KEY FINDINGS

- The planning, development and implementation of the PPP required coordination between many areas and divisions within TfNSW.
- The planning and development phases required significant time and resources to manually identify, review and recommend appropriate protection at two-phase sites.
- There were a range of factors that impacted timelines and cost, many of which were outside of the direct control of delivery stakeholders.
- Key enablers of the program were a strong willingness to deliver PPP by stakeholders, freedom to request further funding when needed and the expertise of service providers.
- Some of the identified barriers to the program included organisational changes, unforeseen timeline blowouts, funding constraints and the need to manage customer sentiment.
- There was no strong evidence that vehicle throughput was impacted by introducing PPP. Findings were mixed as to whether customer complaints increased due to traffic flow efficiency issues.
- Better prioritisation and assessment of constructability should be identified early to ensure project risks are accounted for early.
- PPP has resulted in a culture change; protection is now considered to be embedded as BAU when traffic signals are fixed, modified, or amended.

8.1 Brief Method

The implementation of the PPP was explored through a series of stakeholder interviews. Three key stakeholder groups were interviewed, via Microsoft Teams, over November/December 2022. These stakeholders were identified as being integral to the various stages of the program development and delivery.

8.1.1 Interview Guide

An interview guide was developed to support the consultation, which covered the planning and development phase, the implementation phase, and future phases of the project. The results of the stakeholder interviews are structured based on the areas of enquiry addressed with each group.

8.2 Summary of Findings

8.2.1 Planning & development phase

The role of each of the teams

The Safer Roads (SR) team had a significant role in development and program level approvals of the PPP. Network Operations (NetOps) supported the identification of PPP sites and TCS operations. NetOps provided SR with a list of sites which SR prioritised based on road safety, while NetOps determined the intervention needed for each. Greater Sydney (GS) supported the program primarily through the delivery of site investigations and civil works, where necessary, to implement the PPP. Upon completion, NetOps checked the reconstructed sites to ensure the treatment and timings were operating efficiently and as per design.

How were two-phase PPP sites identified?

Within the *Sydney Coordinated Adaptive Traffic System* (SCATS; the system that monitors, controls, and optimises the traffic light system in NSW), TCS sites that were two-phased sites could be identified, and a manual assessment could be conducted to determine if they had pedestrian protection. However, all stakeholders identified that there was no easy method to extract a complete list of all two-phase signalised intersections or assess if there was adequate protection. Further there was significant workload in terms of analysing and prioritising every intersection, demonstrating the need for pedestrian protection, and ensuring there was not going to be a significant impact on traffic management.

How was the required type of PPP intervention determined (e.g., delay vs arrow)?

The amount of protection that was provided was typically assessed by SR and NetOps; GS was not involved in those decisions. SR stated that the assessment process to determine the type of intervention required at each site was not a formalised process but was more ad hoc. Factors such as the type of protection, the cost associated, the amount of protection provided were all factored into the overall solution.

Prioritisation of delivery

Prioritisation was largely based on an intersection risk model which was a manual assessment process at the time. TCS near a school, hospital, or shopping precinct were also prioritised over typical urban residential streets with low pedestrian volumes.

8.2.2 Implementation phase

Factors that impacted delivery timeframe and cost

Several major factors impacted timeframes and cost of delivery, with many impacting both. These included:

- delivery of other competing major projects across NSW
- limited time available for night works

- liaising with stakeholders i.e., local councils
- costs associated with Arrow vs Delay treatments
- risks associated with older sites requiring significant reconstruction.

Key enablers and barriers

Some of the key enablers included:

- a strong willingness to deliver Pedestrian Protection Program by all stakeholders
- flexibility to request additional funding when needed
- the experience and working relationship with service providers.

Some of the identified barriers included:

- organisational changes causing disruption
- unforeseen timeline blowouts
- funding
- customer views/attitudes towards changes in pedestrian infrastructure.

Did the program impact vehicle throughput at treated intersections?

Most stakeholders did not believe that the program impacted vehicle throughput at all. However, there was no strong evidence which documented this systematically. No formal assessment was conducted by any stakeholder either through traffic modelling or other measures to assess whether throughput was impacted. This was in part due to the data that SCATS could output, particularly in relation to Level of Service, pre-and post-implementation. This type of analysis would also be constrained by resourcing within NetOps whose focus remains on delivery.

One measure, however, of the extent of impact on vehicle throughput was the amount of correspondence received about the operation of the intersection (both by customers and internal stakeholders). Stakeholders' views were mixed on this issue, with some asserting that there had been no change in the number of complaints, and others reporting an increase. However, stakeholders reiterated that irrespective of any impact on vehicle throughout, it was imperative that safety was prioritised over efficiency.

8.2.3 Future phases

Enhancing delivery of future pedestrian protection programs

Stakeholders did not believe that there was much opportunity to enhance the program, given the way that TfNSW is structured. They believed that the greatest risk to the program was in the delivery of future work. Specifically, whilst at a program level all the necessary approvals can be provided to facilitate a work to be delivered, delivery is ultimately prioritised by GS and ROM in competition with other major state projects.

From a delivery perspective, stakeholders suggested that better prioritisation of sites would enhance the future rollout of the PPP, particularly in terms of constructability. One proposed mechanism was to create delivery tiers – e.g., identify at a program level which sites required delay protection vs more complex sites requiring full designs and utilities' investigation - these sites could be started earlier and progressed in parallel.

8.2.4 Final comments

Stakeholders all echoed that the delivery of the PPP was very successful in terms of improving pedestrian safety. One stakeholder stated how important it was that this program brought about a culture change; they felt this was a big win. Specifically, they asserted that senior staff who were originally sceptical about the impact of the program on traffic efficiencies were now on board and had incorporated the practice of adding pedestrian protection into their BAU.

It was stated that this culture change, in terms of thinking about and prioritising pedestrian safety, has been embedded into many parts of the business with the implementation of pedestrian protection at major intersections now standard. Even at older intersections, if any amendments were to be made, pedestrian protection would also be added. This was the case even when new pedestrian legs are implemented.

Stakeholders also highlighted that the program was largely well received by the community, with reference to receiving positive feedback from schools in particular.

9 Conclusion

9.1 Conclusions

The NSW Pedestrian Protection Program aimed to upgrade two-phase signalised intersections with timed pedestrian protection (TPP) to improve pedestrian safety. Overall, the evaluation demonstrated that the program successfully reduced pedestrian crash rates, decreased conflicts between pedestrians and vehicles, and improved pedestrian visibility. These findings support the continued implementation and expansion of PPP in future intersection upgrades.

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