Waka Kotahi Speed Review 2023

Economic impact analysis

June 2023

Building a better working world

Contents

Transmittal Letter

Waka Kotahi Speed Review 2023 – Economic impact analysis

20 June 2023

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Dear Luke,

Thank you again for the opportunity to assist Waka Kotahi in performing the 2023 Speed Review. In accordance with the Consultancy Services Order (CSO) Contract (the 'Contract'), dated 23 March 2023, EY was engaged to independently evaluate the economic impact associated with the speed limit reduction for the State Highway 5 Rangitaiki and Esk Valley segment. The priorities were to provide evidence regarding the effects of the speed limit reduction, both in terms of size and direction (i.e. costs and benefits). Our findings are outlined in this report (the "Report"), setting out our methodology, findings, and qualitative impacts.

In summary, our analysis concludes that the speed limit reduction is likely to have directly led to a decrease in both the number of crashes, and the severity of the crashes that occurred. This greatly offsets costs associated with travel time increases, and when combined with the economic benefits associated with vehicle maintenance and emissions, leads to a large net benefit. While not all economic impacts can be monetised through best practice appraisal tools, it is clear that the speed limit reduction has achieved its goal of reducing the number of fatalities and serious injuries that occur on the segment.

Purpose of the Report and restrictions on its use

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If you would like to clarify any aspect of the report or discuss other related matters then please do not hesitate to contact me.

Yours faithfully

Chris Money
Partner, Strategy and Transactions

Executive Summary

EY has completed an independent review of the costs and benefits attributable to the 18 February 2022 speed limit change on the Rangitaiki to Esk Valley section of State Highway 5 (SH5). Although Waka Kotahi databases and technical manuals represented key inputs to the analysis, EY developed and applied its methodology autonomously. Feedback from Agency officials was limited to terminology and drafting suggestions, for reasons of clarity and accessibility.

Economic impact analysis, in this context, involves estimating relevant outcomes and measuring results in monetary terms (wherever possible). This primarily takes the form of cost-benefit analysis, consistent with Waka Kotahi business case guidance, and makes use of best-practice appraisal tools. Although longer-term and more in-depth research is always possible, we are confident that the most pertinent and significant impacts of the speed limit change have been captured through this assessment.

Analysis found that the speed limit change on SH5 both reduced the frequency of crashes and decreased the severity of injuries that would result from a crash. Approximately **34 crashes were avoided in the year following introduction of the speed limit change**, based on statistical analysis against a comparable prior year. We estimate the monetised value of each avoided crash to be $0.9m based on Waka Kotahi appraisal tools, which when applying the number of average avoided crashes will be equivalent to $31m for a full year. In addition, the reduction in the severity of a crash is equivalent to $3.2m (equivalent to approximately one quarter of a fatality). For the observed year, we see a benefit of $62m from reduced crash severity. This results in total safety benefits of **$93 million** for the year.

The speed limit change on SH5 increased travel time costs for road users. Although some sections of the highway saw a decrease in speed of over 10km/h, the weighted average was 2.3km/h. This implies a travel time increase of **0.5 to 2.8 seconds per km travelled**, and in total, **36 seconds to 3.6 minutes for a single journey.** This translates to a **cost of 23,476 hours for the year across all drivers** relative to an equivalent prior period. This differential in observed speed may be driven by the characteristics of SH5; many sections are classified as curved, winding, narrow, or containing significant roadside hazards. This translates to a total **travel time cost increase of $1.3 million** for the year.

Other costs and benefits were modest, but include a reduction in vehicle operating costs of $156 thousand and reduced emission impacts of $19 thousand for the year. Qualitative impacts related to perceptions of safety, noise, freight were investigated, however we were unable to identify any evidence that would alter the conclusions of our monetised economic analysis. Sensitivity analysis of each cost and benefit similarly indicates that conclusions are robust to alternative assumptions.

We estimate the economic impact of the speed limit change on SH5 to be **$92.6 million** in net benefits for the period March 2022 – February 2023. Sensitivity analysis, using alternative modelling assumptions, leads to a range in net benefits of $65m to $120m. Waka Kotahi can be confident that the speed limit change on SH5 has led to improved economic outcomes for New Zealanders.

1 Introduction

1.1 Background context

Waka Kotahi's Road to Zero initiative was published in 2019, striving for a world in which no fatalities or serious injuries occur on New Zealand's roads. As part of this initiative, the Agency regularly performs speed review processes, examining whether speed limits for specific corridors should be changed.

While technical analysis is a critical part of these speed reviews, Waka Kotahi also recognises the importance of local knowledge and experience. The Agency regularly seeks input from the public, alongside engaging in formal consultation regarding proposed speed limit changes. These consultations play a critical role in revealing any additional information to consider alongside the technical information that may play impact NZTA's final decision.

Waka Kotahi's SH5 speed review evaluates the speed limits the segment of State Highway 5 (SH5) that lies between Rangitaiki and Esk Valley. For the purposes of this report, we refer to the specific segment that was affected by the 2022 speed limit reduction as SH5.

Figure 1. State Highway 5 Speed Limits

This a particularly high-risk passage, with there being 16 fatalities and 75 serious injuries between 2010 and 2019, with the total number of crashes during this timeframe having led to 250 injuries. In addition to performing the speed review, the Agency has provided further investment, which was used to install side barriers, road markings, and maintain the overall roading quality to improve safety outcomes.

Waka Kotahi's technical assessment for this segment suggested that lowering the speed limit would reduce the number of crashes and injuries associated with this corridor. However, formal consultation and public feedback showed that many New Zealanders would prefer the local speed limit remaining at 100km/h. It should be noted that consultation also revealed an underlying theme of unease regarding driver behaviour, as well as concerns about road surface quality.

After evaluating the technical analysis and public feedback, the Agency decided to reduce speed limits on SH5 from 100km/h to 80km/h, implemented on the 18th of February 2022. In this announcement, Waka Kotahi also committed to commissioning an evaluation regarding the impact of the speed limit reduction, considering the safety, social, and economic impact, as key partners and community leaders desired further analysis and evidence demonstrating the appropriateness of the reduced speed limit.

This report details our (EY) independent analysis of the economic impact associated with the change in speed limit for SH5 (henceforth referred to as the Economic Impact Analysis). Our methodology applies an assessment approach that is consistent with Waka Kotahi economic appraisal guidance, and considers both quantitative and qualitative impacts rising from this change. Note that the evaluation is not a full business case nor an economic forecast of future outcomes.

1.2 Driver behaviour

Statistical analysis of safety and other transport-related outcomes essentially involves a 'before and after' comparison, making use of the best available evidence. Although monetised assessment focusses on specific measures such as deaths, injuries and travel time, factors such as driver behaviour represent important context for the analysis.

Measuring speed limit compliance is difficult due to the limited amount of data available and the potential privacy considerations surrounding such data. However, police reporting indicated a decrease in both the median and average speed, amongst those experiencing a crash, for the 2022 calendar year:

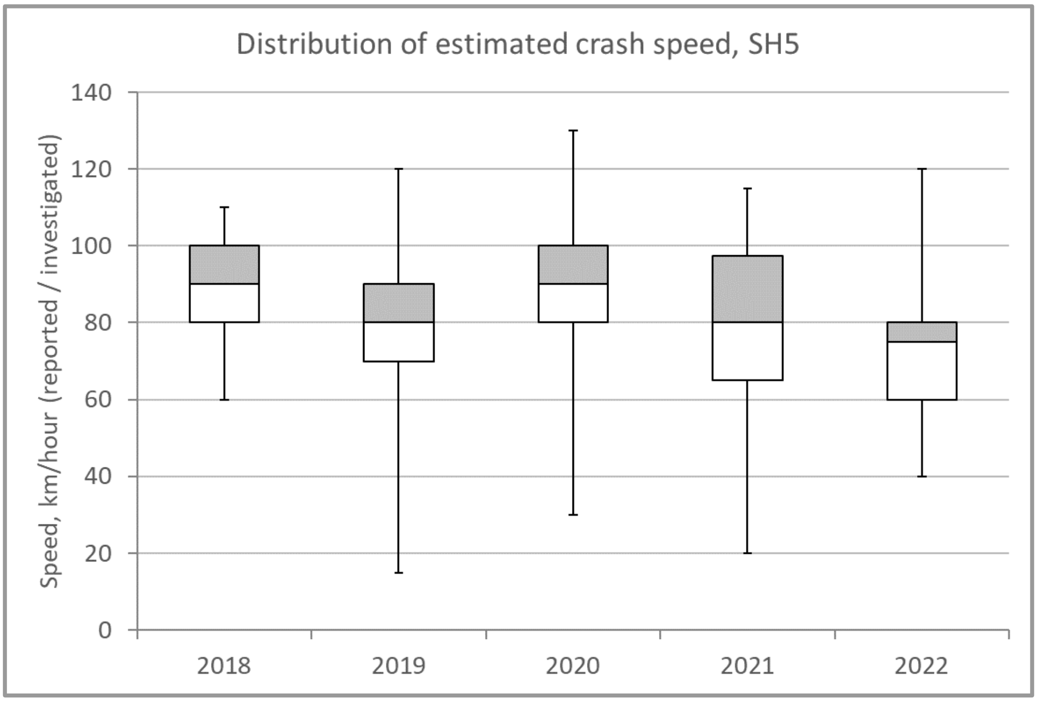


Figure 2. Reported speed data, SH5, by calendar year (Crash Analysis System)

This box and whisker plot provides a visual summary of the dataset, representing the minimum, maximum, median, and quartile crash speeds for each year. The box represents the central quartiles (the blank box representing quartile two, the grey representing quartile three, and the line between representing the median value), with the whiskers showing the full range.

This data suggests that the speed limit change did not significantly affect compliance, within the group of drivers involved in a crash on SH5. 25% of reported crashes, for example, were reported as exceeding the relevant speed limit in both 2020 and 2022 (100km/h and 80km/h limits respectively). The median speed, in particular, was lower in 2022 than in any previous year. It should be noted that the SH5 speed review began in February, rather than at the start of calendar year 2022, so this conclusion should be treated as indicative only.

Observed travel speed data, obtained from MegaMaps, also points to a decrease in average travel speed before and after the speed limit was changed:

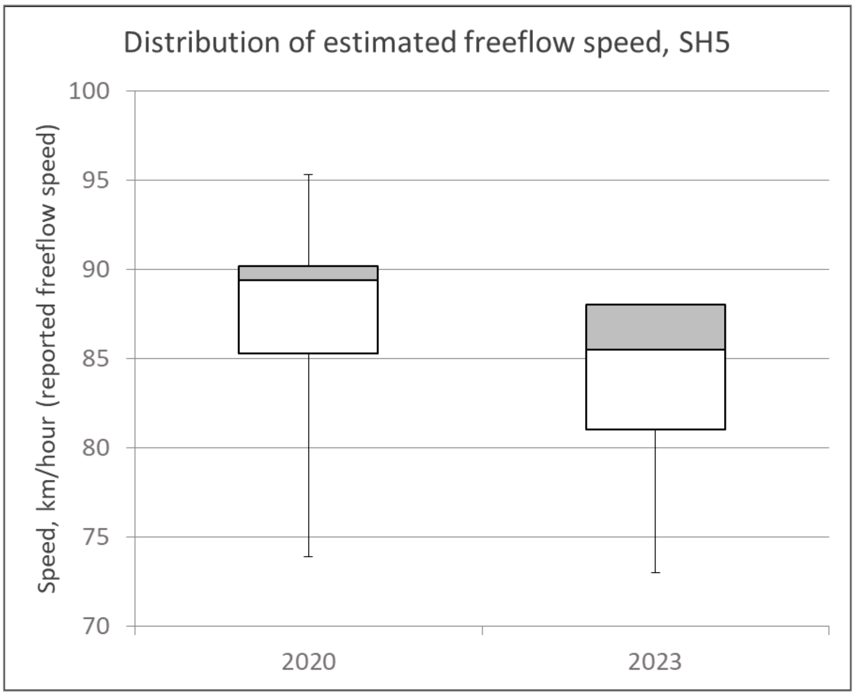


Figure 3. Distribution of observed speeds across SH5, by corridor section and calendar year

While average speeds have decreased by approximately 2km/h, this data indicates a number of drivers still choose to travel over the speed limit, making it difficult to reach a clear conclusion regarding the compliance behaviours of all drivers.

1.3 MBCM updates

Waka Kotahi's Monetised Benefits and Costs Manual (MBCM) is the standard reference for evaluating the economic impact associated with transport activities and investments in New Zealand. On April 14th 2023, Waka Kotahi released a newer version of the MBCM (version 1.6), significantly changing several parameter values and providing revised update factors.

While EY analysis began prior to these new values being released, our outputs reflect these updates, recognising that version 1.6 now represents the latest and best available guidance. Changes are highlighted because the social cost of deaths and serious injuries are a significant driver of our results. Some of these values have increased dramatically, for example, the social cost of a fatality rising from $4.3 million to $12.5 million. The full list of relevant changes are:

- Social cost of deaths and serious injuries;
- Network productivity and utilisation (travel time values);
- Air emission health impacts;
- Greenhouse gas emission impacts;
- Walking and cycling benefits;
- Update factors (changes over time to reflect inflation); and
- Miscellaneous changes for simplified procedures and decision-making.

From a total monetised value perspective, the MBCM update increases the quantified benefits. For clarity and to demonstrate analytical robustness, our results are calculated using both prior (version 1.5) and current MBCM (version 1.6) values. This report presents the two impact sizes separately, but the results using prior MBCM values should be considered a sensitivity because they reflect outdated evidence and research.

2 Methodology

The following chapter presents our methodology and results for the Economic Impact Analysis.

Our estimation for the net economic impact of the speed limit reduction is given as a monetised figure. This is recommended as best practice for economic appraisals within New Zealand.

Note that unless specified otherwise, all references to annual results relate to the March 2022 – February 2023 period.

Where possible, sensitivities have been included to show the full range of effects. For instance, we present effect sizes associated with the low, mid, and high shadow price for carbon, and analyse the changes in vehicle operating cost for a range of speeds.

2.1 Overview

We undertook a three-step approach for our Economic Impact Analysis:

1. Collated key SH5 data over time. These parameters include vehicle-kilometres travelled (VKTs), average travel speed, total journey volumes, and other associated travel data
2. Estimated the change in costs and benefits that is attributable to the decrease in speed limit
3. Performed cost-benefit analysis to determine the total impact size that results from the change in speed limit, relying on monetised values from the MBCM.

Step 2 applied various forms of statistical analysis, including econometrics to appropriately attribute specific valuations to the speed limit decrease. Outputs from step 2 were used to build a cost-benefit analysis model for step 3.

We provide a detailed breakdown of each step below.

2.2 Step 1: Data collation

As our evaluation depended heavily on the quality and form of input data, collation and cleaning was a critical component of our methodology to ensure that our results are accurate and fit for purpose.

Crash and speed related input data was provided by Waka Kotahi. Primary sources were the Waka Kotahi Crash Analysis System (CAS) database and geospatial MegaMaps tool. While we consider this data to be largely robust and appropriate for use for the Economic Impact Analysis, we note some limitations regarding the inputs below:

- The CAS data may not fully capture all crashes, specifically those which do not result in a fatality or serious injury. This is unlikely to affect final valuations in a material fashion, as such crashes are assigned a low monetised value within the MBCM
- Certain CAS values like crash speed are self-reported from external sources such as the police, thus adds some degree of inconsistency. Where possible, we have avoided using potentially inaccurate values within our analysis
- Traffic volumes, free flow speeds, and road conditions obtained from MegaMaps is collated into two temporal periods, 2020 and 2023. These time periods still align with our analysis, as the 2020 observations lie prior to the speed limit reduction, and the 2023 comes after, thus the comparisons we draw capture the effect of the change.

2.3 Step 2: Statistical analysis

This is the most conceptually complex step within our methodology as road crashes have a number of causes and influences. We apply a statistical methodology in order to isolate the effect that is associated with the speed limit change, rather than conflating any potential impacts that may rise from a change in other variables.

2.3.1 Hypothesis testing

One critical exercise that was required prior to quantifying impacts was testing whether the speed limit change had a statistically significant impact on the number of crashes. While published research is clear in that lower speeds tend to result in fewer and less severe crashes, this still required testing to prove the relationship held for this specific time period and location. A hypothesis test provides initial evidence into whether the impacts of the speed limit change are truly material.

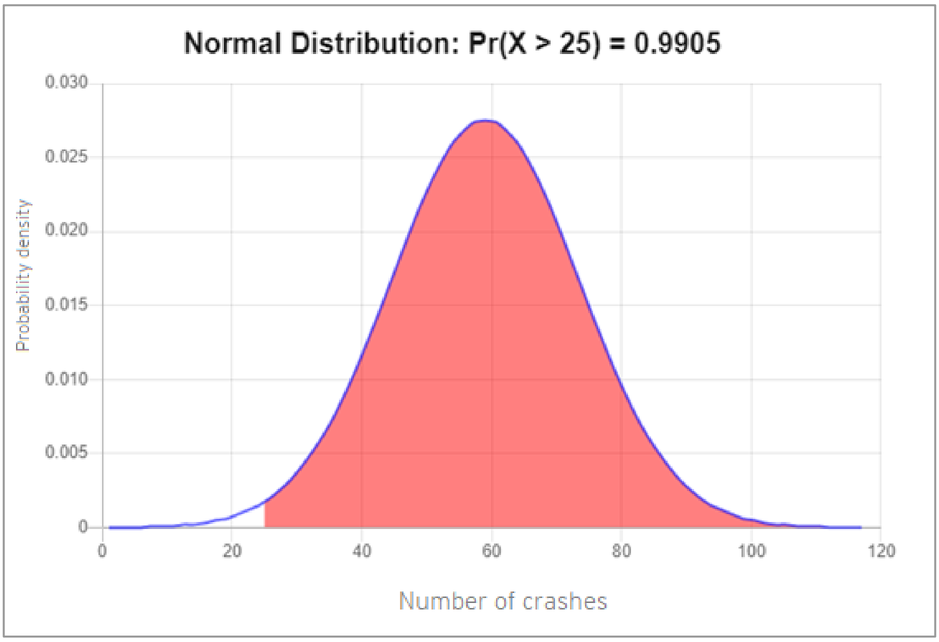
One challenge with this form of hypothesis testing is that the speed limit change was only in effect for one year at the time of analysis, which limits our ability to perform the t-test (and by extension, the z-test), both of which are a traditional methodology for hypothesis testing.

Instead, we constructed a distribution for the average number of crashes that would occur in a year for SH5 from crash data prior to the speed limit reduction. By doing so, we can see whether the observed number of crashes that occurred after the speed limit change stays statistically equivalent with a 100km/h limit, or whether it has changed by a sufficient amount such that it becomes statistically relevant. Note that this process assumes that crashes are distributed in a normal fashion, something that is well supported by historical research.

Due to the speed limit coming into effect in February 2022, we adjusted crash data to ensure consistent annual observations. Thus, we measure the number of crashes that occur from the beginning of March in a given year to the end of February for the next, e.g. March 2018 to February 2019 inclusive.

Furthermore, some observations during the 2022 period that occurred after the decrease still occurred at a posted speed limit of 100km/h. These observations have been cleaned, i.e., removed from the data, to maintain time consistency.

We present the normal distribution of crashes associated with the pre-speed limit change SH5 data, as well as summary statistics below:



Total years	4	Year range	2018-2021
Minimum	38	Maximum	71
Lower quartile	56	Upper quartile	66.5
Median	63.5	Mean	59

Figure 4. Statistical characteristics of crash data on SH5, prior to the speed limit change

The analysis suggests that, for a given year in which the speed limit was set at 100km/h for SH5, one would observe an annual crash count of 25 or lower roughly 1% of the time. It is, therefore, highly unlikely that such a crash count would be caused by random chance or variation. This implies that the speed limit reduction had a material impact on the number of crashes. Our crash count captures all crashes, including crashes that resulted in a fatality, serious injury, minor injury, or a non-injury.

We also perform robustness checks, expanding the dataset to include a selection of similar highways (i.e. routes connecting cities and those with similar geographies). These highways consisted of:

- SH39 Whatawhata – Otorohanga
- SH3 Piopio - Urenui
- SH1 Blenheim – Kekerengu.

With an expanded dataset, the conclusion of the speed limit change having a statistically significant impact (at the 5% level) on the number of crashes holds true.

2.3.2 Econometric analysis of crashes

Having confirmed that the speed limit change had a statistically significant impact on the number of crashes, we proceeded to estimate the attributable effect size. Observed changes are measured in monetised terms. Note that the use of recorded observations within a single year, as opposed to a sample of data or comparison between years, precludes sensitivity analysis being applied to the estimated change in crashes, injuries, and fatalities following the speed limit change.

EY analysis examined two effects that the reduced speed limit could have on crashes:

1. Reducing the total number of crashes
2. Reduce the severity of crashes, represented by a change in crash cost.

As an example, if a crash were to result in a death while travelling at 100km/h but only lead to a serious injury at 80km/h, we can state that there is an associated decrease in the cost associated with this crash that comes from the change in speed. By applying this approach to the change in speed limit and adjusting for other factors, we can quantify this particular effect and thus estimate the avoided cost.

First, we identify the reduction in total crashes. In defining the change between pre- and post-speed limit change, we account for several factors:

- The appropriate time period to consider
- Use of crash statistics from other similar corridors
- Potential travel implications rising from COVID.

For consistency in results and methodology, we apply the same observational sample used to identify whether the speed limit decrease had a statistical impact, and estimate the average, highest, and lowest change in crashes between years.

Table 1. Range of avoided crashes when comparing post speed limit reduction to pre

Sensitivity	Change in crashes
High	63
Average (mean)	34
Low	5

From here, we analysed what the value of one of these crashes would be. We calculate the value of crash from MBCM values, i.e., the total monetised impact of the fatalities, serious injuries, and minor injuries associated with a crash. We derived these monetary values from the current version of the MBCM, but for sensitivity analysis, we also present values calculated using old MBCM parameters. The difference between MBCM version 1.5 and 1.6 for 2023 are given below:

Table 2. Monetised safety impacts, Waka Kotahi Monetised Benefits and Costs Manual

Severity	MBCM 1.5 (2023 $ value)	MBCM 1.6 (2023 $ value)
Minor injury	$34,333	$92,983
Serious injury	$600,831	$910,370
Fatality	$5,550,534	$16,109,880

We use the average value of a crash for the 100k/h speed limit period to identify the avoided crash benefit:

Table 3. Monetised avoided crash benefits

Effect time period	Avoided crash benefit
MBCM 1.5 (2023 $ value)	$460,064
MBCM 1.6 (2023 $ value)	$936,319

We present the total benefits attributable to avoided crashes below:

Table 4. Decrease in annual crashes before and after speed limit change, and monetised value

Sensitivity	Change in crashes	MBCM 1.5 (2023 $ value)	MBCM 1.6 (2023 $ value)
High	63	$28,984,032	$58,988,097
Average (mean)	34	$15,642,176	$31,834,846
Low	5	$2,300,320	$4,681,595

Having considered all crashes, subsequent analysis focusses on the costs associated with crashes that resulted in at least a minor injury. We utilise standard econometric techniques to attribute the effect that the speed limit change has had on this particular cost, utilising an ordinary least squares specification.

Prior to performing this statistical analysis, we first consider our dataset in the context of the Economic Impact Analysis. As noted above, this portion of the analysis examines the set of crashes that results in at least a minor injury. Crashes not resulting in any form of death or injury do not have an MBCM safety value attributed to them and, therefore, are excluded in this analysis.

The initial dataset used for this analysis comes from the Waka Kotahi CAS database, aggregating all crashes that occurred on SH5 from January 2018 to February 2023. We then assigned each crash a total value using MBCM values. Any crash that results in a value of 0 is then cleaned from the dataset. We also consider additional parameters such as season, time, and month, all of which can be derived from CAS information. These parameters reflect other potential causes for an individual to crash, beyond the speed they were travelling at.

One consideration we made for our estimation is the impact that COVID has had on driver behaviour. Therefore, we limited our dataset to the time period post 2020, such that we can reduce the potential variance that COVID has had.

Key features of these results are:

- The speed limit change is statistically significant at the 0.1 level, which means that through pure chance, it is only possible to observe an effect of this particular size less than 10% of the time. This supports the idea that the speed limit change truly had a material impact on the cost associated with a crash. Given that the coefficient is positive for both sets of results, we can state that the severity of a crash decreases as speed limits are lowered.
- The total number of vehicles is the single most important decider in determining the severity crash. This is an intuitive outcome, the greater number of people involved in a crash, the larger safety impacts.
- We observed that seasonal effects are not statistically significant, and thus have little impact on the cost associated with a crash. This could be due to a variety of reasons, but likely that this is resultant due to the fact that both the speed limit and the total number of vehicles have such strong effects that it virtually removes the impact that rises from differing seasons.

Using these values, we can now estimate the decrease in cost associated with a speed limit at 80km/h compared to 100km/h. Note that our econometric analysis estimates the marginal effect associated with a 1km/h change in the limit. Thus, we must multiply this effect by 20 in order to capture the total impact attributable to the speed limit decrease.

Table 5. Reduction in crash cost associated with speed limit change

	Marginal effect (1km/h change in speed limit)	Average cost per crash (100km/h to 80km/h change)
MBCM 1.5 (2023 $ value)	$79,028	$1,580,563
MBCM 1.6 (2023 $ value)	$162,807	$3,256,142

Both of our regressions have adjusted R-squared values which are around 0.18. An adjusted R-square value is a measurement of how well the model can describe variance in the data.

This would imply that our model accounts for at least 18% of the changes in crash cost. While 18% appears low, this is most likely due to the fact that crash costs are still greatly affected by factors that are external to the model (such as speed at impact, vehicle type, total number of passengers). Therefore, we consider our outputs relevant enough such that we can utilise them to calculate the total impact that the speed limit change has had.

We now consider the number of relevant crashes in the 1-year study period to identify the total impact. Of the 25 observed crashes post-speed limit change (March 2022 – February 2023), 19 of them resulted involved a fatality, major and / or minor injury. Thus, we can multiply the change in per crash to estimate the total reduced cost from these crashes over a full year:

Table 6. Total reduced crash costs associated with speed limit change

	Number of crashes	Year's cost savings
MBCM 1.5 (2023 $ value)	19	$30,030,700
MBCM 1.6 (2023 $ value)	19	$61,866,696

Note that performing sensitivity analysis for this effect is difficult. As we are analysing the impact for a full year utilising the true observed numbers, proposing a confidence interval or similar indicator of uncertainty would be disingenuous. Rather, we suggest that inclusion of these cost savings may be comparable to a form of sensitivity analysis, as one may disagree with established literature and suggest that other factors may lead to there being little difference in the cost associated with a crash under two differing speed limits for this particular corridor.

While these safety benefits are the biggest contributor to the benefit associated with the speed limit reduction, we must consider a combination of other effects in order to determine the net effect, and whether it results in a total benefit or cost.

2.4 Step 3: Cost Benefit Analysis

Beyond safety benefits, the speed limit change will affect both the travel time and the total vehicle kilometres travelled (VKTs) on the corridor. For transparency, we will assume that VKTs remain the same pre and post speed limit change. This is because we cannot calculate the effect that the speed limit decrease had on total trips travelled. Changes in travel time will still impact a variety of differing factors, such as:

- Vehicle operating costs;
- Greenhouse gas emissions; and
- Health impacts from pollutants.

We estimate the differences in impacts that result from the speed limit reduction through a cost-benefit analysis model, using the change in travel time to calculate the total impact. We rely on MegaMaps data, outputs from the Vehicle Emissions Prediction Model (VEPM), and MBCM values for this part of our analysis.

2.4.1 Total trips / VKTs

Drawing on MegaMaps data, we take an average of the daily trips in 2020 and 2023 with the length of the corridor (76km) to get total VKTs.

Table 7. Annual trips / VKTs used for analysis

Trip count / Total VKTs	Totals
Total daily trips	3,216 trips
Total yearly trips	1,173,840 trips
Total VKTs	89,199,861 VKTs

We now use these VKTs to calculate the effect changes associated with vehicle operating costs, greenhouse gas emissions and health impacts from other vehicle pollutants. We will monetise these impacts using MBCM values. Prior to calculating, we must first split VKTs by vehicle type. We assume that the New Zealand wide fleet profile for 2022 provided by the VEPM holds true for this corridor, and utilise those ratios for calculation.

2.4.2 Vehicle operating costs

When considering vehicle operating costs, we refer to the MBCM values. We consider three scenarios, with the first being what we observed to be the true change in travel speed, the second being a “low” scenario, where we assume that there is little change in travel speed, and finally a “high” scenario, in which we assume that there was a large change. The last two scenarios are sensitivities, and were obtained from the minimum and maximum freeflow speed changes seen in MegaMaps data.

Table 8. Vehicle speeds pre and post speed limit decrease

Vehicle type	Observed	Low (sensitivity)	High (sensitivity)
Pre-speed limit	86km/h	74km/h	95km/h
Post-speed limit	84km/h	73km/h	88km/h

Note that these values remain unchanged from the MBCM update. We present the present values for vehicle operating costs below:

Table 9. Vehicle operating costs per KM for given speeds

Vehicle operating cost	Observed $ value	Low $ value	High $ value
Pre-speed limit	32.76 cents/km	31.94 cents/km	33.55 cents/km
Post-speed limit	32.59 cents/km	31.87 cents/km	32.94 cents/km

Applying these values then estimates the total change in vehicle costs. We provide the observed effect alongside sensitivities:

Table 10. Total change in vehicle operating costs, per annum

Total impact (2023 $ value)	Observed	Low (sensitivity)	High (sensitivity)
Total change in vehicle operating cost, annual	-$156,128	-$65,053	-$546,449

As travel speeds reduce, the operating cost per kilometre is lowered. Therefore, we can state that the reduction of the speed limit brings an associated benefit with respect to the lowered vehicle operating cost for travellers.

2.4.3 Emission impacts

When considering the emissions impact associated with the speed limit reduction, we will be using VEPM outputs which have been monetised using MBCM values. As VEPM outputs are based on travel speed, we will use the same speeds that we used in vehicle operating cost, with one exception. Due to the fact that the VEPM does not allow speed inputs greater than 86km/h for Heavy Commercial Vehicles (HCVs) and Buses, we will assume that for the high sensitivity that pre-speed limit decrease, they were travelling at 86km/h, and post-speed limit they were travelling at 80km/h.

We present our speed inputs for the VEPM below:

Table 11. Vehicle speeds used to inform vehicle emissions calculations

Vehicle type	Observed	Low (sensitivity)	High (sensitivity)
Pre-speed limit	86km/h	74km/h	95km/h*
Post-speed limit	84km/h	73km/h	88km/h*

From here we use VEPM emission factors in conjunction MBCM effect sizes to calculate greenhouse gas (GHG) emissions effects and pollution health impacts.

Note that GHG emissions are valued using a shadow price, which is a government agreed monetised valuation based on international / national emission goals.

The value for both these impacts were changed with the new MBCM update. We present both prior and current values below:

Table 12. Shadow price of carbon

Shadow price of Carbon (CO2-e) ($/tonne)	MBCM 1.5 (2023 $ value)	MBCM 1.6 (2023 $ value)
Low	$64	$65
Middle	$96	$97
High	$128	$182

The previous version of the MBCM did not provide a middle value, thus deriving it as an average from the low and high gives $96.

Table 13. Associated health costs for emissions

Rural costs for emissions ($/tonne)	MBCM 1.5 (2023 $ value)	MBCM 1.6 (2023 $ value)
$PM_{2.5}$	-	$51,058
PM_{10}	$545,599.99	-
NO_x	$19,388.46	$25,011
CO	$4.90	$0.20
VOC/HC	$1,553.73	$63

Note that the old MBCM values are solely for national level impacts. Furthermore, while the current MBCM provides values for SO_2 impacts, VEPM does not provide specific outputs, thus we exclude it from our analysis. Another point of analytical difference is the addition and removal of $PM_{2.5}$ and PM_{10} effects respectively. While we will provide effect sizes for both categories, the MBCM no longer considers the impacts of PM_{10} and thus, we recommend non-consideration from an evaluation perspective.

The following table summarises the total effect sizes for emission impacts:

Table 14. Change in vehicle emissions costs, by effect, per annum

2023 $ values	MBCM 1.5 – Observed	MBCM 1.5 – Low	MBCM 1.5 – High	MBCM 1.6 – Observed	MBCM 1.6 – Low	MBCM 1.6 – High
CO2-e (low)	$5,241	-$586	$27,785	$5,323	-$595	$28,219
CO2-e (middle)	$7,862	-$879	$41,678	$7,944	-$888	$42,112
CO2-e (high)	$10,483	-$1,172	$55,571	$14,906	-$1,662	$79,015
$PM_{2.5}$	-	-	-	$2,107	$441	$9,204
PM_{10}	-$31,723	-$15,906	-$92,946	-	-	-
NO_x	$8,598	-$2,182	$45,890	$8,946	-$2,270	$47,743
CO	$0.65	$0.14	$3.22	$0.69	$0.15	$3.39
VOC/HC	-$0.53	-$2.01	$4.83	-$0.55	-$2.08	$4.99

Table 15. Total change in vehicle emissions costs, per annum

2023 $ values	MBCM 1.5			MBCM 1.6		
	Observed	Low	High	Observed	Low	High
Total (low)	-$17,884	-$18,676	-$19,263	$16,376	-$2,426	$85,174
Total (middle)	-$15,263	-$18,969	-$5,370	$18,997	-$2,719	$99,067
Total (high)	-$12,642	-$19,262	$8,523	$25,959	-$3,493	$135,970

As travel speeds reduce, we should also see a decrease in the total amount of emissions. For our observed speeds, we see a benefit from reduced emissions that is within the range of $16k to $26k. Analysis conducted using the MBCM version 1.5 shows negative impacts due to the increase in PM_{10}. This is not applicable to current guidance. The low sensitivity shows a cost associated with a travel speed decrease. We believe that this is a function of VEPM calculations regarding emissions at lower travel speeds.

2.4.4 Travel time impacts

Finally, we use the observed free-flow speed to calculate the travel time for before and after the speed limit change. We present these values below:

Table 16. Vehicle speeds and total travel time

	Observed	Low (sensitivity)	High (sensitivity)
Pre-speed limit	86	74	95
Post-speed limit	84	73	88
Time taken pre-change	0.88 hours	1.03 hours	0.80 hours
Time taken post-change	0.90 hours	1.04 hours	0.86 hours
Journey time increase	1.2 minutes	0.6 minutes	3.6 minutes
Total additional hours	23,476 hours	11,738 hours	70,430 hours

We use the composite value of travel time for rural strategic corridors to calculate the cost associated with the increase in journey length.

We provide the values we use below:

Table 17. Travel time values applied to cost-benefit analysis

Composite values of travel time ($/h/vehicle)	MBCM 1.5 (2023 $ value)	MBCM 1.6 (2023 $ value)
Rural strategic – All periods	$38.46	$51.93

Therefore, we calculate total annual travel time costs associated with the change in speed limit on SH5.

Table 18. Total change in travel time costs, per annum

Travel time impacts (2023 $ value)	MBCM 1.5			MBCM 1.6		
	Observed	Low	High	Observed	Low	High
Change in travelled hours	23,476 hours	11,738 hours	70,430 hours	23,476 hours	11,738 hours	70,430 hours
Hourly cost of time	$38.46	$38.46	$38.46	$51.93	$51.93	$51.93
Total cost	-$949,810	-$635,082	-$2,872,608	-$1,282,461	-$857,506	-$3,878,679

As travel speeds reduce, travel times will increase. As we have not attributed any changes in VKT to the speed limit reduction, the direction of the impact will always be negative. For our observed speeds, we see an estimated increase in journey times by 1.2 minutes, an increase of 23,476 hours spent travelling on SH5 over one year, and thus, an associated cost of $1.3m.

3 Qualitative impacts

While our quantitative analysis conclusively points towards there being a large economic benefit associated with the speed limit reduction, there are also several other impacts associated with a change in speed limit that are potentially relevant, but cannot be easily measured in dollar terms. This could be for a variety of reasons, such as:

- The impact being challenging to quantify, such that a single years of data for a specific highway is insufficient to produce a robust estimate of the effect that is attributable to a change in speed limit
- Data not being collected at a sufficiently granular level to permit monetised estimates (e.g., noise modelling)
- Economic appraisal tools in New Zealand not providing a method to measure such impacts in monetised terms (e.g., perceptions of safety).

While we cannot overcome these limitations and integrate all factors into our monetised analysis, we can consider key impacts from a qualitative perspective. This following section evaluates the potential ramification that the speed limit reduction could have on:

- Perceptions of safety;
- Noise; and
- Further impacts on freight.

3.1 Perceptions of safety

Waka Kotahi recognises safety under the Land Transport Benefits Framework, including the impact it can have on behaviour and wellbeing. Associated impacts are not monetised however, and quantified data is largely limited to survey responses.

Perceptions of road safety can represent a material impact to New Zealanders, over and above more traditional and tangible transport impacts. This is because individuals' opinions about safety are an important measure of liveability, with discomfort around the danger of roads acting as a potential barrier to access, social inclusion, and physical and mental health. Furthermore, given that crashes are the second largest cause of death and injury for visiting tourists and business travellers, the perception around New Zealand's road safety has the potential to affect the tourism industry.

Published research indicates that humans are not adept at judging risk, including the relationship between crash statistics and the likely outcomes of unsafe driving behaviours. This does not alter the underlying relationship between crashes and perception however, and international research identifies a direct relationship between travel behaviour and traffic incidents.[1] Improved perceptions of safety can, therefore, be viewed as an additional benefit of the speed limit change on SH5.

3.2 Noise

Waka Kotahi and international research identifies a positive relationship between motorway noise and vehicle speed. This research also points to the cost associated with changes in noise level, in several cases pointing to health implications in addition to a negative experience.

Available data is not sufficiently granular to quantify and monetise the noise impacts specific to a change in speed limit on SH5. Such analysis would need to consider the relatively low

[1] See, for example: https://trid.trb.org/view/1722929

housing density along the affected section, suggesting that the quantum of impacts would be small.

Nevertheless the directionality of this impact is clear. Published evidence points to increased vehicle speed contributing to noise. The decrease in speed created by the 80km/h speed limit can, therefore, be considered a benefit from the perspective of noise impacts.

3.3 Further impacts on freight

Recognising the relatively small, quantified impact associated with the change in travel time (i.e. a change in average speed of 2.3km/h), it is nevertheless important to consider the wider impacts that the speed limit reduction may have on freight, as they are a critical user of the roading network.

While the speed limit decreasing from 100km/h to 80km/h would appear to affect all users equally, HCVs have operated under a maximum speed of 90km/h across the country since 2004, and thus would only realise a partial reduction in speeds. All else being equal, the change in speed limit is likely to have had a lower impact on heavy vehicle travel speeds when compared to light vehicle. However, we note that specific characteristics of road freight travel, for example work-time rules, are not captured in this analysis

This does not preclude the existence of wider costs for the freight industry, given that travel time is only one of several factors affecting industry costs. A recent study by the Ministry of Transport identified that travel time represent about 44 per cent of road freight costs.[2] Other resource costs such as fuel and vehicle maintenance make up approximately 53% of freight travel costs. Duties and levies paid by goods vehicles make up the remaining 4 per cent of costs.

Analysis of vehicle operating costs indicate that an 80km/h travel speed generally reduces costs compared to a 100km/h travel speed. The same pattern applies to external costs such as vehicle emissions. Heavy vehicle duties such as Road User Charges are unlikely to change significantly in the absence of change to kilometres travelled.

Based on the key sources of freight cost identified by the Ministry of Transport, it is not clear that the speed limit change on SH5 has created material cost increases for freight, above and beyond the travel time implications included in the monetised analysis.

[2] https://www.transport.govt.nz/assets/Uploads/DTCC-Draft-Synthesis-Report-07-August-2022.pdf

4 Conclusion

Given our analysis, we conclude that:

- The speed limit reduction has made a material difference in reducing the number of crashes.
- This reduction offsets any negative economic impact generated by the increase in travel time.

Aggregating all results, we can estimate the total impact that the speed limit change has had. As we had value ranges for safety impacts (in terms of avoided crashes) and greenhouse gas emission effects (with respect to CO2-e), we will present our final results as a range.

Table 19. Summary table

	MBCM 1.5			MBCM 1.6		
	Observed	Low	High	Observed	Low	High
Avoided crash benefits	$2.3m to $29m	$2.3m to $29m	$2.3m to $29m	$4.6m to $59m	$4.6m to $59m	$4.6m to $59m
Reduced cost of a crash benefits	$30m	$30m	$30m	$62m	$62m	$62m
Vehicle operating cost impact	$156k	$65k	$546k	$156k	$65k	$546k
GHG emission impact	$5k to $10k	-$1k	$27k to $55k	$5k to $14k	-$2k to -$3.5k	$85k to $135k
Health impact of pollution	-$23k	-$18k	-$47k	$11k	-$1.8k	$57k
Travel time impacts	-$950k	-$635k	-$2.9m	-$1.3m	-$858k	-$3.9m
Midpoint totals	**$44.7m**	**$45.1m**	**$43.3m**	**$92.6m**	**$93.1m**	**$91m**
Total range	**$31m to $58m**	**$32m to $58m**	**$29m to $56m**	**$65m to $120m**	**$66m to $120m**	**$63m to $118m**

Our results conclude that the speed limit reduction results in crash benefits that have a range of $65m to $120m. Additional economic impacts are estimated to be in the region of -$1.1m. While we see small economic benefits associated with a reduction in vehicle operating costs and reduced emissions at lower speeds, the cost associated with an increase in travel time result in additional impacts being a negative.

This leads to a net economic benefit that ranges between $65m to $120m. This range essentially translates to an annual benefit that would be generated every year when comparing against a world in which the speed limit remained at 100km/h.

Approaching this from another perspective, the benefit that has been produced through the speed limit reduction is monetarily equal to 5 to 9.6 avoided fatalities. We believe this to be an apt comparison as a large proportion of our final results come from the avoided crash and reduced cost of a crash benefits.

Furthermore, lower speed limits have resulted in drivers travelling at lower speeds. Due to lack of data, we cannot probe deeper into the level of behavioural change associated with the speed limit reduction, the statistics suggest that the change has been adopted by drivers, therefore the speed limit reduction has led to lower travel speeds.

While we note that freight may be impacted by the speed limit reduction, we also emphasize the fact that the speed limit reduction makes roads safer, which in turn makes the journey for truck drivers safer, and reduces any potential accident or injury that they may experience. This is a critical point and when approaching from a resilience perspective, highlights the potential for there being a large amount of non-monetised benefits that rise from the speed limit reduction.