The Value of Rail in New Zealand

Report for the Ministry of Transport

February 2021

Contents

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Project Overview

Background

The Ministry of Transport (MoT) has commissioned Ernst & Young (EY) to undertake desktop modelling to better understand the benefits of rail transportation in New Zealand. KiwiRail Holdings Limited (KiwiRail) were heavily engaged in the development of the report. Waka Kotahi, NZ Transport Agency (NZTA) and the New Zealand Treasury were also consulted in the early stages of model development.

Modelling takes account of rail freight across New Zealand and passenger rail in Auckland and Wellington. Inter-island ferries and long-distance passenger rail within the KiwiRail network are out of scope.

This study includes direct, indirect and externality benefits, consistent with the Waka Kotahi Monetised Benefits and Cost Manual. The majority of benefits are calculated in net terms, with air pollution, fuel use, greenhouse gas emissions, maintenance and safety values reflecting the difference between road and rail impacts. Time savings are the one exception, with impacts on the road network being calculated in gross terms. Such an approach is required to maintain consistency with previous (2016) modelling.

This analysis is performed using a central scenario based on current traffic and a 'growth' scenario involving increased volumes:

- All rail transportation services[1] are discontinued, based on current (2019) volumes

- All rail transportation services are discontinued, based on 120% of current volumes.[2]

Figure 1. KiwiRail Network

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[1] Defined as commercial rail freight and metropolitan transport in Auckland and Wellington. Scenic rail services, as well as non-commercial operations not in the purview of KiwiRail, are out of scope.

[2] This scenario considers the impact of increased congestion on New Zealand roads, as well as forecast increases in rail freight volumes.

Values are estimated by measuring the impact of shifting all rail services to road. Four categories of benefit were examined in the 2016 Value of Rail modelling, based on discussions with stakeholders and industry representatives.

This report includes an additional two benefit categories, taking advantage of new research published by Waka Kotahi, NZTA, MoT and Ministry for the Environment (MfE). The six impacts consist of:

- Road congestion (including value of time)
- Greenhouse gas emissions
- Safety
- Maintenance
- **New:** Fuel savings
- **New:** Air pollution (NOx, PM10, PM2.5 and SOx).[3]

For several of these impacts, sensitivity analysis has been performed to identify the impact of alternative assumptions. For example if road congestion was limited to the 'increment' specified in NZTA guidance, or if traffic modelling results were not updated for historic growth.

What this modelling is and what it is not

This study is not a full business case or economic forecasting model. While the methodology is consistent with economic appraisal guidance, it does not attempt to capture all the strategic, financial, commercial and infrastructure-management implications of discontinuing rail services in New Zealand. Rail travel (freight and passenger) provides a wider range of value to New Zealand economy than what is captured through this analysis, for example:

- *Economic Impacts*: The stimulus and employment effects of the rail industry on output (GDP).

- *Opportunity cost avoided (capex)*: It is unlikely that the New Zealand state highway network could absorb an increase in road vehicle tonne kilometres (TKMs) of almost 20% without significant additional investment.

- *Cost to serve differentials*: Current rail freight services are being purchased by private firms because they are less expensive than alternative mode choices. For many industries, rail supports a more cost-effective supply chain.

2016 Value of Rail model

In 2016, EY developed a comparative, static economic model (the 2016 Value of Rail model), used to estimate the value of freight and passenger rail services in New Zealand.

The model explored a scenario where rail services did not exist, and contemporary freight and passenger volumes were shifted to road.[4] Outputs work were subsequently published online.[5]

2020 Value of Rail methodology

The 2020 study applies the same conceptual approach as 2016 modelling, estimating the impact on New Zealand if freight and passenger rail services were to be discontinued.

As noted on page 4 above, both studies include direct, indirect and externality benefits. Modelling has been updated to reflect recent rail traffic volumes, additional benefit categories and contemporary analytical inputs. A high-level overview of the methodology to determine the value of rail is provided at Figure 2 below.

Figure 2. EY 2020 Value of rail assessment methodology

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[3] Nitrogen oxide, particulate matter and sulphur oxides.

[4] Freight volumes were transferred onto hypothetical truck movements and passenger boardings were transferred to a combination of private vehicles and other public transport.

[5] https://www.kiwirail.co.nz/news/506/78/Study-highlights-rail-s-value-to-New-Zealand.html

Analysis included within the 2020 modelling, over and above the modelling performed in 2016, consists of:

- **Exploring multiple scenarios.** The 2016 Value of Rail model applied outturn rail travel data. The 2020 model considers two alternate scenarios (current rail volumes; 120 percent of current rail volumes) and performs traffic-related sensitivity testing.

- **Refined High and Low impact estimates**. This range of results takes account of the two largest sources of uncertainty, and where modelling assumptions have the largest impact, namely the inclusion of metro road traffic uplift when calculating congestion benefits, and the choice of input data for air pollution (NOx) calculations. These are detailed on pages 20 and 23 respectively.

- **Presentation of aggregate data**. The 2016 Value of Rail model considered a line by line assessment of value, whereas the 2020 modelling considers wider impacts in aggregate (i.e. total net tonne-kilometres, or NTKs, vs line by line NTKs).

- **Updates to monetisation values**. Contemporary research, guidance and statistics have been drawn upon. These include updates to core input data (such as the value of time in the EEM)[6] as well as updated assumptions (such as measurement of carbon dioxide equivalent emissions by MfE). References are provided in footnotes throughout the report.

- **Refinement of traffic modelling parameters.** A range of amendments to the modelling have been made to improve the accuracy of results.

- **Presentation of benefits as they accrue to heavy and light vehicles.** Rather than presenting benefits as they accrue from rail passenger and rail freight uses, modelling is based on vehicle types and associated impacts.

The remainder of this report outlines the results of analysis (Chapter 2), describes the technical specifications of the modelling and explains the core assumptions underpinning each stage of reporting (Chapter 3).

Annex 1 provides a methodology for the consideration of an augmented base case. Annex 2 provides a comparison to the 2016 Value of Rail work. Annex 3 and Annex 4 then provide the technical specifications of the transport modelling undertaken in Wellington and Auckland respectively.

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[6] The Waka Kotahi Economic Evaluation Manual was the latest guidance available when modelling was performed.

2 Findings

Findings

The following chapter presents the findings of the value of rail modelling.

First, the core findings of the value of rail modelling are presented through monetised estimates. Results are presented in the form of a low - high range in order to convey the implications of alternative traffic growth and air pollution assumptions:

- Low Impact: Traffic modelling outputs are scaled for passenger rail growth in Auckland and Wellington (c. 25%). National emissions estimates, published by MBIE, are used to calculate nitrogen oxide impacts.

- High Impact: Traffic modelling outputs are scaled for rail and road traffic growth in Auckland and Wellington (c. 40% - 50%). Ministry for the Environment (MfE) emissions guidance is used to calculate nitrogen oxide impacts.

Second, the implications of a 20% uplift in rail volume are presented. These results are provided to demonstrate how impacts could be expected to change over time and indicate the sensitivity of different types of benefit to volume growth.

Third, mode-shift related sensitivities are presented. Truck conversion factors, [7] for example, influence the outcome of modelling. An alternative results table is included to communicate the impact of an alternative assumption.

Fourth, sensitivities related to traffic modelling are outlined. This identifies the impact of assumptions related to historic travel growth. It also notes the effect of calculating the cost of congestion using the marginal cost of congestion, as opposed to the full value of time, which provides an indication of net congestion impacts in Auckland and Wellington.

Finally, a short comparison to the 2016 Value of Rail modelling is included to demonstrate the dynamic nature of this modelling and provide a reference point to the original work.

Core findings

Updated modelling estimates the total value of rail to be $1.7b - $2.1b for the year 2019.

Table 1: Value of Rail core findings, millions NZD (2019)

Benefit[8]	2019 Impacts, low-high ($m)	% of benefits
Time (congestion) savings	**$939 - $1054**	**49% - 55%**
Reduced air pollution	**$170 - $474**	**10% - 22%**
NOx emissions	$92 - $394	5% - 18%
SOx emissions	<$1	<1%
Brake & tire (PM10)	$21 - $22	1%
Exhaust (PM2.5)	$57 - $58	3%
Reduced fuel use	**$211 - $222**	**10% - 12%**
Reduced GHG emissions	**$178 - $182**	**9% - 10%**
Maintenance benefits	**$104 - $107**	**5% - 6%**
Safety	**$94 - $98**	**5% - 6%**
Death	$63 - $65	3% - 4%
Serious injuries	$25 - $27	1%
Minor injuries	$5 - $6	<1%
Total	**$1,695 - $2,137**	**100%**

As demonstrated by Table 1, rail transportation provides the largest net benefits to the road sector and society through:

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[7] The average load of a New Zealand heavy road vehicle. The tare, or weight of the truck itself, is excluded.

[8] Please note that impact and percentage totals may not add due to rounding. This applies to all results tables within the report.

- Time (and congestion) savings ($939m - $1,054m, making up 49% - 55% of benefits)

- Reduced air pollution ($170m - $1474m, making up 10% - 22% of benefits)

- Reduced fuel use and maintenance costs ($315m - $329m, making up 14% of benefits)

- Reduced greenhouse gas (GHG) emissions ($171m - $182m, making up 9% -10% of the benefits).

A summary of the monetisation factors underpinning calculations is provided in Table 2. Further detail about the sources for these calculations, as well as the underlying methodology, is provided in Chapter 3.

Table 2: Monetisation values and conversion factors for core findings

Benefit	Value (2019 dollars)
Truck conversion factor	9.6t (rail NTKs to road KMs)
Time (congestion) savings[9]	
Morning commuter peak	$29.50 / hour
Daytime interpeak peak	$27.64 / hour
Afternoon commuter peak	$28.46 / hour
Safety	Average of 4 years
Death	$4,470,200 per death
Serious injury	$472,152 per injury
Minor injury	$25,441 per injury
Reduced GHG emissions	$71.50 / tonne CO2-e

No rail network, 120% of current volumes scenario

As demonstrated below, benefits increase by approximately 9% if rail freight volumes increase by 20%. The table below identifies impacts against the 'low impact' scenario. The relative proportion of benefits remains broadly the same.

> Sensitivity analysis using 120% of rail freight volumes, along with the 'low impact' scenario described above, estimates the total value of rail at $1.8 billion for the year 2019.

Table 3: Value of Rail, 120% of current rail freight volumes scenario, millions NZD (2019)

Benefit	Impacts, low ($m)	% of benefits
Time (congestion) savings	**$967**	**53%**
Reduced air pollution	**$199**	**11%**
NOx emissions	$108	6%
SOx emissions	$0	0%
Brake & tire (PM10)	$24	1%
Exhaust emissions (PM2.5)	$66	4%
Reduced fuel use	**$239**	**13%**
Reduced GHG emissions	**$209**	**11%**
Maintenance benefits	**$121**	**7%**
Safety	**$107**	**6%**
Death	$73	4%
Serious injuries	$29	2%
Minor injuries	$6	0%
Total	**$1,841**	**100%**

The 20% uplift in rail freight NTKs does not directly translate into a 20% uplift in benefits for two main reasons:

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[9] As noted on page 4, these are gross benefits, based on the change in travel time on the road network only

- **Traffic modelling outputs:** The complex (non-linear) relationship between the number of vehicles that enter/exit a network and the time taken, distance travelled and number of vehicles across the network.

- **Differences between freight and passenger volumes**: Alternative modelling scenarios would imply a different heavy / light vehicle mix on the road network. In particular, light vehicle travel is expected to increase less than heavy vehicle travel, in relative terms. Alternative results then arise due to impacts by vehicle class (e.g. greater air pollution from trucks).

Sensitivity modelling – truck conversion factors

Our core findings are based on a 9.6t conversion factor, in line with the most recently available estimate published by MoT.[10] The 2016 study was instead based upon 12t, reflecting discussions with industry representatives and other stakeholders at the time. We present a sensitivity analysis to identify the impact of applying this approach.

> Sensitivity analysis using a 12 tonne conversion factor, along with the 'low impacts' scenario approach as above, estimates the total value of rail at $1.5 billion for the year 2019.

A lower truck conversion factor implies that more truck trips are necessary to replace the freight services provided by rail. Table 4 demonstrates the comparative change in benefits given the 12t conversion factor, applying the 'low impact' scenario.

Sensitivity modelling – traffic model uplifts

In order to add nuance to the central findings, sensitivity analysis was performed using alternative approaches to traffic modelling impacts (for example recognising that Wellington and Auckland models rely on 2013 and 2016 demand data respectively). We note that these simple adjustments to traffic modelling outputs provide indicative estimates

only, as scaling based on volume growth does not account for network constraints or other dynamic relationships.

The three traffic-related sensitivity tests consist of:

- 'Congestion only' benefits, as opposed to the full value of time, in order to estimate net travel benefits in Auckland and Wellington. A 'congestion increment', as specified by Waka Kotahi guidance, is used as a proxy for the differential in travel cost between rail and road.

Table 4: Truck conversion sensitivity modelling, the effect of a 12t conversion factor, millions NZD (2019)

Benefit	Impacts, low ($m)	% of benefits
Time (congestion) savings	**$931**	**61%**
Reduced air pollution	**$135**	**9%**
NOx emissions	$71	5%
SOx emissions	$0	0%
Brake & tire (PM10)	$18	1%
Exhaust emissions (PM2.5)	$47	3%
Reduced fuel use	**$170**	**11%**
Reduced GHG emissions	**$142**	**9%**
Maintenance benefits	**$72**	**5%**
Safety	**$77**	**5%**
Death	$50	3%
Serious injuries	$22	1%
Minor injuries	$5	0%
Total	**$1,527**	**100%**

- No growth' benefits, making direct use of 2013 and 2016 traffic modelling results without any adjustment for growth in passenger rail patronage in Auckland or Wellington. Outputs are adjusted for inflation only.

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[10] https://www.transport.govt.nz/mot-resources/transport-dashboard/5-domestic-freight-road-rail-and-coastal-shipping/fr005-average-load-of-heavy-road-vehicles-tonnes/

- • 'Full growth' benefits, which considers changes in both road traffic and rail patronage since traffic modelling was performed. Heavy and light vehicle growth is considered separately, such that potential interactions and cumulative costs are ignored.

The 'congestion only' column provides an estimate of the value of rail in net terms. This represents a conservative approach, however, because additional FTEs required to operate an expanded heavy vehicle fleet are not accounted for. Rough calculations suggest that at least 4,000 new drivers would be required in net terms, representing a significant economic cost.[11]

Table 5: Traffic sensitivity modelling, congestion only, no growth and full growth, millions NZD (2019)

Benefit	Congestion only ($m, NZD)	No growth ($m, NZD)	Full growth ($m, NZD)
Congestion / time savings	**$275**	**$765**	**$1,054**
Reduced air pollution	**$170**	**$163**	**$175**
NOx emissions	$92	$89	$95
SOx emissions	$0	$0	$0
Brake & tire (PM10)	$21	$20	$22
Exhaust emissions (PM2.5)	$57	$54	$58
Reduced fuel use	**$211**	**$194**	**$222**
Reduced GHG emissions	**$178**	**$171**	**$182**
Maintenance benefits	**$104**	**$98**	**$107**
Safety	**$94**	**$87**	**$98**
Death	$63	$59	$65

Benefit	Congestion only ($m, NZD)	No growth ($m, NZD)	Full growth ($m, NZD)
Serious injuries	$25	$23	$27
Minor injuries	$5	$5	$6
Total	**$1,031**	**$1,478**	**$1,837**

Comparison to 2016 Value of Rail modelling

A comparison to the 2016 Value of Rail analysis is provided below (low impact scenario). In aggregate, the benefits provided by rail have increased by 15%, from $1.472b in 2016 to $1.695b in 2020 – see overleaf.
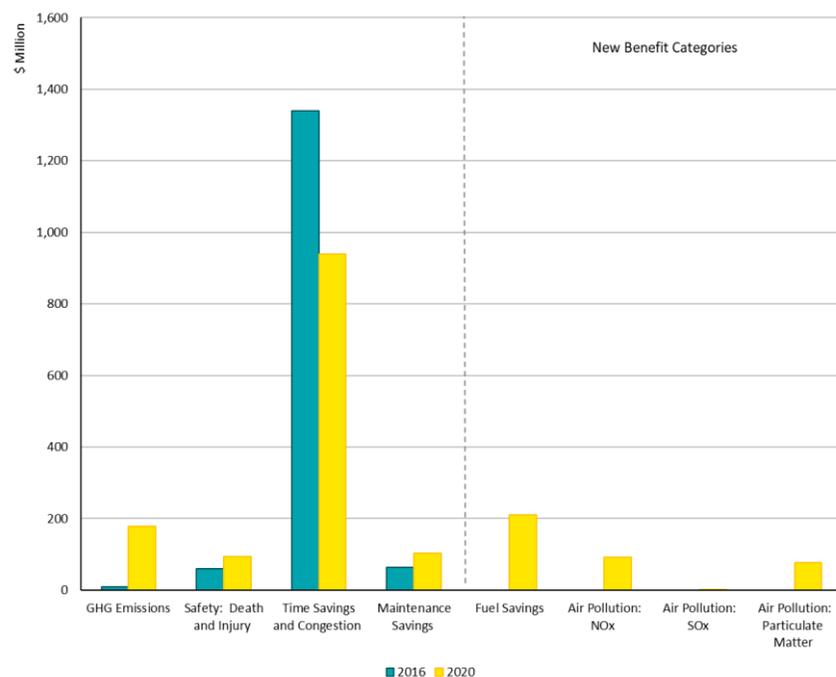
Increased benefits in the 2020 modelling primarily arise from GHG emissions, air pollution and fuel cost impacts, benefit categories that were not measured in 2016. Safety and maintenance savings have also improved, albeit providing a more marginal effect.

Time (congestion) benefits have decreased significantly since the 2016 study, largely due to additional investment in road infrastructure in Auckland, particularly the Waterview Tunnel. NZTA highlight that the project represented the biggest change in travel patterns since the opening of the Auckland Harbour Bridge in 1959.[12] Increased network capacity results in rail transport having a lower impact on time savings, due to roads being less congested.

We note that the AT model is based on 2016 traffic volumes, meaning that the time and congestion savings represent conservative estimates.

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[11] This assumes a constant speed of 50 km/h, 37.5 hours a week. The total number of train drivers in New Zealand is subtracted to create net estimate (2018 census).

[12] https://www.nzta.govt.nz/projects/the-western-ring-route/waterview-tunnel/

Figure 3: Core findings of Value of Rail (2020) compared to Value of Rail (2016)

Table 6: Value of Rail 2020 (core findings) compared with Value of Rail 2016

Benefit	Value of Rail 2020, $m	Value of Rail 2016, $m
Time (congestion) savings	**$939 - $1054**	**$1,340 - $1,394**
Reduced air pollution	**$170 - $474**	**-**
NOx emissions	$92 - $394	-
SOx emissions	<$1	-
Brake & tire (PM10)	$21 - $22	-
Exhaust emissions (PM2.5)	$57 - $58	-
Reduced fuel use	**$211 - $222**	**-**
Reduced GHG emissions	**$178 - $182**	**$8 – $9**
Maintenance benefits	**$104 - $107**	**$63 -$66**
Safety	**$94 - $98**	**$60 - $69**
Death	$63 - $65	-
Serious injuries	$25 - $27	-
Minor injuries	$5 - $6	-
Total	**$1,695 - $2,137**	**$1,472 – 1,537**

It is also noticeable that emissions and safety benefits have increased both proportionally (per tonne) and in absolute (dollar) terms. This is because monetisation and emissions factors have been updated to reflect contemporary thinking and research. GHG emissions, for example, reflect MfE guidance published in 2019, taking account of carbon dioxide equivalent values and the composition of New Zealand's heavy vehicle fleet.

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Methodology

Stage 1: Determine 2019 rail volumes

The establishment of the base case is important for any comparative analysis. For the EY value of rail assessment, it was been agreed that the base case should represent the current levels of rail traffic (financial year 2019). The following section outlines the base case which has been deployed in the 2020 Value of Rail model.
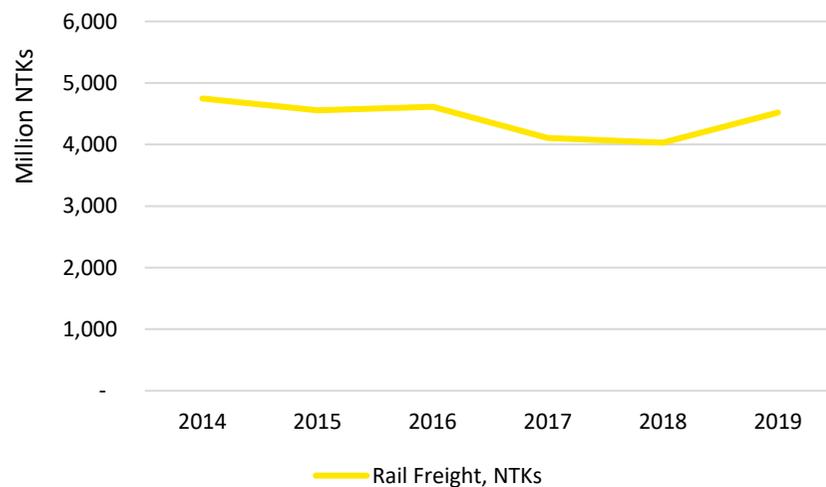
Figure 4: Rail freight growth (NTK)

Table 7: Summary of base case volumes

Year	Total NTK	Year-on-year growth
2015	4,555,538,933	-
2016	4,614,346,265	+1%
2017	4,107,124,092	-11%
2018	4,031,154,811	-2%
2019	4,520,177,361	+12%
Change since 2015	(35,361,572)	-1% (Total growth)

Base case methodology

As noted above, rail freight volumes are based on FY2019 Net Tonne-Kilometres (NTK) data, provided by KiwiRail. Metro rail passenger volumes in Auckland and Wellington are also adjusted for 2019 patronage levels.

EY explored adjusting the tonne kms data for the effects of the Kaikoura earthquake, making use of 2015 tonne kms data as part of the base case. This was ultimately not perused due to the subjectivity involved, for example the extent to which rail freight traffic on earthquake-affected lines can be expected to 'catch-up' to other lines in the near future.

Urban and rural demarcations are made based on the following definitions/regional boundaries:

- Auckland: All freight south of POAL is assumed to be within the urban environments until Papakura (i.e. 36km)

- Wellington: All freight North of CentrePort on SH1 is assumed to be within the urban environment until Waikanae (i.e. 60km).

Stage 2: Convert rail volumes to road travel volumes

There are two steps involved in Stage 2:

- The determination of relevant freight volume scenarios

- Converting rail volumes into commensurate traffic volumes.

Determination of relevant scenarios

A range of scenarios were originally considered as part of this package of work ranging from managed decline through to significant investment in the rail network.

Eventually, a decision was reached to test two key scenarios:

1. No rail network, current (2019) freight and passenger volumes

Assumes that all freight and passenger travel currently provided through rail is shifted to the road network. As explained in Stage 1, base case volumes involve 2019 outturn data. This is effectively a 're-run' of the 2016 Value of Rail work completed by EY.

2. No rail network, 120 percent of freight volumes

Freight: Applies a 20 percent uplift to 2019 outturn freight volumes. This is a realistic projection for medium-term industry growth and aligns with the Ministry of Transport's report "Transport Outlook: Future State". This report suggests that a 20% increase in freight volumes would be achieved by approximately 2027/28.

As all input data is based on pre-2020 activity, modelling does not reflect the impacts of COVID-19.

It is important to note that these scenarios have explicitly been developed as point in time estimates. The outputs of the EY modelling represent values for a single year and do not measure effects over time – i.e. there will not be a cumulative build-up of benefits. Figure 5 demonstrates this concept visually.

Figure 5: Conceptual depiction of Value of Rail results

Value of rail modelling will only show gold shaded value – not the cumulative build up (sum of all cells)
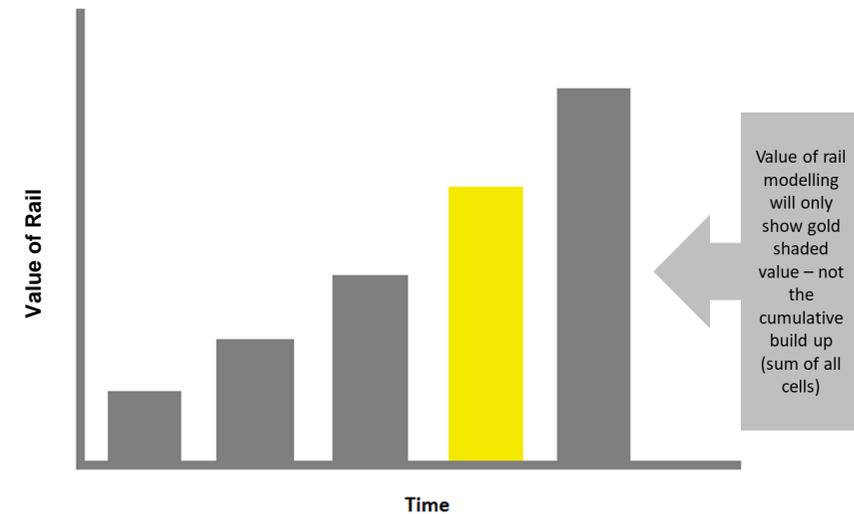
Conversion of rail volumes into traffic volumes

In order to determine the value of different rail scenarios, an assessment of the alternative transport system is necessary. In other words, if the rail network did not exist, what is a reasonable estimate of the change in traffic volume on New Zealand roads? This impact fundamentally drives the value assessments in Stage 4.

Different approaches were taken to determine the alternate traffic volumes for freight and passenger travel.

Freight

A conversion factor of 9.6 tonnes per truck was deployed for this analysis, making use of published MoT data. [13] That being, every 9.6 tonnes of freight volume carried on the rail network equates to one additional truck on the road. Given that rail freight volumes are reported in Net Tonne-Kilometres (NTKs), [14] traffic was adjusted for the comparative length of travel of each journey to calculate equivalent road kilometres travelled.

Modelling assumes that all new trucks on the road consistently carry 9.6 tonnes and does not attempt to adjust for empty return trips, beyond what is already in the national average. Findings therefore represent a conservative value if an absence of rail freight would increase the proportion of 'empty' road journeys.

For the sensitivity analysis, a 12t truck conversion factor was employed. This is consistent with the conversion factor used from Value of Rail 2016. The following table highlights the change in truck trips under each scenario, before any uplifts for metro growth are applied.

Table 8: Daily trucks to be removed/added for the transport modelling

Scenario	Auckland	Wellington
No rail network, current volumes	781 increase	298 increase
No rail network, 120% of volumes	156 increase (additional)	60 increase (additional)

We note that the '120% of current volumes' row was originally calculated in reverse, such that the impact of a 20% decrease in traffic volumes was estimated. These values are additional to the 'no rail network' estimate, such that the total estimated change for Auckland and Wellington is 937 and 358 trucks respectively under the 120% scenario.
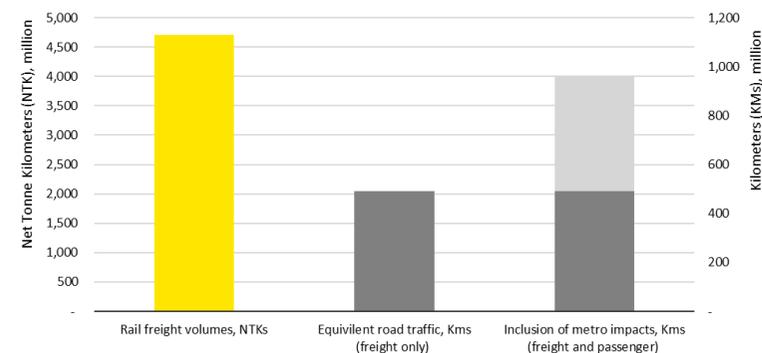
Passenger

Passenger rail conversion factors have only been applied in the Metro areas (Wellington and Auckland) as large-scale passenger rail services do not operate outside of these cities. These impacts are additional to the freight effects described above, and do not apply the same 'per tonne' conversion factor.

The precise conversion rates have been taken from Auckland Transport (AT) and Greater Wellington Regional Council (GWRC) transport models. These models have in-built vectors, based on travel demand surveying, that show the different behavioural decisions of passengers. EY has not adjusted these assumptions throughout the conversion process, with the exception of the sensitivities described on page 9.

The 'rail to road' conversion process is summarised in Figure 6 below. Rail freight volumes (the left-hand bar) are converted to equivalent road freight kilometres (the middle bar) using the 9.6 tonne conversion factor. Metro impacts are then added to account for passenger rail in Auckland and Wellington (the right-hand bar).

Figure 6: Conversion of rail volumes into traffic volumes

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[13] https://www.transport.govt.nz/mot-resources/transport-dashboard/5-domestic-freight-road-rail-and-coastal-shipping/fr005-average-load-of-heavy-road-vehicles-tonnes/

[14] This is the total volume of freight moved across the KiwiRail network. For consistency with the truck conversion factor, it is exclusive of the tare (unladen weight) of the locomotive and wagons.

Stage 3: Undertake traffic modelling

A fundamental feature of this analysis is the incorporation of transport modelling in the metro areas (Wellington and Auckland) where rail passenger services are available. This feature is important as it provides a level of dynamism to the modelling. That said, it adds an additional layer of complexity to the analytical task.

Results are calculated as the difference between 'with and without rail' journey times and travel distance, considering road travel only (i.e. rail travel time is not considered). A sensitivity analysis, which seeks to estimate marginal impacts across both modes, is described on page 10.

Total alternate truck trips/counts were established in Stage 2 and the results of these have been fed into the traffic modelling.

Auckland Transport's Macro Strategic Model (MSM) model and GWRC's Wellington Regional Strategic Model (WTSM) were employed to undertake this task. Both models have different operating assumptions but appear to be built on the same traffic modelling principles. Table 9 provides a list of the core assumptions.

Table 9: Characteristics of the traffic modelling

Key features	AT model	GWRC model
Vehicle demand	Based on 2016 traffic demand assumptions. In this sense, the demand assumptions are conservative as traffic has grown between 2016 and 2018 (and again between 2018 and 2020).	Based on 2013 traffic volumes and rail patronage. Using a 2013 base model has limitations due to the increases in both traffic and patronage demand in subsequent years, however using the 2013 model was considered a practical approach.
Network capacity	Based on 2018 network capacity. Crucially this includes the incorporation of	Based on the 2013 network capacity. There are natural limitations due to large

Key features	AT model	GWRC model
	the Waterview tunnel. Again, this represents a conservative assessment as 2018 (higher) capacity is matched with 2016 (lower) demand.	investment in the region with Transmission Gully and M2PP road projects, we note that these projects are nearing completion but are not yet fully operative. This is noted as a limitation to the analysis.
Public Transport (PT) boardings	The 2016 Value of Rail model assumed that the PT network could accommodate all passengers who would normally use rail. However, AT modelling has since been updated to allow for 'PT crowding' to be considered. That being, a bus can only accommodate a certain level of passengers before new buses must enter the network to accommodate the overflow. This capacity feature is proposed to be employed to provide a more realistic view of network impacts.	The 2016 Value of Rail modelling assumed that the PT network could accommodate all passengers who would normally use rail. This assumption still holds in the Wellington metro area as the GWRC model has not been updated for this functionality and therefore represents a conservative estimate of impacts.
AM : IP : PM periods	AT's traffic model assumes a 1:3.5:1 split between AM : IP : PM periods for HCV vehicles and a 1:3.5:1 split for passenger vehicles. This is primarily a function of the model build where the focus on traffic modelling is based on understanding the effects of the AM : IP : PM periods.	GWRC's traffic model assumes a 1:5.4:1 split between AM : IP : PM periods for HCV vehicles and a 1:7:1 split for passenger vehicles. To calculate the daily numbers the interpeak 2 hour outputs as a proxy for both the 7 hour interpeak period between the AM and

Key features	AT model	GWRC model
	This therefore represents a conservative estimate for daily traffic.[15]	PM peaks as well as the evening/early morning off peak times (so effectively represents a 20 hour period).[16] This means in practice that IP results get multiplied by 5.4 for truck volume changes and 7 for passenger vehicle changes.
Passenger rail assumptions	ATs model cannot exogenously insert 20% passenger boarding increases. AT needs to alter the drivers of passenger rail (fares, reliability, efficiency etc) until they get 20% passenger boarding changes. In practice this has resulted in: • Freq rail *1.4 (Headway *1/1.4) • SS runtime * 0.7 (Speed/0.7) • Rail Fare * 0.7 Figures were eventually within 19% - 21% for all travel time periods.	GWRCs model cannot exogenously insert 20% passenger boarding increases. GWRC needs to alter the drivers of passenger rail (fares, reliability, efficiency etc) until they get 20% passenger boarding changes. In practice this has resulted in: • A number of tests were run to determine which In Vehicle Time (IVT) factor would lead to the desired increase in patronage. The IVT factor is 0.9 by default and was changed to 0.25 in order to achieve a 20% increase in patronage.

Key features	AT model	GWRC model
		Figures that were eventually within 19% - 21% for all travel time periods.
Yearly conversion	A yearly conversion was undertaken to gross up numbers from daily to yearly. A 280 day conversion was used to take into consideration the weekend traffic compared to a 245 weekday. 280 is considered conservative as it does not account for all days of the weekend.	A yearly conversion was undertaken to gross up numbers from daily to yearly. A 280 day conversion was used to take into consideration the weekend traffic compared to a 245 weekday. 280 is considered conservative as it does not account for all days of the weekend.

Traffic volumes provided

As noted above, changes in truck trips/counts associated with each scenario were derived by EY in Stage 2 and provided direct to AT and GWRC to determine changes in traffic volumes. Changes in passenger counts associated with changes in passenger volumes have been determined endogenously by GWRC and AT models.

Table 10 demonstrates the daily volumes sent to AT and GWRC under each scenario.

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[15] The traffic model effectively calculates 11 hrs of the day. So there is up to 13 hrs of volumes that is not being captured.

[16] When traffic models are done, they are typically run on a two hour period. So, for IP, there is up to 4 hrs hours of volumes that is not being captured.

Table 10: Daily truck counts provided to AT and GWRC

	No rail network, current volumes		No rail network, 120% of current volume	
	Auckland	**Wellington**	**Auckland**	**Wellington**
Totals (daily)	781 truck increase	298 truck increase	156 trucks increase	60 trucks increase
AM – Peak	112	43	22	9
IP	558	213	111	43
PM - Peak	112	43	22	9

Outputs from the transport modelling undertaken by AT and GWRC have been used for the remainder of the value of rail modelling and are detailed further in the appendices.

These outputs have determined the following calculations:

- *Total vehicle minutes:* Value of time (and congestion)

- *Total km travelled:* Safety, emissions, fuel use, air pollution and maintenance benefits.

Interregional (rural) benefits are driven off the aggregate figures determined in the previous stage of analysis. Specifically the 2016 modelling produced an estimate of time and congestion costs outside of Auckland and Wellington, per tonne-km, capturing the impact of increased heavy goods vehicle traffic on road users. This represents a conservative estimate of cost if traffic on New Zealand's highways has increased over the last four years.

Step 4: Undertake impact assessment

Impact assessment is based on a marginal change in traffic volume, applying metrics such as vehicle counts and travel time. This valuation process uses well-established economic values, as well as sensitivity tests where appropriate, to provide a reasonable indication of the value of rail under different investment scenarios.

An important feature of this modelling is the calculation of gross and net benefits (or disbenefits):

- **Gross benefits** are those that result from an increase or decrease in *road traffic only* under a given scenario. For example, the GHG emissions avoided if heavy vehicle travel is reduced.

- **Net benefits** also encompass the rail impacts of a given scenario. For example, the GHG avoided if heavy vehicle travel is reduced, minus the GHG emissions associated with rail transportation.

Each benefit category is explained below, including the approach to monetisation (converting impacts to dollar terms). To aid communication, relevant volume drivers are reiterated under each heading. A summary of the core assumptions used in the modelling is then provided at the conclusion of each section.

Value of congestion

Volume drivers

- *Urban:* Changes in time taken to complete road travel have been employed as the input variable that drives this assessment. This has been taken from the traffic modelling undertaken by AT and GWRC respectively.

- *Rural:* The volume driver for this has been total NTKs less the metro NTKs.

As traffic modelling is based on historic levels of demand (2013 and 2016 for Wellington and Auckland respectively), outputs are adjusted for volume growth over the last 3-6 years in these metro areas. The 'low impact' scenario takes account of passenger rail growth only, whereas the 'high impact' scenario includes road and rail traffic growth.

In both cases, traffic model impacts are multiplied by volume increases, such that dynamic and / or cumulative interactions are not considered. This represents a conservative approach in light of road network capacity limitations.

Monetisation values

The value of time metrics included in the EEM have been used to determine time and congestion benefits. The latter is applied to morning and afternoon peak times only. Different value of time proxies have been assumed for metro and interregional benefits. These figures are consistent with best practice in transport evaluation.

Specifically:

- *Urban:* The value of time (congestion) has been derived from the values of time listed under table A4.3 in the EEM, adjusted for inflation. In essence the AM: IP: PM: traffic counts align to the commensurate base value of time metric as per below. As noted above, the increment for congestion is applied at morning and afternoon peak times only.

- *Rural:* The total lower bound interregional freight benefit from the 2016 Value of Rail report divided by the total tonne kms of the 2016 Value of Rail report has been employed to derive a benefit per tonne km. The average rural benefit is calculated at $0.028 per tonne km removed.

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This approach is considered appropriate because of the aggregate nature of the 2020 analysis. In 2016, a line-by-line assessment was undertaken which meant that vehicle flow rates could be determined for each road, and hence the marginal impacts of changes in rail across different roads could be estimated. By definition, this calculation is not possible at an aggregate level. Accordingly, an 'average' of the 2016 estimate is applied.

Consideration was given to using different value of time metrics prescribed by the EEM, notably trip purpose. This was not progressed, however, as it would require additional assumptions to be made about the general purpose of AM: IP: PM: travel.

Update factors were applied to all values to account inflation.[17] In particular, travel time cost savings, crash cost savings and emission reduction benefits. 2019 prices have been applied across the board, making use of published update factors wherever possible.

Net congestion figures

As noted on page 16, value of congestion in this study examines the 'with vs. without rail' impacts on road travel in Auckland and Wellington. It does not take account of travel time impacts on other modes, for example passenger rail travel, and is therefore measured in gross terms. A sensitivity analysis, exploring the impact of an alternative methodology, can be found on pages 10-11.

The off-setting congestion impact on the rail network is not be considered within this assessment. This is because metro rail in New Zealand is not yet facing the same capacity constraints as urban roads.

Summary

	Values (NZD, 2019)
Morning Commuter peak	$29.28 / hour
Daytime Inter peak	$27.64 / hour
Afternoon Commuter Peak	$28.46 / hour
Rural	$0.029 per tonne km

Greenhouse Gas Emissions

Volume drivers

- *Urban:* Changes in vehicle kilometres travelled have been employed as the input variable that drives this assessment in metro areas. This has been directly taken from the traffic modelling undertaken by AT and GWRC.

- *Rural:* The volume driver for interregional traffic has been total new NTKs less the metro NTKs.

An average km per tonne proxy has then been derived to undertake this assessment, based on guidance published by MfE.[18] Published emissions factors for small trucks (table 41) are adjusted to reflect the difference in truck size (table 45), as well as the proportional NTKs specified in the Vehicle Emissions Prediction Model (VEPM).[19]

Monetisation values

The value for emissions benefits are sourced from the NZTA EEM ($71.50 per tonne of CO_2-e in 2019 dollars). Urban and rural volumes are considered interchangeably for this assessment.

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[17] https://www.nzta.govt.nz/assets/resources/econoic-evaluation-manual/economic-evaluation-manual/docs/eem-update-factors.pdf

[18] https://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/2019-detailed-guide.pdf

[19] https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/air-quality-climate/planning-and-assessment/vehicle-emissions-prediction-model/

Net emission values

MfE guidance provides emissions factors for both rail and road freight, permitting an estimate of the difference between modes. The volume calculations described above produce an average emissions per tonne km figure for both modes. The net result represents the GHG emissions created by additional road freight, minus the emissions currently created by rail freight. This is equivalent to almost 2.5m tonnes of CO2-e per year.

Summary

The value of GHG emissions used in the analysis, as recommended by the EEM, is provided below.

	Values (NZD, 2019)
CO2-e, per tonne	$71.50

Safety

Volume drivers

- *Urban:* Changes in vehicle kilometres travelled have been employed as the input variable that drives this assessment in metro areas. This has been directly taken from the traffic modelling undertaken by AT and GWRC.

- *Rural:* The volume driver for interregional traffic has been total NTKs less the metro NTKs.

A death, serious and minor injury per km/NTK was derived from the NZTA Crash Analysis System (CAS). A death, serious and minor per km/NTK was calculated by taking the total yearly deaths, serious and minor injury divided by the total kms/NTK travelled. A road freight

equivalent factor was established by taking deaths, serious and minor injuries involving trucks divided by the total kms/NTK travelled.

An average of four-year incident counts were undertaken to smooth out any outliers and/or year to year fluctuations for the lower bound.

Monetisation values

Safety benefits have been derived from well-understood proxies of the value of life and injury.[20] These statistical values are widely utilised in transport project appraisals:

- The value of an avoided death: $4,470,200

- The value of an avoided serious injury: $472,152

- The value of an avoided minor injury: $25,441.

Net safety values

Impacts are based on an estimate of additional safety incidents per NTK, were rail services to be replaced by road transport. An average incident per km / tonne-km was derived for rail, light vehicles and heavy vehicles, based on total incidents divided by traffic.

Net results represent the death and injuries likely to be created by additional trucks and cars on the road, minus the incidents currently caused by rail. This results in 14 avoided deaths, 53 avoided serious injuries, and 210 avoided minor injuries.

Summary

	Values (NZD, 2019)
Value of avoided deaths	$4,470,200
Value of avoided serious injuries	$472,152
Value of avoided minor injuries	$25,441

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[20] https://www.transport.govt.nz/assets/Uploads/Research/Documents/a5f9a063d1/Social-cost-of-road-crashes-and-injuries-2017-update-FINAL.PDF

Air Pollution

A similar approach to that of Greenhouse Gas Emissions is applied to calculate wider air pollution impacts. Nitrous oxide (NOx), Sulphur oxide (SOx), and Particulate Matter (PMx) all have well-established effects on human health, and thus are included in transport cost appraisal.

Volume drivers

- *Urban:* Changes in vehicle kilometres travelled have been employed as the input variable that drives this assessment in metro areas. This has been directly taken from the traffic modelling undertaken by AT and GWRC.

- *Rural:* The volume driver for interregional traffic has been total NTKs less the metro NTKs.

Multiple estimates of emissions factors have been published in recent years, and no single study provides a comprehensive assessment of air pollution across relevent modes and vehicle classes in New Zealand.

Road-related emissions are thoroughly explored in the NZTA Vehicle Emissions Prediction Model (VEPM)[21], but this analysis does not extend to rail. MfE research[22] compares road and rail emissions directly, but requires the use of nitrous oxide (a gas that primarily causes damage through greenhouse effects, rather than to human health directly) as a proxy for ratios of nitrogen oxide emissions.[23]

This creates challenges for accurately estimating the differentials in air pollution across road and rail transport. NOx represents the largest source of uncertainty, as alternative modelling assumptions have a large impact on benefit results.

MfE-based estimates of road freight NOx emissions are roughly three times larger than VEPM-based estimates, with annual, national energy sector estimates published by MBIE[24] falling in between the two.

To take account of this issue, two different methodologies have been explored:

- The 'low impact' scenario applies a combination of NZTA and MBIE (national, annual energy sector emissions) modelling. This directly measures nitrogen oxides, as defined in the EEM, but requires an amalgamation of two different data sources.

- The 'high impact' scenario applies MfE research, comparing the emissions factors associated with rail and road freight. New truck routes, in the absence of rail, are assumed to involve a mix of urban and long-haul delivery. This approach makes use of a single study, but measures a different chemical compound to that recommended in the EEM.

Sulphur oxide (SOx) emissions make an insignificant impact on the value of rail regardless of the methodology applied (i.e. less than $1 million), so MfE calorific-based emission factors have been applied to both the high and low scenario.

Values

Monetising the health costs associated with air pollution is performed according to the EEM. Specifically, a 'damage cost approach' is applied in light of the national scale of rail freight transport:

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[21] https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/air-quality-climate/planning-and-assessment/vehicle-emissions-prediction-model/

[22] https://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/2019-detailed-guide.pdf

[23] MfE emissions factors are measured in carbon-dioxide equivalent units (CO2-e), however the conversion between N_2O and CO2-e (298) is very similar to the ratio of NO_x to N_2O road emissions in NZ according to MBIE (293), such that these two effects cancel out.

[24] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/new-zealand-energy-sector-greenhouse-gas-emissions/

"The damage cost approach is much simpler than undertaking exposure modelling, which requires detailed understanding of the sources, receptors, terrain and meteorology to arrive at predicted concentrations to which exposure response functions are then applied. However, it utilises factors which apply to the project as a whole, rather than at a local scale." (EEM, page 5-385)

We note that results would differ were a more localised approach to air pollution modelling be applied, for example exposure modelling as referenced above. Given that freight networks span all of New Zealand, spatial analysis would be a significant task.

It is very possible that such an approach would identify a *larger* difference between rail and road impacts due to the location of associated infrastructure. This would be the case if rail tracks were, on average, further away from population centres than national highways, leading to lower levels of exposure for any given volume of emissions.

EEM values of $17,818 per tonne of NOx and $501,425 per tonne of PM10 were deployed (2019 dollars). Although the latter figure is very large, the average volume produced by road vehicles is much smaller, such that NOx creates a much greater impact in total dollar terms.

Following discussions with MoT, a PM2.5 value of $546,554 has also been applied, in order to recognise the comparatively higher health costs associated with these emissions. This is based on EEM factors as well as the PM2.5 -> PM10 conversion factor recommended in New Zealand research.[25]

SOx calculations make use of research by the UK Department for Environment, Food & Rural Affairs (DEFRA 2015), a source cited by the EEM. This research estimates that the social cost of SOx is 1.2% higher than that of NOx, hence the EEM value is uprated by this amount. A value of $18,031 per tonne of SOx was deployed.

Net emission values

Consistent with GHG emissions, an average emissions per km / tonne-km factor is calculated for rail freight, heavy goods vehicles (HGV) and passenger vehicles. The net benefit is based on the air pollution created by additional truck and passenger vehicle travel, minus the volumes of NOx and SOx created by rail freight. Particulate matter emissions are not calculated for rail due to data limitations. The net total avoided is 39,651 tonnes of NOx, 3 tonnes of SOx and 144 tonnes of PMx.

Summary

	Values (NZD, 2019)
Nitrogen oxide, per tonne	$17,818.70
Sulphur oxide, per tonne	$18,031.40
Brake & tire emissions (PM10), per tonne	$501,425.40
Exhaust emissions (PM2.5), per tonne	$546,553.70

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[25] https://www.researchgate.net/profile/Jayne_Metcalfe/publication/307534676_Updated_Health_and_Air_Pollution_in_New_Zealand_Study/links/57c78e4208ae9d64047ea059/Updated-Health-and-Air-Pollution-in-New-Zealand-Study.pdf

Fuel Costs

Volume drivers

- *Urban:* Changes in vehicle kilometres travelled have been employed as the input variable that drives this assessment in metro areas, separated into petrol and diesel road vehicles. This has been directly taken from the traffic modelling undertaken by AT and GWRC.

- *Rural:* The volume driver for interregional traffic has been total NTKs less the metro NTKs.

Fuel requirements per km for heavy and light vehicles are drawn from the Vehicle Emissions Prediction Model. Close to 100% of HGV's consume diesel, whereas passenger vehicle fuel is approximately 90% petrol. Rail consumption of diesel is based on KiwiRail outturn data.

Values

Diesel and Petrol prices are drawn from the Ministry of Business, Innovation and Employment (MBIE) energy statistics.[26] The commercial cost of diesel in 2019 was $1.02 per litre, and the average cost of petrol was $2.13 per litre (including both premium and regular petrol).

The price of diesel does not include Road User Charges (RUCs), while the published price of petrol is inclusive of fuel excise duty (FED). A fair comparison requires taxation to be treated consistently. We have therefore excluded excise charges from the published petrol price.[27] This results in a petrol price of $1.28 per litre.

Net fuel costs

Net values were calculated based on the difference between rail and road fuel requirements. Road freight costs are based on the additional NTK moved. Fuel consumed by rail freight was then subtracted to provide an estimate of increased cost.

Summary

	Values (NZD, 2019)
Diesel, per litre (excluding RUCs)	$1.02
Petrol, per litre (excluding FED)	$1.28

Maintenance

Volume drivers

- *Urban:* Changes in vehicle kilometres travelled have been employed as the input variable that drives this assessment in metro areas. This has been directly taken from the traffic modelling undertaken by AT and GWRC.

- *Rural:* The volume driver for interregional traffic has been total NTKs less the metro NTKs under each scenario.

Values

Maintenance data is measured in dollar terms, so values do not need to be monetised using a source such as the EEM. For consistency, maintenance across road and rail has been defined broadly, including drainage, signals and emergency reinstatement.

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[26] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-prices/

[27] 40% is approximated based on historical data. Current fuel taxes can be found here: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-generation-and-markets/liquid-fuel-market/duties-taxes-and-direct-levies-on-motor-fuels-in-new-zealand/

Maintenance expenditure is based off KiwiRail outturn data for rail, and Road User Charges (RUC) for road vehicles (published by MoT). In both cases, an average impacts value was derived from national annual expenditure divided by total traffic.

Net maintenance values

Net maintenance values have been calculated as the expected cost of additional road freight, using a per km estimate, less total rail maintenance costs, using a per NTK estimate.

	Values (NZD, 2019)
KiwiRail total rail maintenance expenditure	$57.8 million
Light vehicles maintenance cost, $ per km	$0.01
Heavy vehicles maintenance cost, $ per km	$0.28

Stage 5: Limitations and assumptions of findings

A wide range of assumptions have been applied within this modelling exercise, leading to a number of caveats and limitations:

- The scenarios were determined by MoT, and do not represent a forecast of likely rail freight growth.
- This is a comparative, static model that demonstrates values at a single point in time. All dollar values are reported in 2019 terms (e.g. adjusting 2018 EEM figures for inflation).
- As noted on page 4, benefits are defined broadly for the purposes of this study, extending to indirect costs and benefits affecting third parties.
- References to the EEM reflect that the majority of modelling was performed in 2019, prior to the publication of the Waka Kotahi Monetised Benefits and Cost Manual.
- The study does not account for any behavioural change as a result of the differing scenarios beyond the outputs of traffic modelling. For example changes to road travel patterns or firm responses to alternative supply chain configurations.
- The calculation of benefits has been undertaken at the network level, in contrast to the previous line by line analysis. This was due to data availability and the challenge of accurately assigning rail freight to analogous road routes.
- Modelling assumes that all new trucks on the road consistently carry 9.6 tonnes and does not attempt to adjust for empty return trips, beyond what is already in the national average. Double handling of freight has not been considered.
- Traffic modelling results reflect a number of assumptions, detailed in Annex 2 and 3 below. Simple, proportional uplifts have been applied to reflect metro patronage growth and truck conversation factors. This does not account for dynamic interactions, cumulative impacts or network capacity limits.
- Congestion costs only include time delays and exclude any benefits of increased travel time reliability.

- Safety impacts are based on national averages, i.e. the ratio of incidents divided by total NTKs/Kms. Neither subnational safety profiles nor the cause of crashes is considered in the analysis.
- The assessment does not estimate the relationship between congestion and driver frustration. Greater congestion may, in reality, lead to a higher rate of crashes.
- Rail deaths and injuries may include suicides and level-crossing incidents. Such incidents are unlikely to scale with rail freight volumes, so may inflate the safety costs of rail relative to road.
- National Road User Charges (RUC) revenue is used as a proxy for total road maintenance costs. The difference between rail and road maintenance costs, and be extension the value of rail, would be higher if the full cost of replacements were included.
- Emissions factors for GHGs are based on published MfE guidance. Published factors for heavy vehicles are specific to small trucks (<7,500kg), so are adjusted to reflect the full HGV vehicle fleet (almost 80% of which are larger).
- Other emissions (NOx, SOx and PMx) calculations are based on a combination of NZTA, MfE and MBIE data. As the Vehicle Emissions Prediction Model (VEPM) does not contain comparable road and rail data, national MBIE data is instead applied to ensure a consistent source. A more detailed discussion of this methodology is provided on page 23.
- Air pollution impacts are calculated on a per-tonne basis and do not account for sources, receptors, terrain or meteorology. NOx and SOx are calculated on a net basis (i.e. road emissions minus rail emissions). PM is assumed to be exclusive to road, reflecting that research focusses on the effects of such emissions in enclosed environments or coal engines.
- PM2.5 impacts are uplifted to reflect published PM2.5 -> PM10 conversion rates.

Appendices

Annex 1: Key differences with the 2016 Value of Rail Model

2016 model	2020 model
Methodology	
• Line by line analysis: Analogous roads were deduced where rail freight would be transferred. • Time (congestion), safety, emissions (carbon) and maintenance benefits considered.	• Aggregate analysis: Total NTKs used as basis for analysis due to the difficulty of accurately allocating rail freight to roads. • Time (congestion), safety, emissions (carbon dioxide equivalent or CO2-e), air pollution, fuel use, and maintenance benefits considered.
Value inputs	
• Hypothetical input value ranges were used to demonstrate sensitivities.	• Inclusion of ranges based on traffic model uplifts (metro patronage and truck conversion factors) and air pollution emissions factors. • Official updates for values of CO2-e, time and safety. All values reported in 2019 terms. • Truck conversion factor of 9.6, based on the latest published MoT data.
Transport modelling	
• Yearly scaling based on 365 days. • 1:5:1 am:ip:pm split used to estimate total traffic volumes.	• Includes Waterview on the road network for traffic modelling (continuation of 2016 demand with 2018 network capacity). • Yearly scaling based on 280 day for traffic modelling along with 312 day working week for truck conversion. • Outputs uprated for traffic growth since 2013 / 2016 in Wellington / Auckland. • 1:3.5:1 used for Auckland • 1:5-7:1 used for Wellington

Annex 2: GWRC traffic modelling

The following represents an abridged version of the technical note provided by the GWRC. Multiple scenarios were run due to the four stage model design of the WTSM and to enable a greater understanding of flows and results.

The WTSM is a strategic (macro) model that was developed to inform high level transport policy and planning.

- The current base year for WTSM is 2013.
- Congestion is potentially underrepresented as WTSM models an average 2hr period (thus averaging congestion during the peak 2hr as opposed to representing congestion during the peak of the peak) and has a relatively coarse representation of intersections and traffic blocking back (both areas where delays occur)
- HCV are represented as part of the vehicle flows and the disruption due to HCV (as compared to cars) is likely underrepresented.

It should be noted that WTSM represents vehicle demand flows rather than actual flows. Therefore it assumes that all demand can get through the network to reach its final destination. In reality, and of relevance to the interpretation of the removal of rail results, the demand flows estimated by WTSM would result in significant delays and be unlikely to be accommodated by the network within the modelled 2hr period.

- Changes to the freight volumes to & from the port alone result in very little changes to other vehicles and the PT network.
- A 20% increase in Rail passengers results in a decrease in Bus patronage as well as in vehicle trips. The main drop is in bus numbers; the drop in car numbers is smaller, particularly percentage wise, although in the short-term the drop in vehicle numbers could be greater as the modelling includes the impact of trip re-distribution

- The removal of the rail network results in a major mode shift to cars and buses in the short term.
- Over the longer term, the removal of the rail network could result in major trip re-distribution (people change destination away from Wellington CBD in response to change in accessibility) and mode shift to buses (assuming the capacity is provided), lessening the modal shift and potential increase to cars on SH1 / SH2 into Wellington

Modelling the no rail network, 120% volume scenario

Combination of a decrease in HCV to/from port, with IVT parameters identified in previous runs to reflect a scenario where there is both a reduction in truck volumes and an increase in rail patronage. A full model run is undertaken for this scenario.

Modelling the no rail network, current volumes scenario

Increase in HCV to/from port + run assignment only model without rail network and with adjusted car and PT demand matrices, representing the possible shorter term impact of a 'no rail network' scenario that does not include trip re-distribution and mainly focusses on re-assignment.

The results should be considered as indicative, particularly as the tests where the rail network is removed go beyond the bounds of what WTSM is normally used and designed for.

GWRC abridged tables

Daily factors	Car	HCV	PT
AM	1	1	1
IP	7	5.4	6.6
PM	1	1	1

Annual factors	Car	HCV	PT
AM	245	245	245
IP	1715	1324	1613
PM	245	245	245

To calculate the daily numbers interpeak 2 hour outputs are used as a proxy for both the 7 hour interpeak period between the AM and PM peaks as well as the evening/early morning off peak times (so effectively represents a 20 hour period).

The numbers themselves are derived from the average of a range of daily traffic counts from across the region which has found this differing relationship between cars and HCVs. The ratios at any individual site, or particular type of road (i.e. urban vs motorway) will differ, but at a regional level across the whole model these numbers will be in the right ballpark.

The annual factors only take into account workdays, we have amended these to 280 to account for weekends. 280 is below the midpoint of 245 and 365 therefore should account for weekends whilst remaining conservative.

GWRC Base daily

	Car trips	HCV trips	Car VHrs	Car Vkms	HCV Vkms	HCV Vhrs
AM	157847	8376	31031	1330336	68157	1598
IP	149415	9294	19870	945921	64618	1292
PM	191081	6642	33262	1416276	55405	1308

GWRC – No rail network, 120% volume scenario

	Car trips	HCV trips	Car VHrs	Car Vkms	HCV Vkms	HCV Vhrs
AM	157023	8360	29833	1299687	67855	1562
IP	149175	9269	19748	938721	64059	1283
PM	190493	6626	32687	1399854	55074	1288

GWRC - No rail network, current volumes scenario

	Car trips	HCV trips	Car VHrs	Car Vkms	HCV Vkms	HCV Vhrs
AM	167199	8452	64134	1628868	70773	2525
IP	151401	9422	20827	1000230	67488	1344
PM	198289	6719	51092	1638569	57726	1806

Annex 3: AT traffic modelling

The following represents an abridged version of the salient points of discussion with AT.

The transport model used is a Macro Strategic Model (MSM) which is a four stage model. The model is based on land use and trip generation and matches trip ends and assignments based on time costs and estimates.

The base year of the model is 2016, updates to congestion have not been incorporated due to delays in the latest census data.

The base model was amended to include the Waterview tunnel on the transport network in the transport model runs. Network capacity is based on 2018 parameters.

20% increase in rail scenario

The modelling scenario of a 20% increase in rail patronage proved difficult. Multiple runs were undertaken to establish the 20% increase. Exogenous changes were made to obtain the number namely changing:

- Frequency of rail multiplied by 1.4 taking headway (1/1.4)
- SS runtime *.07 (Speed/0.7)
- Rail fare * 0.7
- $ per km *0.7
- Boarding $ *0.7

The station dwell was kept constant for the purposes of the analysis.

Yearly conversion factor

Most transport modelling requests are for the effects on the AM peak interpeak and PM peak where it is known traffic congestion is at its worse in Auckland. There is currently no assignment for outside these times.

To arrive at an annual figure the following was suggested:

An 11hr VKT / VMT based on the following equation:

*11hr = AM + 3.5 * IP + PM*

This 11hr value captures around 70% - 75% of the 24hr trips. In addition utilising 280 days to represent a year would conservatively account for weekends.

AT Base daily

Period	Car trips	HCV trips	Car Min	Car vkt	HCV min	HCV vkt
AM	530222	28536	8847334	5371868	560598	352334
IP	470031	29165	5520130	4229480	477458	379498
PM	581248	22628	9133906	5845303	453596	296106

AT - No rail network, 120% volume scenario

Period	Car trips	HCV trips	Car Min	Car vkt	HCV min	HCV vkt
AM	529303	28514	8746840	5355233	555497	351061
IP	468754	29128	5497391	4216823	474811	377324
PM	579942	22606	9055306	5826042	449563	294820

AT - No rail network, current volumes scenario

Period	Car trips	HCV trips	Car Min	Car vkt	HCV min	HCV vkt
AM	530086	28648	9125948	5405559	580307	359081
IP	472026	29351	5564139	4252956	488855	390502
PM	581905	22740	9310890	5879297	468119	302691