Transport for NSW
Economic Parameter Values

This document applies to all agencies within the NSW Transport cluster

Evaluation & Assurance
Group Finance & Investment
Corporate Services

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1 Introduction

1.1 Purpose

This document recommends economic parameter values for common benefits and costs in transport cost-benefit analysis (CBA). By providing best-practice approaches and economic parameter values, this document supports the consistent application of CBA across the NSW Transport cluster.

This document is targeted at CBA practitioners and also includes accompanying Excel tools.

1.2 How to use this document

This document provides recommended economic parameter values to be used in the CBA of initiatives within the NSW Transport cluster. Recommendations begin with **bold text** for ease of use. However, it is not intended to enforce strict compliance with a particular approach where it does not support sensible analysis.

Parameter values that are not recommended in this document may still be used. This may occur when project-specific information points to more relevant parameters, or when the relevant parameter value is not available within this document. If parameter values are used which are not recommended, they should be accompanied by evidence to support their validity. Good practice would involve calculating results with recommended and preferred parameters and explaining the difference.

This document should be read with the Transport for NSW Cost-Benefit Analysis Guide (the Guide), which provides overarching guidance for undertaking CBA and Transport for NSW (TfNSW) recommended approaches.

1.3 What has changed?

This document was previously Appendix 4 of the Principles and Guidelines: Economic Appraisal of Transport Investments and Initiatives (Principles and Guidelines). The Principles and Guidelines is in the process of being updated to reflect recent research, and will be split into a suite of products targeted at various audiences.

Since the 2018 edition, the values in this document have been adjusted to reflect data available as of August 2019 and updated to reflect new information where available. Some additional information from other guidance documents has been included in this version for the first time.

The format of this document has also changed. The recommended parameter values are at the beginning of each section.

This document has three accompanying Excel tools:

- Economic Parameter Values in Excel
    - this tool provides all the tables in this document in Excel
    - this tool also includes parameter values for use with the Public Transport Project Model (PTPM), which are included in Appendix C. PTPM is a demand model that is often used to evaluate projects in Greater Sydney.
- Rural Vehicle Operating Cost and Fuel Consumption Excel tool

  - parameter values for rural vehicle operating costs in rural areas can be calculated using this tool rather than the look-up tables in Appendix D.
- Urban Vehicle Operating Cost Excel tool
  - parameter values for urban vehicle operating costs in urban areas can be calculated using this tool.

Updated recommendations in this version are summarised in **Table 1.**

Table 1 Updated recommendations in the 2019 version

Section	Updated recommendations

Value of travel time (Section 2)	• Recommended values of time for light commercial vehicles (LCV) and heavy commercial vehicles (HCV) in urban areas are:
	  • Urban LCV = **$36.30** per vehicle hour
	  • Urban HCV = **$60.88** per vehicle hour.
	These are to be used where project-specific data is not available.

Vehicle operating costs (Section 3)	• TfNSW recommends the approach outlined in Transport for NSW *Technical Note on Calculating Road Vehicle Operating Costs.*
	• For urban vehicle operating cost models,
	  • Inclusion of a depreciation-adjusted Australian Transport Assessment and Planning (ATAP) interrupted flow VOC model for calculating resource costs for private vehicles (**Table 12**)
	  • Inclusion of updated perceived operating cost values (**Table 13**).
	• TfNSW recommends treating kilometres travelled at speeds below 5km/h as travelling at 5km/h for the purpose of calculating VOC, unless evidence can be provided for their inclusion.
	• TfNSW recommends calculating VOC for HCVs based on updated vehicle mix data (**Table 18** and **Table 19**). The contact for project-specific heavy commercial vehicle counts, used to calculate the mix of vehicles classes for a specific road corridor is sam.m.smith@rms.nsw.gov.au in Network & Asset Intelligence.

Urban road congestion cost (Section 4)	• TfNSW recommends not including urban road congestion costs in a CBA if the economic benefits of road user travel time savings, reliability, urban vehicle operating costs, or environmental impacts have been separately assessed; to avoid double counting benefits (**Table 20**).
Road safety benefits (Section 5)	• Inclusion of additional crash rate data which can be used to calculate project-specific crash values **(Table 27, Table 28).**
Environmental impacts (Section 6)	• TfNSW recommends air pollution and greenhouse gas (GHG) emissions be calculated using the upper and lower range for congested and free-flow conditions, respectively. For all other externality types, the midpoint estimate should be used.
Active transport (Section 7)	• The benefits of tolling cost savings and public transport fare savings have been removed **(Table 45).**
Expansion factors (Section 10.1)	• Recommendation for expansion and annualisation factors by benefit stream for urban public transport projects. Requirement that road projects use project-specific expansion and annualisation factors **(Table 52).**
Public transport attributes (Section 11)	• Recommended values for heavy rail, light rail and bus crowding multipliers have been updated **(Table 57).** • Recommendation that stop/station amenity benefit should be applied to all passengers entering, transferring through, and exiting stations. Vehicle quality benefits should be applied on a per trip basis. • Recommendation for the inclusion of benefits for public transport users switching to preferred modes, based on intrinsic mode preference values **(Table 61).**
Cost estimation (Section 15)	• TfNSW recommends that cost estimates in **Section 15 (Table 67 - Table 76)** should only be used strategically. For example, they can be used to calculate the cost of network wide changes, where indicative costs are needed. For the majority of projects, **Section 15** does not provide adequate cost estimation. • Where possible TfNSW recommends that expected value should be used for the CBA as a preference over the P50 value. However, estimates at P50 value can be used in the CBA.

Source: Evaluation & Assurance, TfNSW (2019).

Table 2 Appendices in the 2019 version

Appendices	Title	New / existing
A	Value of travel time –additional information	Existing
B	Vehicle classification	New
C	Parameters for use with strategic demand models	New
D	Rural VOC tables	Existing
E	Key indices	Existing

Source: Evaluation & Assurance, TfNSW (2019).

1.4 Urban and rural parameters

This document includes parameters that are valued differently depending on whether the impacts occur in urban or rural areas. For the purposes of CBA of NSW Transport cluster projects, 'urban' tends to refer to:

- Sydney
- Newcastle
- Wollongong
- Other town centres in NSW where the posted road speed limit is equal to or less than 80 kilometres per hour.

Other areas are generally considered to be rural, especially where road traffic is free-flowing. However, it is good practice to consider whether urban or rural parameters are appropriate on a case-by-case basis for projects, and whether project-specific parameters may need to be estimated.

1.5 Changes to come

The field of transport economics is constantly evolving. TfNSW is currently working to update the content of this document to reflect the most up-to-date research.

Comments or questions should be directed to EconomicAdvisory@transport.nsw.gov.au

2 Travel time savings

TfNSW recommends the following values of travel time (VTT) for CBA:

- VTT (private) = $17.72 per person hour
- VTT (business) = $57.48 per person hour.

VTT (business) should only be applied for travel between two business locations. Commuting to and from work should use the private value of travel time.

The VTT per hour of vehicle travel can be calculated from the occupancy rate, value per occupant and value of freight (**Table 3**). An overall value, referred to as 'vehicle hour', can be estimated by weighing total traffic by vehicle composition (**Table 4** and **Table 5**).

The values in **Table 3** are based on average weekly earnings of private travellers and the cost of wages for business travellers (Australian Transport Assessment and Planning, 2016). It is assumed that the VTT for occupants is the same for both urban and rural roads. If available, values derived from project specific surveys can replace the occupancy rates from **Table 6** and **Table 7.**

Many strategic transport demand models report travel time for light commercial vehicle (LCV) and heavy commercial vehicle (HCV). Where detailed commercial vehicle data is available (e.g. by vehicle type), specific values of travel time can be derived using the data outlined in **Table 3**.

If detailed commercial vehicle data is not available, **TfNSW recommends** the following values of time be used in CBA for urban areas:

- VTT of urban LCV = $36.30 per vehicle hour
- VTT of urban HCV = $60.88 per vehicle hour.

Detailed commercial vehicle data should be used in CBA for rural areas. This is because the vehicle mix on rural roads differs significantly depending on its location, particularly on key freight routes and corridors across NSW. Figures in **Table 5** can be used where the assumed commercial vehicle mix is not likely to have a material impact on the CBA results.

2.1 Actual and perceived travel time

Travellers make travel decisions based on their perception of the total perceived cost of travel, including travel time, as well as a number of other quality and service factors such as comfort, reliability, security and cleanliness.

Travellers may perceive one mode of transport as better than another even after these tangible benefits have been accounted for. For example, light rail can be preferred over bus even when accounting for travel time and vehicle quality attributes.

In strategic demand models, in-vehicle time weights are often applied to different public transport modes in order to correctly predict travel behaviour. This reflects that travellers may perceive their travel time to have reduced when they switch to a preferred mode, such as from bus to light rail. **TfNSW recommends** that these 'intrinsic mode preference' impacts are assessed and reported separately from travel time savings (e.g. using the approach outlined in **Section 11.5**).

In addition, **TfNSW requires** that benefits estimated using perceived travel time must clearly report the proportion of travel time savings that are actual versus perceived.

Table 3 Value of travel time – urban and rural roads

Vehicle type	All	Non-urban		Urban		Non-urban		Urban	
	Value per occupant ($/ person-hour)	Occupancy rate (persons /vehicle)	Freight ($/vehicle-hour)	Occupancy rate (persons /vehicle)	Freight ($/vehicle-hour)	Value per occupant ($/km)	Freight ($/vehicle-km)	Value per occupant ($/km)	Freight ($/vehicle-km)
Cars (all types)									
Cars - Private	17.72	1.70		1.41		0.20		0.35	
Cars - Business	57.48	1.30		1.06		0.64		1.15	
Utility vehicles									
Courier van utility	30.04	1.00		1.00		0.33		0.60	
4WD mid-size Petrol	30.04	1.50		1.50		0.33		0.60	
Rigid trucks									
Light Rigid	30.04	1.30	0.83	1.19	1.63	0.33	0.01	0.60	0.03
Medium Rigid	30.40	1.20	2.25	1.19	4.43	0.34	0.03	0.61	0.09
Heavy Rigid	30.96	1.00	7.72	1.19	15.17	0.34	0.09	0.62	0.30
Articulated trucks									
4 Axle	31.69	1.00	16.59	1.19	32.69	0.35	0.18	0.55	0.57
5 Axle	31.69	1.00	21.16	1.19	41.68	0.35	0.24	0.55	0.73
6 Axle	31.69	1.00	22.82	1.19	44.94	0.35	0.25	0.55	0.79
Combination vehicles									
Rigid + 5 Axle Dog	32.15	1.00	32.62	1.19	67.31	0.36	0.36	0.56	1.18
B-Double	32.15	1.00	33.62	1.19	69.36	0.36	0.37	0.56	1.21
Twin steer + 5 Axle Dog	32.15	1.00	31.52	1.19	65.07	0.36	0.35	0.56	1.14
A-Double	33.07	1.00	44.14	1.19	91.10	0.37	0.49	0.58	1.59
B-Triple	33.07	1.00	45.06	1.19	92.98	0.37	0.50	0.58	1.62
A B combination	33.07	1.00	54.27	1.19	111.99	0.37	0.60	0.58	1.96
A-Triple	33.63	1.00	65.07	1.19	134.26	0.37	0.72	0.59	2.35
Double B-Double	33.63	1.00	65.81	1.19	135.80	0.37	0.73	0.59	2.37
Buses									
Heavy Bus (Driver)	30.40	1.00		1.19		0.34		0.53	
Heavy Bus (Passenger)	17.72	20.00		20.00		0.20		0.31	

Source: Values are based on ATAP 2016 PV3 Road Parameter Values pg. 16-19, except Urban occupancy rates which are estimated from the 2014/15 Household Travel Survey (5 years pooled unlinked trips dataset provided by Transport Performance and Analytics, TfNSW). Values per occupant are indexed from May 2013 Average Weekly Earnings (AWE) to May 2019 AWE (ABS Series ID A84994877K). Freight values are indexed from June 2013 prices to June 2019 prices (ABS Series ID A2314058K).
Notes: To obtain values per km (last 4 columns), the following speeds were assumed: Non-urban – 90km/h; Urban (Cars, Utility vehicles, Rigid trucks) – 50km/h; Urban (All other vehicle types) – 57km/h.

Table 4 Average hourly value of travel time by vehicle type − urban

Period	Time + Freight value ($ per vehicle)	Default yearly hours	Proportion of AM peak hourly volume
Peak hours	30.95	2,000	1.00
Peak shoulders	30.95	800	0.75
Business hours	32.07	3,450	0.62
Other hours	24.80	3,310	0.17
Total		8,760	
Average hourly value ($ per vehicle hr, weighted by vehicle type and annual average kilometres travelled)			
Car			29.61
Light commercial vehicle (LCV)			36.30
Heavy commercial vehicle (HCV)			60.88
Bus (including driver and average of 20 passengers)			390.64

Source: Estimated by Evaluation and Assurance, TfNSW. Values have been indexed to June 2019 prices (ABS Series ID A84994877K).

Table 5 Average hourly value of travel time by vehicle type − rural

Vehicle type	% of vehicle type in vehicle fleet	Occupancy	VTT for occupants		VTT for freight ($/vehicle-hr)	Total VTT ($/vehicle-hr)
			$/person-hr	$/vehicle-hr		
Private car	62.56	1.7	17.72	30.12		30.12
Business car	8.79	1.3	57.48	74.73		74.73
Utility vehicle*	15.84	1 to 1.5	30.04	36.30		36.30
Heavy commercial**	11.14	1 and 1.3	31.05	32.98	11.52	44.50
Combination vehicles***	3.95	1	34.78	32.22	34.78	67.00
Bus	0.77	21	48.12	384.78		384.78
Average hourly value ($ per vehicle hr)						
Car						35.62
Light commercial vehicle (LCV)						36.30
Heavy commercial vehicle (HCV)						51.90
Bus (including driver and average of 20 passengers)						384.78

Source: Estimated by Evaluation and Assurance, TfNSW. Values have been indexed to June 2019 prices (ABS Series ID A84994877K).
Vehicle composition is estimated using the ABS Survey of Motor Vehicle Use 2018. Split of private and business car trips estimated using BTS Household Travel Survey data 2014/15.
*Light commercial/courier van utility and 4WD mid-size petrol.
**Heavy commercial vehicles include rigid trucks and articulated trucks (4 axle, 5 axle and 6 axle).
***Combination vehicles include B-Double + Road Trains.

2.2 Additional information: Value of travel time

This section is intended to aid in the application of the figures in **Table 3**.

Table 7 present vehicle occupancy and vehicle composition for cars on urban roads, respectively. Figures are categorised by the time of day:

- peak hours are trips arriving from 7:00AM to 10:00AM and 4:00PM to 7:00PM
- business hours refer to trips arriving from 10:00AM to 4:00PM
- other hours refers to all other times.

Table 6 Vehicle occupancy − urban

Hours	Private car	Business car	Commercial	
			Light	Heavy
Peak hours	1.41	1.07	1.21	1.19
Business hours	1.43	1.06	1.17	1.19
Other	1.39	1.07	1.16	1.19
All	1.41	1.06	1.19	1.19

Source: Estimated by Evaluation and Assurance, TfNSW using the 2014/15 Household Travel Survey (5 years pooled unlinked trips dataset provided by Transport Performance and Analytics, TfNSW).

Table 7 Vehicle composition − urban

Hours	Private car %	Business car %	Commercial	
			Light %	Heavy %
Peak hours	71	9	16	4
Business hours	66	11	16	7
Other	67	9	18	6
All	68	10	16	6

Source: Estimated by Evaluation and Assurance, TfNSW using the 2014/15 Household Travel Survey (5 years pooled unlinked trips dataset provided by Transport Performance and Analytics, TfNSW).
Note: Proportions are based on the number of trips by vehicle type, weighted by average trip length.

2.3 Value of access, waiting, transfer and unexpected delay time

TfNSW recommends the multipliers in **Table 8** to be applied for access / egress walking, waiting times and unexpected delays.

When travel times are unreliable, travellers will include buffer times to their journey. **TfNSW recommends** additional buffer time built into a journey (because of travel time variability) be treated *equally as costly* as the time spent traveling.

Table 8 Access, waiting, transfer and unexpected delay time multipliers

Category	ATAP recommended	TfNSW recommended
Access / egress walking	1.5	1.5
Waiting time		
Bus stop/rail platform waiting time	1.4	1.4
Transfer waiting time	1.5	1.5
Unexpected delay time		
Departure delay time	6.4	3.2
Arrival on vehicle delay waiting	2.9	
Non-specific delay waiting	2.3	
Average delay waiting	3.2	

Source: Australian Transport Council (ATC) Guidelines Public Transport Parameter Review Report by Douglas Economics, October 2015.

Parts of a journey are less comfortable than others. For example, waiting times, egress walking and unexpected delays are less comfortable to the traveller than on-board time. **TfNSW recommends** applying the multipliers provided in **Table 8** which convert less comfortable parts of a journey into equivalent on-board time. For example, 1 minute walking time is equivalent to 1.5 minutes on-board train time, and a 1 minute train-delay is equal to 3.2 minutes of on-board train time.

The value of waiting time can be used to evaluate initiatives which change frequency. An increase in service frequency would reduce waiting time. The unexpected delay time multiplier is used for valuing unexpected service delays, e.g. as a result of incidents.

Unexpected delays are more costly to the traveller compared to expected delays. Travellers are likely to build a buffer into their journey consistent with expected delays, which is unlikely to disrupt the rest of their day. However, an unexpected delay is more costly to the traveller, as this is unlikely to have been planned for.

2.4 Value of transfers

Changing vehicles during a journey is inconvenient. Consequently, a traveller attaches a disutility to a transfer. **TfNSW recommends** the equivalent in-vehicle times (IVT) for vehicle transfers in **Table 9**. For example, a bus-to-bus transfer is equivalent to 14.8 minutes of IVT. These figures were derived from a stated preference study commissioned by TfNSW (Douglas Economics, 2014).

Table 9 Value of transfer

Mode	TfNSW recommended (1) (IVT min / transfer)			ATAP recommended (2) (IVT min / transfer)
	Train	Bus	Light Rail	
Train*	7.2	13.7	4.1	Same mode transfer: 6 Different mode transfer: 10
Bus		14.8	3.8	
Light Rail			5.2	

Sources: (1) Douglas Economics, 2014. *TfNSW values sourced from Passenger service quality values for bus, LRT and rail in inner Sydney*, report to Bureau of Transport Statistics, TfNSW. (2) ATAP values sourced from ATC Guidelines Public Transport Parameter Review Report by Douglas Economics, October 2015.
Note: *The train-to-train penalty is higher than the value estimated by RailCorp Economic Unit in 2011, which recommended a transfer penalty equivalent to an IVT of 6 min. IVT of 7.2 is preferred as the stated preference surveys used to calculate this figure are more recent.

3 Road vehicle operating costs

TfNSW recommends using an approach for estimating VOC that is outlined in Transport for NSW *Technical Note on Calculating Road Vehicle Operating Costs*. For a copy of this document, please email EconomicAdvisory@transport.nsw.gov.au.

TfNSW recommends the use of a depreciation-adjusted version of the ATAP PV2 VOC model for estimating vehicle operating cost (VOC) benefits for urban project CBA. For rural projects, **TfNSW recommends** use of the ATAP PV2 uninterrupted flow VOC and fuel consumption models.

For urban vehicle operating cost models, **TfNSW recommends** treating kilometres travelled at speeds below 5km/h as travelling at 5km/h for the purpose of calculating VOC. This is because VOC models produce high per-kilometre values at speeds below 5km/h, which may be inappropriate for inclusion in CBAs when applied to outputs from strategic demand models.

Table 10 Urban vehicle operating cost models: low speed resource costs ($/km)

Vehicle operating cost model	Speed (km/h)									
	1	2	3	4	5	6	7	8	9	10
TfNSW depreciation adjusted VOC model (2019) – medium car										
VOC model value	5.04	2.61	1.80	1.39	1.15	0.98	0.87	0.78	0.71	0.65
TfNSW recommended value	1.15	1.15	1.15	1.15	1.15	0.98	0.87	0.78	0.71	0.65

Source: Estimated by Evaluation and Assurance, TfNSW. Estimates based on the coefficients in Table 11 then indexed from June 2013 to June 2019 prices (ABS Series ID A2326616R).

Three types of costs are discussed in this section:

- **Resource costs:** should be used in a CBA. Resource costs represent the value of a resource to society, which is often estimated as the market price excluding taxes and subsidies. Taxes and subsidies are transfers between individuals and government and do not reflect the underlying value of a resource.
- **Perceived costs:** should be used for travel demand modelling, as well as in CBA which assesses the impacts of induced demand. This is the cost perceived by drivers. **TfNSW recommends** the values used in **Table 13** or in the transport model be used in CBA. The values in **Table 13** reflects the mix of costs perceived by private vehicle users and the full financial costs perceived by commercial vehicle operators.
- **Financial costs:** are used in a financial appraisal. It only includes the direct effect on an individual's or organisation's finances and uses accounting concepts. The financial cost will include market costs, including taxes and subsidies. These values should not be used in CBA.

3.1 Urban vehicle operating cost models

The VOC model used determines the parameter values that are used in the benefit equation. VOC models are generally used to calculate the **resource cost** of travel. For urban project CBAs, interrupted flow VOC models reflect the change in operating costs with speed (in kilometres per hour) and the difference between driving in free-flow or stop-start traffic.

3.1.1 TfNSW depreciation adjusted VOC model

The depreciation adjusted VOC model for private vehicles uses the base formula from ATAP PV2 (2016), with an additional depreciation adjustment.

Equation 1 VOC model for private vehicles, stop-start model

$$c = A + \frac{B}{V} + \left(D \times \frac{60}{V}\right) + E$$

Source: TfNSW Evaluation & Assurance (2020)

Equation 2 VOC model for private vehicles, free-flow model

$$c = C_0 + C_1 V + C_2 V^2 + D + E$$

Source: TfNSW Evaluation & Assurance (2020)

Where:

- **c** represents VOCs (cents/km)
- **V** represents journey speed (km/h)
- **A**, **B**, C_0, C_1, and C_2 are model coefficients, as listed in **Table 11** below.
- **D** and **E** are adjustments to remove HDM-4 depreciation estimates, and to add the use-based component of depreciation back into the VOC model, respectively. Coefficient D is multiplied by $60/V$ for the stop-start model, removing an adjustment made in ATAP PV2 to account for reduced utilisation in lower journey speed environments.

Table 11 Depreciation-adjusted VOC model coefficients

Vehicle Type	Stop-start model		Free-flow model			Depreciation adjustment	
	A	B	C_0	C_1	C_2	D	E
Cars							
Small Car	13.3475	893.4041	27.4909	-0.1335	0.0011	-7.2945	1.6848
Medium Car	13.4831	1401.9961	37.3509	-0.1866	0.0013	-15.2457	3.6508
Large Car	15.3783	1959.3314	49.2120	-0.2367	0.0015	-21.8147	5.2239
Utility vehicles							
Courier Van-Utility	17.0281	1450.1832	41.1315	-0.1966	0.0015	-9.8032	1.2244
4WD Mid-Size Petrol	22.4914	1419.9117	43.3391	-0.1646	0.0014	-16.1181	1.8397
Rigid trucks							
Light Rigid	36.2991	1649.3983	55.0413	-0.2651	0.0027	-12.2342	1.4239
Medium Rigid	38.2589	2414.8697	66.9773	-0.3208	0.0028	-25.5155	3.1336
Heavy Rigid	61.0795	2731.3507	87.9327	-0.5904	0.0057	-30.2617	3.5267
Heavy Bus	68.9837	4949.7869	133.2524	-0.6910	0.0050	-44.4406	5.1376
Articulated trucks							
Articulated 4 Axle	90.3703	3550.8738	119.3189	-0.7736	0.0077	-37.0309	4.2054
Articulated 5 Axle	97.3792	3941.5427	128.1211	-0.7266	0.0071	-40.8365	4.6375
Articulated 6 Axle	105.4576	4264.9639	137.5122	-0.7350	0.0071	-44.2721	5.0277
Combination vehicles							
Rigid + 5 Axle Dog	130.9546	3985.6067	145.4988	-0.6842	0.0069	-38.6538	4.3897
B-Double	131.4257	4907.0762	161.8582	-0.7724	0.0073	-50.5418	5.7397
Twin steer + 5 Axle	135.9194	4680.3125	160.2120	-0.7385	0.0072	-47.1008	5.3489
A-Double	153.8668	6082.3124	196.1207	-0.8901	0.0079	-63.8098	7.2465
B-Triple	159.6593	7623.6772	228.8270	-1.0555	0.0087	-83.0071	9.4266
A B combination	182.0005	6686.9568	223.0189	-0.9635	0.0085	-69.5421	7.8974
A-Triple	203.7212	7624.1800	253.3243	-1.0826	0.0092	-79.9724	9.0820
B-Double	213.2552	7454.6907	255.0945	-1.0560	0.0092	-50.5418	5.7397

Source: TfNSW Evaluation & Assurance (2020) based on ATAP (2016). Coefficients produce VOC estimates in June 2019 prices

Table 12 Urban vehicle operating costs: resource cost (cents/km)

Vehicle type	TfNSW depreciation adjusted VOC model									
	20	30	40	50	60	70	80	90	100	110
Car (all types)										
Small car	37.82	30.22	26.43	24.15	22.63	21.54	20.73	20.10	19.59	19.18
Medium car	41.50	33.38	29.32	26.88	25.25	24.09	23.22	22.55	22.01	21.56
Large car	53.12	42.28	36.86	33.61	31.44	29.89	28.73	27.83	27.11	26.52
Utility vehicles										
Courier Van-Utility	61.35	46.99	39.80	35.49	32.62	30.57	29.03	27.83	26.87	26.09
4WD Petrol	46.97	39.43	35.65	33.39	31.88	30.80	29.99	29.36	28.86	28.45
Rigid trucks										
Light Rigid	83.49	68.23	60.61	56.03	52.98	50.80	49.16	47.89	46.88	46.04
Medium Rigid	85.59	70.86	63.49	59.07	56.12	54.02	52.44	51.21	50.23	49.43
Heavy Rigid	10.39	95.13	87.50	82.92	79.87	77.69	76.05	74.78	73.76	72.93
Heavy Bus	188.29	150.23	131.21	119.79	112.18	106.74	102.66	99.49	96.95	94.88
Articulated trucks										
Articulated 4 Axle	161.03	138.88	127.80	121.16	116.73	113.56	111.19	109.34	107.87	106.66
Articulated 5 Axle	176.58	151.73	139.30	131.84	126.87	123.32	120.66	118.59	116.93	115.57
Articulated 6 Axle	190.92	164.11	150.70	142.66	137.30	133.47	130.59	128.36	126.57	125.11
Combination vehicles										
Rigid+5 Axle Dog	218.66	190.89	177.00	168.67	163.12	159.15	156.17	153.86	152.01	150.49
B-Double	230.89	199.65	184.03	174.66	168.41	163.94	160.60	157.99	155.91	154.21
Twin steer+5 Axle	233.98	203.08	187.62	178.35	172.17	167.76	164.45	161.87	159.81	158.13
A-Double	273.80	236.24	217.46	206.19	198.68	193.31	189.28	186.15	183.65	181.60
B-Triple	301.25	257.19	235.17	221.95	213.14	206.85	202.13	198.46	195.52	193.12
A B combination	315.62	273.71	252.76	240.19	231.81	225.82	221.33	217.84	215.04	212.76
A-Triple	354.09	307.00	283.45	269.32	259.90	253.17	248.13	244.20	241.06	238.49
B-Double	230.89	199.65	184.03	174.66	168.41	163.94	160.60	157.99	155.91	154.21

Source: Estimated by Evaluation and Assurance, TfNSW. Estimates based on the coefficients in Table 11

TfNSW recommends using the behavioural VOC used in the transport forecasting approach if using a constant perceived VOC per kilometre. For variable perceived costs, **TfNSW recommends** the parameters in in **Table 13**.

Perceived VOC are the sum of all operating costs that are considered by travellers in making travel decisions. The perceived VOC parameters shown in **Table 13** differ from resource cost parameters because:

- travellers take into account taxes and subsidies, such as GST, fuel excise and rebates, which are transfers to and from the government and not economic costs
- travellers do not perceive or misperceive some costs when making travel decisions, such as the impacts of additional travel on maintenance, engine oil, and tyre costs
- travel costs are paid for by other parties, so the perceived vehicle operating cost is zero for some travellers
- some travellers incorrectly allocate other costs as part of the marginal cost of travel, for instance, insurance or time-based depreciation costs
- some travellers may not perceive that VOC are higher during congested conditions, and lower when travelling at high speeds. Travellers may instead perceive VOC as a constant cost per kilometre.

Table 13 Urban vehicle operating costs: perceived cost (cents/km)

Vehicle type	TfNSW perceived VOC model									
	20	30	40	50	60	70	80	90	100	110
Car (all types)										
Small car	42.78	36.97	34.07	32.33	31.17	30.34	29.72	29.24	28.85	28.53
Medium car	53.36	44.30	39.78	37.06	35.25	33.95	32.98	32.23	31.62	31.13
Large car	66.37	53.65	47.30	43.48	40.94	39.12	37.76	36.70	35.85	35.16
Utility vehicles										
Courier Van-Utility	71.93	55.50	47.29	42.37	39.08	36.73	34.98	33.61	32.51	31.62
4WD Petrol	59.98	50.20	45.31	42.37	40.41	39.01	37.97	37.15	36.50	35.96
Rigid trucks										
Light Rigid	88.74	72.94	65.03	60.29	57.13	54.87	53.18	51.86	50.81	49.95
Medium Rigid	93.77	78.44	70.78	66.18	63.12	60.93	59.29	58.01	56.99	56.15
Heavy Rigid	126.59	109.33	100.70	95.52	92.07	89.61	87.76	86.32	85.17	84.23
Heavy Bus	204.30	163.77	143.51	131.35	123.24	117.45	113.11	109.73	107.03	104.82
Articulated trucks										
Articulated 4 Axle	180.54	156.67	144.74	137.58	132.80	129.39	126.84	124.85	123.26	121.95
Articulated 5 Axle	197.70	170.95	157.57	149.55	144.19	140.37	137.51	135.28	133.49	132.03
Articulated 6 Axle	214.00	185.14	170.70	162.05	156.27	152.15	149.06	146.65	144.73	143.16
Combination vehicles										
Rigid+5 Axle Dog	245.82	215.74	200.70	191.67	185.66	181.36	178.14	175.63	173.62	171.98
B-Double	259.84	226.16	209.32	199.22	192.48	187.67	184.06	181.25	179.01	177.17
Twin steer+5 Axle	263.06	229.69	213.01	203.00	196.32	191.55	187.98	185.20	182.97	181.15
A-Double	307.08	266.81	246.67	234.59	226.54	220.78	216.47	213.11	210.43	208.23
B-Triple	335.91	289.06	265.64	251.59	242.22	235.53	230.51	226.60	223.48	220.92
A B combination	354.00	309.11	286.66	273.19	264.21	257.80	252.99	249.25	246.26	243.81
A-Triple	396.42	346.12	320.97	305.88	295.82	288.63	283.24	279.05	275.70	272.95
B-Double	259.84	226.16	209.32	199.22	192.48	187.67	184.06	181.25	179.01	177.17

Source: Estimated by Evaluation and Assurance, TfNSW
Note: Private vehicle perceived costs have been estimated by Evaluation and Assurance based on (Shiftan & Bekhor, 2002). LCV and HCV perceived costs have been estimated by Evaluation & Assurance based on resource costs plus taxes and subsidies.

Fuel use parameters and VOC per stop on urban roads are provided in **Table 14** and **Table 15**. **TfNSW recommends** using the values presented in **Table 15** for projects that impact the number of vehicle stops rather than speed of travel, for example, intersection upgrades. These costs are already included in the ATAP 2016 VOC model.

Table 14 Fuel use parameters for cars

Parameter	Value	Units
Fuel cost*	75.92	Cents/L
Fuel used per stop**	0.04	L
Fuel consumption***	9.0 to 12.0	L/100km

Sources: * Fuel cost is a resource cost and is based on 2018-19 average petrol price excluding GST and fuel excise Terminal Gate Prices (TPG) (Australian Institute of Petroleum).
** Fuel used per stop based on SCATS values.
*** Fuel consumption based on 2015 NGTSM, medium car.

Table 15 Vehicle operating cost per stop

Vehicle	VOC/stop (excl. fuel) (cents)	Fuel consumption per stop (L)	Fuel cost (cents/L)	VOC/stop (incl. fuel) (cents)
Car	4.62	0.04	75.92	7.80
Light truck	10.7	0.22	82.61	29.20
Heavy truck	19.6	0.72	82.61	78.88

Source: Fuel consumption per stop is based on estimates of 0.42 stops per km (based on SCATES data). Fuel cost is a resource cost and is based on 2017/18 average fuel price TGP excluding GST and fuel excise (Australian Institute of Petroleum). Diesel fuel price used for Light and Heavy trucks (Australian Institute of Petroleum).

3.2 Rural vehicle operating cost model

3.2.1 Rural Evaluation System model

REVS is the model used in the CBA of NSW rural road projects. The system is based on the National Association of Australian State Road Authorities Improved Model for Project Assessment and Costing (NIMPAC) road planning model.[1] The REVS model uses the economic parameters provided in **Table 17.**

The REVS is designed to be used on rural and outer urban roads because it assumes uninterrupted traffic flows. However, it can be used on roads in towns where traffic flow is predominantly uninterrupted. The REVS is also designed to handle small networks of interacting roads, where an improvement to a single road can affect traffic conditions on other roads in the network. In this situation a traffic survey would first be required to establish the redistribution of traffic. Stop/Give Way signs, traffic lights, pedestrian crossings and the like will reduce the applicability of REVS in an urban situation.

3.2.2 ATAP VOC model – rural

The functional form of the ATAP VOC model for rural areas is given by **Equation 3.** Estimated VOCs can be found in **Table 82** to **Table 97** in Appendix D. There is also an Excel tool to calculate Rural VOC and Fuel Consumption.

Equation 3 ATAP VOC model - rural

$$\boldsymbol{VOC = Base\ VOC \times \left(k_1 + \frac{k_2}{V} + k_3V^2 + k_4IRI + k_5IRI^2 + k_6GVM\right)}$$

Where:

- **VOC** = vehicle operating cost (cents/km)
- **Base VOC** = lowest VOC point in curve from raw HDM-4 output
- **V** = vehicle speed (km/hr)
- **IRI** = International Roughness Index (m/km)
- **GVM** = gross vehicle mass (tonnes)
- **k_1 to k_6** = model coefficients.

The International Roughness Index (IRI) is a scoring process for the roughness of the road surface. At low values the road surface is characterised as good or very good with little surface imperfections. A fair road is characterised with surface imperfections. Poor roads are characterised with frequent minor depressions and very poor roads with frequent shallow depressions or deep shallow depressions (**Table 16**) (Gillespie, et al., 2002).

Table 16 Description of road surface conditions

Measure	Sealed road				
Pavement condition	Very Poor	Poor	Fair	Good	Very Good
International Roughness Index (IRI)	8+	6-7	4-5	3	0-2

Source: National Association of Australian State Road Authorities.

TfNSW recommends the rural ATAP fuel consumption model as presented in Australian Transport Assessment and Planning PV2 Road Parameter Values (2016). The functional form is described in **Equation 4.** Look up tables of estimated VOC values are provided in

[1] The National Association of Australian State Road Authorities is now Austroads.

Table 98 in **Appendix D.** Estimates can also be calculated using the Excel tool to calculate Rural VOC and Fuel Consumption.

Equation 4 ATAP fuel consumption - rural

$$\boldsymbol{Fuel\ consumption = Base\ Fuel \times \left(k_1 + \frac{k_2}{V} + k_3 V^2 + k_4 IRI + k_5 GVM\right)}$$

Where:

- Fuel consumption is in L/km
- **Base Fuel** = lowest fuel consumption point in curve from raw HDM-4 output
- **V** = vehicle speed (km/hr)
- **IRI** = International Roughness Index (m/km)
- **GVM** = gross vehicle mass (tonnes)
- **k_1 to k_5** = model coefficients.

Table 17 Rural Evaluation System model economic parameters

Parameters	Identifier	Units	Car	2x-4ty Truck	2x-6ty Truck	3 Axle Truck	4 Axle Truck	5 Axle Semi	6 Axle Semi	B-Double	B-Triple	Quad Group Semi
Road user cost parameters												
Petrol price	PETROL	cent/litre	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9
Diesel price	DIESEL	cent/litre	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6
Oil price	OIL	cent/litre	782	474	474	474	474	474	474	474	474	474
New tyre price	TYRE	$ per tyre	138	174	385	744	690	705	701	668	704	732
Retread tyre price	RETRED	$ per tyre	69	88	196	250	250	241	247	253	280	259
Repair and servicing cost	REPAIR	cents/km	7.1	7.5	10.8	15.7	21.5	25.0	25.6	29.8	39.7	29.2
New vehicle price	VEHCLE	$	24,205	27,759	79,497	180,223	245,201	272,135	296,449	342,783	558,770	319,302
Sales tax rate	TAX	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Time depreciation rate	TIMDEP	%/ year	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distance depreciation rate	DISDEP	%/ 1000km	0.224	0.311	0.311	0.205	0.155	0.137	0.137	0.137	0.137	0.0
Time and crash parameters												
Commercial time value	COMMTIM	$/ hr/ person	57.48	30.04	31.45	38.67	48.29	52.85	54.52	65.77	78.14	78.14
Commercial vehicle occupancy	COMMOCC	Persons/ vehicle	1.3	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Weighted average crash cost	UACCST	$/ crash	Rural Urban	$313,536.13 $144,284.44								
Private car occupancy	PRIVOCC	Persons/ vehicle	1.7									
Private time value	PRIVTIM	cents/ hr/ person	17.72									

Source: Estimated by Evaluation and Assurance, TfNSW. Values are indexed to June 2019 prices. The REVS model refers to its economic parameters inputs as the “SWIDE file”.

Table 18 provides the proportion of vehicles in urban and rural areas used to calculate the heavy VOCs.

Table 18 Mix of vehicles

Vehicle type	% Urban	% Regional	% Overall
Cars (all types)	77.40	71.35	76.06
Cars	77.40	71.35	76.06
Utility vehicles	16.58	15.84	16.41
Courier van utility	9.66	9.23	9.56
4WD Mid-Size Petrol	6.92	6.61	6.85
Rigid trucks	3.62	5.00	3.93
Light Rigid (previously LCV 2 axle-4tyre)	0.58	0.80	0.63
Medium Rigid (previously 2 axle-6 tyre)	1.00	1.38	1.09
Heavy Rigid (previously 3 axle)	2.04	2.82	2.21
Articulated trucks	0.76	3.07	1.27
4 axle	0.23	0.32	0.25
5 axle	0.07	0.39	0.14
6 axle	0.46	2.36	0.88
Combination vehicles	0.77	3.95	1.45
Rigid + 5 Axle Dog	0.01	0.06	0.02
B-Double	0.70	3.60	1.34
Twin steer + 5 Axle Dog	0.01	0.06	0.02
A-Double	0.01	0.06	0.02
B-Triple	0.01	0.04	0.01
A B combination	0.01	0.0	0.01
A-Triple	0.01	0.04	0.01
B-Double	0.01	0.05	0.02
Buses	0.86	0.77	0.84
Heavy Bus	0.86	0.77	0.84

Source: Estimated by Evaluation and Assurance, TfNSW from ABS Survey of Motor Vehicle Use 2018.

Additional information on freight vehicle types, average payloads, and distance travelled can be found at the following sources:

- The Traffic Volume Viewer website, to identify relevant Permanent or Sample Classifiers. Requests for freight data by Austroad heavy vehicle class can be sent to Network & Asset Intelligence.
- The *Who Moves What Where* report, available on the National Transport Commission website.
- ABS Category 2993.0 Road freight movements, 2014.

Table 19 contains commercial vehicle mixes for selected Traffic Volume Viewer Classifiers, sourced from Network & Asset Intelligence.

Table 19 Commercial vehicle class mix: selected Sydney Classifiers

Commercial vehicle class	Mobbs Lane, Mobbs Hill	Daines Parade, Beacon Hill	Newbridge Road, Milperra	New Beach Road, Rushcutters Bay
Rigid trucks	6.36%	6.67%	8.01%	5.34%
Two Axle Truck or Bus	5.41%	5.37%	6.56%	4.93%
Three Axle Truck or Bus	0.63%	0.84%	1.14%	0.28%
Four Axle Truck	0.32%	0.46%	0.32%	0.13%
Articulated trucks	1.54%	0.77%	2.08%	0.17%
Three Axle Articulated	0.14%	0.25%	0.26%	0.08%
Four Axle Articulated	0.06%	0.14%	0.21%	0.03%
Five Axle Articulated	0.12%	0.07%	0.32%	0.02%
Six Axle Articulated	0.99%	0.25%	1.13%	0.04%
B Double	0.23%	0.06%	0.14%	0.01%
Double Road Train	0.00%	0.00%	0.01%	0.00%
Triple Road Train	0.00%	0.00%	0.00%	0.00%

Source: Network & Asset Intelligence (2019).

4 Urban road congestion cost

The marginal congestion cost includes the impacts from:

- extra travel time
- increased travel time variability
- increased VOC due to higher fuel consumption
- poorer air quality, as vehicles on congested roads emit more harmful pollutants compared to free-flowing traffic conditions.

TfNSW recommends not including the marginal cost of congestion in a CBA if the economic benefits of road user travel time savings, reliability, urban vehicle operating costs, or environmental impacts have been separately assessed; in order to avoid double counting benefits.

TfNSW recommends the marginal congestion costs presented in **Table 20** to be used for the Greater Sydney Region. As the impacts of cars, freight vehicles and buses are different, VKT has been converted into Passenger Car Equivalent Units (PCU) kilometre travelled (PCU-km). Passenger Car Equivalent (PCE) factors of buses and trucks are presented in **Table 21.**

Table 20 Marginal road congestion cost in Sydney

Vehicle type	PCE factors	Marginal congestion cost in Sydney (cents/vkt)
Passenger vehicles & LCVs	1.00	44.88
Rigid trucks	3.00	134.64
Trailers	6.00	269.28
Articulated trucks	5.00	224.40
B doubles	8.00	359.04
Double road train	8.00	359.04
Triple road train	10.00	448.80
2 axle buses	2.00	89.76
3 axle buses	3.00	134.64

Source: BITRE (2016) Estimating urban traffic and congestion cost trends in Australian cities. Working paper 74, Bureau of Infrastructure, Transport and Regional Economics Values indexed from June 2010 prices to June 2019 prices (ABS Series ID A2325846C).

4.1 Passenger Car Equivalent (PCE) units

TfNSW recommends the use of the PCE factors in **Table 21** which have been used to calculate the values in **Table 20**. The recommended values can be adjusted using the PCE range provided, considering:

- the terrain type
- the gradient of the road and the distance vehicles are traveling at that gradient (grade severity and length of grade)
- traffic mix.

These factors affect the performance of heavy vehicles and subsequently affect traffic flow.

Table 21 also presents the findings from a literature review on PCE.

Table 21 Passenger car equivalency factors

Vehicle Type	NTC	ARRB		Mainroads Western Australia			USA	DfT UK	National Guidelines	TfNSW	
		Urban	Rural	Flat terrain	Rolling terrain	Mountainous terrain				Range	Recommended
Passenger vehicles & LCVs	1.0			1.0	1.3	2.0	1.0	1.0	0.99-1.12	1.0 - 2.0	1.0
Rigid trucks	2.0	4.9	1.4 - 7.9	1.2 - 2.0	1.7 - 5.0	3.0 - 8.0	1.5	1.9	1.23 - 1.56	1.2 - 8.0	3.0
Trailers	2.0 - 3.0	6.5 - 8.7	1.7 - 13.0				2.0			1.7 - 13.0	6.0
Articulated trucks	3.0			2.5	5.0	10.0		2.9	1.78 - 1.89	2.5 - 10.0	5.0
B doubles	4.0	8.8 - 22.3	1.9 - 15.6	4.0	10.0	16.0			2.22	1.9 - 16.0	8.0
Double road trains	4.0			4.0	10.0	16.0			2.75 - 2.90	4.0 - 16.0	8.0
Triple road trains	5.0	9.7 - 24.0	4.2 - 25.7	9.0	22.0	35.0			2.82 - 3.38	4.2 - 35.0	10.0
2 axle buses	1.0 - 2.0			1.2	1.7	3.0				1.0 - 3.0	2.0
3 axle buses	3.0			1.7	3.5	6.0			1.59	1.7 - 6.0	3.0

Source:
(1) NTC - National Transport Commission, Heavy vehicle charges - Report to the Standing Council of Transport and Infrastructure, February 2012.
(2) ARRB - ARRB Consulting, Review of passenger car equivalency factors for heavy vehicles, October 2007.
(3) Mainroads Western Australia - Mainroads Western Australia, Policy and guidelines for overtaking lanes, December 2011.
(4) USA - US Highway Capacity Manual & Al-Kaisy, A. (2006) Passenger car equivalents for heavy vehicles at freeways and multilane highways: some critical issues, ITE Journal, March 2006.
(5) DfT UK - UK Department for Transport, Transport Analysis Guidance (TAG).
(6) NGTSM update 2015.

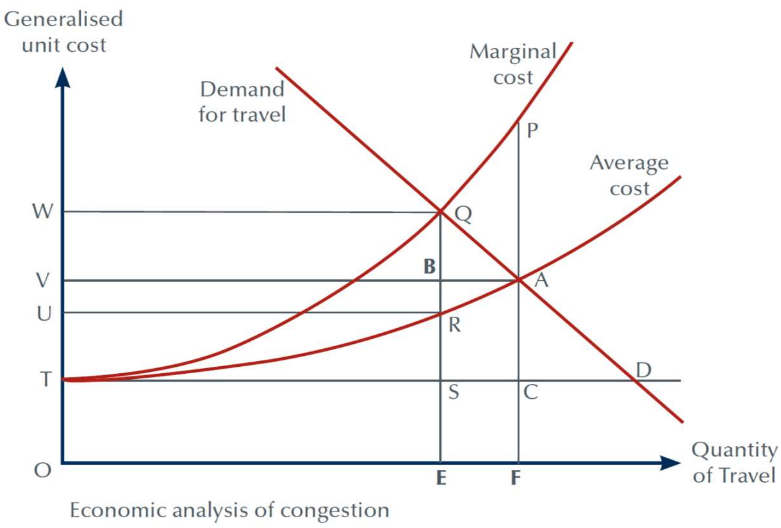
4.2 Additional information: urban road congestion cost

4.2.1 Marginal and average congestion cost

The marginal congestion cost is the incremental congestion delay an individual traveller imposes when entering traffic. The average congestion cost is the total congestion delay per VKT. The marginal congestion cost increases at a faster rate that the average congestion cost as the volume of traffic increases. By joining the congested traffic flow, the additional traveller adds to the congestion, and causes a small increase in the delay experienced by each of the other users.

Marginal cost varies at different levels of congestion. When congestion is low, marginal cost is close to average cost. When congestion is high, marginal cost is higher than average cost (**Figure 1**).

Figure 1 Average and marginal congestion costs



Source: BITRE (2007)

In **Figure 1**, the net increase in costs from the increased traffic congestion is therefore equal to area **VBRU** less area **BAQ**, which given the geometry of the marginal cost curve, is equal to area **PAQ**. Where:

- **VBRU** is an increase in total travel costs for all existing users (due to the higher congestion at point **A**)
- **BAQ** is an increase in consumer surplus amount for extra travellers (whose overall utility improves).

The congestion cost in Sydney was estimated by the Bureau of Infrastructure Transport and Regional Economics (BITRE) at $3.53 billion in 2005 and projected to increase to $7.76 billion by 2020.[2] An update to the BITRE report was released in 2016, which estimated the cost of congestion in Sydney as $6.12 billion as at 2015,

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2 BITRE (2007) Estimating urban traffic and congestion cost trends in Australian cities. Working paper 71, Bureau of Infrastructure, Transport and Regional Economics. Values indexed from June 2005 prices to June 2019 prices (ABS Series ID A2325846C).

and projected 2020 congestion costs of $9.63 billion, an increase on the 2005 forecast. [3]

Table 22 presents 2016 BITRE estimates of the average social costs of congestion in Australian capital cities.

Table 22 Average congestion costs: Sydney and Australian capital cities

Year	Sydney		Australian capital cities	
	Total congestion cost ($b)	Unit cost of congestion (cents/PCU km)	Total congestion cost ($b)	Unit cost of congestion (cents/PCU km)
Original estimate in 2010 prices				
2020	$8.04	15.75	$16.45	10.69
2021	$8.40	16.07	$17.51	11.14
2022	$8.74	16.30	$18.56	11.53
2023	$9.08	16.55	$19.77	11.97
2024	$9.40	16.75	$21.02	12.38
Indexed to June 2019 prices				
2020	$9.63	18.88	$19.71	12.81
2021	$10.07	19.25	$20.98	13.35
2022	$10.47	19.54	$22.24	13.82
2023	$10.87	19.83	$23.69	14.34
2024	$11.26	20.08	$25.19	14.84

Source: BITRE (2016) Estimating urban traffic and congestion cost trends in Australian cities. Working paper 74, Bureau of Infrastructure, Transport and Regional Economics Values indexed from June 2010 prices to June 2019 prices (ABS Series ID A2325846C).

Estimating changes in congestion costs between two years can be used as a proxy for the marginal congestion cost.[4] This is done using the BITRE forecast of the social cost of congestion and projections of total metropolitan vehicle kilometres travelled in passenger car unit equivalents (PCU) from 1990-2020.[5]

Total metropolitan vehicle kilometres are represented in PCUs to take into account the impact of differing vehicle class such as cars, light commercial vehicles, rigid trucks and articulated trucks.

The marginal social cost of congestion is calculated by dividing the change in the social cost of congestion between 2 consecutive years by the change in PCU kilometres travelled. This value is then indexed from 2005/06 prices to June 2019 prices using CPI (Sydney). The estimated marginal congestion cost is $0.46 per vkt in 2020 as shown in **Table 24**. This is a marginal value representing the social cost of congestion imposed by each additional passenger car to all other vehicles on the road.

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3 BITRE (2016) Estimating urban traffic and congestion cost trends in Australian cities. Working paper 74, Bureau of Infrastructure, Transport and Regional Economics Values indexed from June 2010 prices to June 2019 prices (ABS Series ID A2325846C).

4 This method was originally developed by PwC Australia.

5 BITRE (2007) Estimating urban traffic and congestion cost trends in Australian cities. Working paper 71, Bureau of Infrastructure, Transport and Regional Economics.

Table 23 Marginal congestion cost by road type in Sydney

Road category	Marginal congestion cost (cents/vkt) in 1996 dollars	Marginal congestion cost (cents/vkt) indexed to June 2019
Freeways	13.00	22.49
CBD streets	62.00	107.25
Arterial roads (inner)	21.00	36.33
Arterial roads (outer)	7.00	12.11

Source: Traffic congestion and road user charges in Australian capital cities, Report 92, Bureau of Transport and Communications Economics, 1996. Values indexed from June 1996 prices to June 2019 prices (ABS Series ID A2325806K).

Table 24 Marginal congestion cost over time, Sydney-wide

Cost	2020	2021	2022	2023	2024	2025
Social Cost ($billion)	8.04	8.40	8.74	9.08	9.40	9.72
Change in Social Cost ($billion)	0.41	0.37	0.33	0.34	0.32	0.32
Billion pcu-km	45.45	46.56	47.70	48.81	49.91	51.00
Change in pcu-km	1.07	1.11	1.14	1.11	1.10	1.09
MSC in 2005/6 dollar ($/pcu-km)	0.38	0.33	0.29	0.31	0.30	0.29
MSC in 2019 dollar ($/pcu-km)	0.46	0.40	0.36	0.37	0.36	0.35

Source: BITRE (2016) Estimating urban traffic and congestion cost trends in Australian cities. Working paper 74, Bureau of Infrastructure, Transport and Regional Economics Values indexed from June 2010 prices to June 2019 prices (ABS Series ID A2325846C).

5 Road safety benefits

TfNSW recommends that road safety benefits be estimated based on the Inclusive Willingness-to-Pay (WTP) values in **Table 26**. Where detailed crash data is not available, the average crash costs by road type in **Table 25** can be used to estimate the economic benefit.

Table 25 Average crash costs by road type, WTP values - urban

Road type	Average crash cost ($/mvkt)		
	All crashes	Bus crashes	Car crashes
Local/sub-arterial	87,690	141,376	87,581
Arterial	63,854	103,217	63,745
Freeway	19,900	32,037	19,900
Weighted average	71,727	115,791	71,617

Source: TfNSW estimate. Indexed from June 2014 prices to June 2019 prices (ABS Series ID A2325806K).

Detailed road safety analysis can be undertaken using the Road User Movement (RUM) codes, and Inclusive WTP costs. The Safer Roads team in the Centre for Road Safety maintains a model that calculates road safety benefits and costs for road infrastructure projects. The Safer Roads team also maintains the Crash Reduction Factor matrix that records the literature based crash reduction or increase factors of individual road safety countermeasures, by RUM code.

For details, please contact saferroads@transport.nsw.gov.au.

5.1 Inclusive Willingness-to-Pay

The **Inclusive WTP** approach represents the individuals WTP to avoid death or injury; as well as the cost to society due to the crash, such as emergency costs. The WTP values are derived from a stated preference survey. The rationale for incorporating these additional costs is that individuals do not factor costs that are not incurred by the individual.

The Inclusive WTP approach is recommended by the Australian Government Department of Infrastructure, Transport, Cities and Regional Development (DITCRD) and has been adopted by ATAP. The values are a combination of WTP values with some additional vehicle, emergency and other crash related costs.

Table 26 Costs per casualty and per crash – Inclusive WTP approach

Accident type	Urban	Rural	Average
Inclusive WTP costs per casualty			
Fatality	$7,425,549	$8,130,381	$7,752,786
Serious injury (injury requiring hospitalisation)	$445,526	$589,855	$495,874
Moderate injury (attendance at an emergency department)	$68,550	$87,906	$77,472
Minor injury (not requiring attendance at an emergency department or hospital)	$68,550	$87,906	$77,472
Unknown injury type	$196,095	$250,420	$216,079
Inclusive WTP costs per crash			
Fatal crash (at least one person killed)	$7,808,768	$9,242,523	$8,586,767
Serious injury crash (at least one person hospitalised, but no fatalities)	$507,553	$700,151	$574,265
Moderate injury crash (at least one person attended emergency, but no serious injuries or fatalities)	$85,296	$112,608	$97,512
Minor injury crash (at least one person received a minor injury, but no moderate / serious injuries or fatalities)	$78,389	$103,484	$89,314
Unknown injury type crash	$177,264	$243,098	$210,809
Property damage only	$10,338	$10,338	$10,338

Source: Values from the Economic Valuation of Safety Benefits, Serious Injuries, Final Report, PricewaterhouseCoopers (PWC) for the former Roads and Traffic Authority and indexed from December 2007 to June 2019 (ABS Series ID A2325846C).
Notes: Unknown injury type crash is non-fatal casualty crash where injury severity is unknown.

Definitions:

- A **fatality** occurs when a person dies within 30 days of a crash, from injuries due to the crash.
- A **fatal crash** is a road traffic crash on public roads in which at least one person in the crash dies within 30 days from injuries received in that crash.
- A **serious injury** is when a person is admitted to hospital as a result of a road traffic crash on public roads who does not die within 30 days as a result of those injuries.
- A **serious injury crash** is a road traffic crash on public roads in which at least one person was admitted to hospital as a result of the crash, and in which there were no fatalities as a result of that crash.
- A **moderate injury** is when a person attends an emergency department following a road traffic crash on public roads but is not subsequently admitted to hospital.
- A **moderate injury crash** is a road traffic crash on public roads in which at least one person attends an emergency department following that crash but is not subsequently admitted to hospital. There were no serious injuries or fatalities from that crash.
- **Minor injury** occurs when a person injured from a road traffic crash on public roads that does not attend an emergency department and is not admitted to hospital.
- A **minor injury crash** is a road traffic crash on public roads in which at least one person injured from that crash does not attend an emergency department and is not admitted to hospital. There were no moderate injuries, serious injuries or fatalities from that crash.
- **Urban** refers to Sydney, Newcastle and Wollongong metropolitan areas, and town centres where the speed limit is up to and including 80km/h.

- **Rural** refers to areas outside the Sydney, Newcastle and Wollongong metropolitan areas, where the speed limit is more than 80km/h.

5.2 Crash rates

Crash rates for NSW roads were estimated by Austroads for a range of single and combined attributes. A selection of crash rate tables are included below, with more information available at the Austroads website.

Table 27 NSW Crash rates – single attribute

Attribute	100m VKT (5 years)	Fatal	Fatal crash rate	Injury	Injury crash rate	All crashes	Total crash rate
Carriageway							
Divided	905.88	339	0.37	17,386	19.19	24,990	27.59
Single	947.45	763	0.81	19,902	21.01	26,823	28.31
Environment							
Rural	791.00	625	0.79	9,518	12.03	21,657	27.38
Urban	1,194.65	642	0.54	34,446	28.83	82,964	69.45
Surface							
Asphalt concrete	1,151.24	623	0.54	32,097	27.88	77,699	67.49
Concrete	183.34	83	0.45	2,521	13.75	6,361	34.69
Spray seal	647.71	559	0.86	9,322	14.39	20,525	31.69
Unsealed	3.35	2	0.60	24	7.16	36	10.75

Source: Road Safety Engineering Risk Assessment Part 7: Crash Rates Database, AP-T152-10, Austroads 2010.
Notes: Contact Economic Advisory for more detail on road class if required for a CBA.

Table 28 NSW crash rates – rural and urban by carriageway

Attribute	100m VKT (5 years)	Fatal	Fatal crash rates	Injury	Injury crash rates	All crashes	Total crash rates
Rural by carriageway							
Divided	174.14	72	0.41	1,782	10.23	4,632	26.6
Single	616.86	553	0.9	7,736	12.54	17,025	27.6
Urban by carriageway							
Divided	755.21	335	0.44	18,982	25.13	46,715	61.86
Single	439.44	307	0.7	15,464	35.19	36,249	82.49

Source: Road Safety Engineering Risk Assessment Part 7: Crash Rates Database, AP-T152-10, Austroads 2010.

5.3 Additional information: crash values

For additional information, the breakdown of the WTP values and the additional costs are provided in **Table 29** and **Table 30**, respectively. The calculations for average crash costs also draw on the average number of persons killed and injured per crash, as presented in **Table 31**.

Table 29 and **Table 30** are not intended to be directly used in CBA for road projects. The WTP values may be used in CBA of maritime, railway and other initiatives where the inclusive costs are not applicable.

Table 29 Value per casualty and per crash – willingness to pay approach

Accident type	Urban	Rural	Average
WTP value per casualty			
Value of fatality risk prevention	$7,261,155	$7,965,987	$7,588,392
Value of serious injury risk prevention (requiring hospitalisation)	$261,947	$406,276	$312,295
Value of moderate injury risk prevention (attendance at emergency department)	$55,151	$74,506	$64,073
Value of minor injury prevention	$55,151	$74,506	$64,073
Value of unknown injury type prevention	$128,463	$182,788	$148,447
WTP value per crash			
Fatal crash (at least one person killed)	$7,571,245	$8,981,595	$8,333,309
Serious injury crash (at least one person hospitalised, but no fatalities)	$302,651	$486,727	$366,226
Moderate injury crash (at least one person attended emergency, but no serious injuries or fatalities)	$68,623	$95,443	$80,647
Minor injury crash (at least one person received a minor injury, but no moderate / serious injuries or fatalities)	$63,067	$87,710	$73,866

Source: Estimated by Evaluation and Assurance, TfNSW. Values indexed from December 2007 prices to June 2019 prices (ABS Series ID A2325806K).

Table 30 Vehicle and general costs ($ per person) in inclusive WTP values

Cost category	Crash type			
	Fatality	Serious injury	Moderate/ Minor injury	Unknown injury
Vehicle costs				
Repairs*	$14,617	$12,214	$12,053	$12,104
Unavailability of vehicles*	$1,855	$1,645	$869	$1,117
Towing*	$436	$387	$204	$263
Total vehicle costs*	$16,908	$14,247	$13,127	$13,484
General costs				
Travel delays**	$82,061	$99,317	$130	$31,739
Insurance administration**	$52,586	$63,646	$83	$20,339
Police**	$10,580	$3,635	$55	$1,196
Property**	$1,704	$2,061	$3	$659
Fire**	$556	$673	$2	$216
Total general costs**	$147,487	$169,332	$272	$54,149
Total inclusive costs (vehicle plus general)	$164,395	$183,579	$13,399	$67,632

Source: NGTSM 2015. *Values indexed from June 2013 prices to June 2019 prices (ABS Series ID A2328771A). **Values indexed from June 3013 prices to June 2019 prices (ABS Series ID A2325846C).

Table 31 Average number of persons killed and injured in a crash

Crash type	Urban	Rural	Average
Fatal crash			
Average no. of persons killed per crash	1.03	1.10	1.08
Average no. of persons hospitalised per crash	0.32	0.39	0.37
Average no. of persons with moderate injury per crash	0.65	0.40	0.48
Average no. of persons with minor/other injury per crash	0.09	0.19	0.16
Serious injury crash			
Average no. of persons hospitalised per crash	1.10	1.14	1.11
Average no. of persons with moderate injury per crash	0.18	0.21	0.19
Average no. of persons with minor/other injury per crash	0.11	0.11	0.11
Moderate injury crash			
Average no. of persons with moderate injury per crash	1.11	1.16	1.13
Average no. of persons with minor/other injury per crash	0.13	0.12	0.13
Minor injury crash			
Average no. of persons with minor/other injury per crash	1.14	1.18	1.15

Source: Number of persons is estimated by Evaluation and Assurance, TfNSW based on casualty and crash data provided by the Centre for Road Safety for urban and rural 2011 to 2015.

5.3.1 The Human Capital approach to crash valuation

Although **not** recommended by TfNSW, the Human Capital approach is commonly used to value the impact of crashes. The Human Capital approach aggregates various identifiable costs, such as: loss of income, medical expenses, long term care, insurance cost, vehicle repair, property damage, travel delays and policing. The value of a statistical life or a fatality is the discounted present value of these costs over a period of up to 40 years.

There are several limitations of the Human Capital approach. Firstly, public policy is designed to reduce the risk of crashes or injuries. However, the Human Capital approach concentrates on what has been lost, rather than prevented. Secondly, it includes lost productivity and income and therefore undervalues fatalities involving non-working individuals. Thirdly, it does not make allowance for pain and suffering. Due to these limitations, the contemporary trend of economic evaluation is to use the crash values derived from the WTP approach. Human Capital accident costs were originally estimated by the Bureau of Transport Economics (BTE 2000). These values were then updated by the NGTSM (**Table 32**). As noted above, the human capital approach is not the preferred method for calculating crash values.

Table 32 Crash cost per person – Human Capital approach

Cost components	Fatality	Serious injury	Other injury
Human costs*			
Ambulance	$644	$644	$350
Hospital in-patient	$3,481	$13,928	$71
Other medical	$2,581	$20,909	$101
Long-term care	$0	$158,211	$0
Labour in the** workplace	$842,409	$39,832	$0
Labour in the** household	$700,776	$33,213	$0
Quality of life**	$774,043	$83,046	$4,413
Insurance claims***	$20,654	$36,397	$2,175
Criminal prosecution***	$2,665	$771	$95
Correctional services***	$14,648	$0	$0
Workplace disruptions***	$13,902	$14,287	$926
Funeral***	$2,926	$0	$0
Coroner***	$960	$0	$0
Vehicle costs			
Repairs****	$14,617	$12,214	$12,053
Unavailability of vehicles****	$1,855	$1,645	$869
Towing****	$436	$387	$204
General costs			
Travel delays***	$82,061	$99,317	$130
Insurance administration***	$52,586	$63,646	$83
Police***	$10,580	$3,635	$55
Property***	$1,704	$2,061	$3
Fire***	$556	$673	$2
Total costs	$2,544,084	$584,816	$21,531

Source: NGTSM 2015
*Values are indexed from June 2013 prices to June 2019 prices (ABS Series ID A2331111C).
**Values are indexed from May 2013 AWE to May 2019 AWE (ABS Series ID A84998729F).
***Values are indexed from June 2013 to June 2019 prices (ABS Series ID A2325846C).
****Values are indexed from June 2013 to June 2019 prices (ABS Series ID A2328771A).

Table 33 presents the cost per crash using a Human Capital approach, by location.

Table 33 Cost per crash – Human Capital approach

Crash type	Urban	Urban freeway	Rural
Fatal crash	$2,920,470	$3,000,341	$3,308,260
Serious / Other injury crash	$628,460	$660,899	$677,145

Source: NGTSM, Road Parameter Values (2015). Indexed from May 2013 AWE to May 2019 AWE (ABS Series ID A84998729F).

5.3.2 Literature review of a value of a statistical life

A literature review indicates that the value of a statistical life (VSL) ranges from around $2 million to $11 million in March 2019 prices (excluding the two lowest and two highest outliers).

Table 34 Values of statistical life from existing international literature

Studies	Value of Statistical Life ($m)	Approximate Value in June 2019 (AUD $m)
Andersson (2005), Sweden	USD1.3	$1.79
Krupnick et al (2000), Canada	USD1.3	$2.10
RTA (2009) Human Capital Cost	AUD1.69	$2.25
Transport Canada (2007)*	AUD2.21 in 2007	$2.91
Mrozek and Taylor (2001)	USD2.0	$3.04
Guria et al (1999), NZ*	USD2.1	$3.51
Jones-Lee (1994)	USD2.1	$3.93
Tsuge et al (2005), Japan	USD2.9	$3.99
Kneisner and Leith (1991), Australia	USD2.2	$4.29
UK Dept for Transport (2007)*	AUD3.39 in 2007	$4.47
Jones-Lee et at (1995), UK	USD2.7	$4.81
Jenkins et al (2001)	USD3.2	$4.87
NZ Ministry of Transport (2007)*	AUD3.95 in 2007	$5.20
US Federal Highway Administration (2007)*	AUD4.45 in 2007	$5.86
Desaigues and Rabl (1995), France	USD3.4	$6.05
Desvouges et al (1998)	USD3.6	$6.10
Johannesson et al (1997), Sweden	USD3.8	$6.49
Van den Burgh et al (1997), US and UK	USD3.9	$6.67
PWC (2008), Australia	AUD5.95m in 2008	$7.44
Gayer et al (2000), US	USD4.7	$7.61
Meng and Smith (1999), Canada	USD5.2	$8.69
Day (1999), US, Canada, UK	USD5.6	$9.36
Viscusi (1993)	median USD5.5	$10.43
Baranzini and Luzzi (2001), Switzerland	USD7.5	$11.42
Schwab-Christe (1995), Switzerland	USD7.5	$13.36
Miller et al (1997), Australia	median USD15.2	$25.98
ATAP Guidelines (2016), Australia	AUD7.53	$8.47
Median international literature value		$5.86

Source: Values indexed to June 2019 prices (ABS Series ID A2325806K). *Sourced from PWC (2008).

6 Environmental impacts

TfNSW recommends the use of the parameter values for environmental externalities in **Table 35** and **Table 36** for car and public transport vehicles, and in **Table 39** and **Table 40** for freight vehicles.

TfNSW recommends air pollution and greenhouse gas (GHG) emissions be calculated using the upper and lower range for congested and free-flow conditions, respectively. For all other externality types, the midpoint estimate should be used.

Table 35 Externality unit costs by transport mode and location − urban

Externality type (range)	Car*	Bus*	Rail**	Light rail***	Ferry****
	Cents per car km	Cents per bus km	Cents per car km	Cents per vehicle km	Cents per vessel km
Air pollution	3.37 (3.29 to 3.44)	37.90 (26.82 to 42.15)	4.99	41.42	955.63
GHG emissions	2.66 (2.34 to 2.97)	15.61 N/A	0.80	32.69	93.83
Noise	1.10 (0.78 to 1.41)	2.66 (1.56 to 3.75)	2.57		
Water pollution	0.51 (0.48 to 0.52)	5.66 (4.00 to 6.32)			
Nature and landscape	0.06 (0.06 to 0.23)	0.17 (0.17 to 0.80)			
Urban separation	0.78 (0.46 to 1.09)	2.51 (1.56 to 3.44)			
Upstream / downstream costs	4.53 (3.90 to 5.15)	23.42 (18.73 to 28.10)			

Sources:
*Guide to Project Evaluation, Part 4, Project Evaluation Data, Austroads, 2012. Values in brackets represent lower and higher ranges. These values are based on Austroads (2003) and Austroads (2012) derived from studies on 5 countries considered comparable to Australia.
**North West Rail Economic Evaluation.
***National Guidelines for Transport System Management in Australia, Part 3, Appraisal of initiatives, Australian Transport Council 2006.
****TfNSW estimate based on Independent Pricing and Regulatory Tribunal NSW (IPART) (2014) Cost of Emissions for NSW Light Rail.
Indexed to June 2019 prices (ABS Series ID A2325806K).

Table 36 Externality unit costs by transport mode and location − rural

Externality type (range)	Car*	Bus*	Rail
	Cents per car km	Cents per bus km	Cents per car km
Air pollution	0.04 (0.02 to 0.04)	0.00 (0.00 to 0.42)	
GHG emissions	2.66 (2.34 to 2.97)	15.61 N/A	0.82
Water pollution	0.05 (0.05 to 0.05)	0.06 (0.04 to 0.06)	
Nature and landscape	0.62 (0.62 to 2.18)	1.72 (1.72 to 7.97)	
Upstream / downstream costs	4.53 (3.90 to 5.15)	23.42 (18.73 to 28.10)	

Sources: *Guide to Project Evaluation, Part 4, Project Evaluation Data, Austroads, 2012; ** North West Rail Economic Evaluation.
Values indexed to June 2019 prices (ABS Series ID A2325806K).
Note: Noise externalities and urban separation are not applicable for rural areas.

6.1 Air pollution and greenhouse gas emissions

Air pollution is predominantly an urban issue. The parameter values given in **Table 35** are a function of vehicle kilometres travelled (vkt), population distribution, and population density. As a rule of thumb, the parameter values for air pollution for a passenger car in a rural area is 1 per cent of the corresponding values in an urban area (**Table 35**).

Air pollution is lower in free flowing conditions than on congested roads. A project that improves an urban road may reduce road congestion and increase the average travel speed, which will reduce air pollution. Vehicle pollutions of carbon monoxide (CO), hydrocarbon (HC), nitrogen oxide (NOx) and particles increase by 22 per cent, 33 per cent, 14 per cent and 13 per cent respectively when driving conditions change from free flowing (urban vehicle speed 25 km/h or above) to congested conditions (urban vehicle speed less than 25 km/h).

Since GHG have a global impact, the same value is applied to urban and rural areas in **Table 35**. Vehicles generate more GHG on congested roads.

6.2 Noise pollution

Noise pollution is mostly an urban issue. The externality value is a function of population distribution and the location of the travelling vehicle. Therefore, the rural noise unit cost is set to zero for passenger cars and buses, and not included in **Table 36**. This does not imply that rural noise impacts are always negligible, as the particular situation of each project needs to be considered. For rural towns, the urban value is assumed. For urban freeways where there are noise barriers or no noise exposure to residential areas, the rural value is assumed.

6.3 Water pollution

Water pollution includes organic waste or persistent toxicants run-off from roads generated from vehicle use. These include engine oil leakage and disposal, road surface, particulate matter and other air pollutants from exhaust and tyre degradation. Using the WTP methodology, the water pollution parameter value represents approximately 15 per cent of the air pollution. Concentrations of pollutants in urban waterways are significantly higher compared to rural areas.

6.4 Nature and landscape impacts

Nature and landscape impacts are driven by the infrastructure ‘footprint’. For example, habitat loss, loss of natural vegetation or reduction in visual amenity as infrastructure is constructed. Key impacts in rural areas are natural impacts; while key impacts in urban areas are mostly amenity/visual, as the urban environment is already dominated by infrastructure. The impacts on nature and the landscape are assumed to be higher for rural areas. Therefore, the impact in urban locations are 10 per cent that for rural locations.

6.5 Urban separation

Urban separation is only an externality in urban areas. This negative externality is due to time lost to pedestrians, lack of non-motorised transport provision, and visual intrusion.

6.6 Upstream and downstream impacts

Upstream and downstream costs refer to the indirect costs of transport including energy generation, vehicle production and maintenance, and infrastructure construction and maintenance.

6.7 Environmental impacts per passenger

Table 37 and **Table 38** present environmental externality costs per passenger for cars, buses, rail, light rail and ferries. **Table 38** estimates the average load as well as at 100 per cent capacity. These values may be used for initiatives that change volume of passengers on public transport vehicles, or result in mode switch between different vehicle types.

Table 37 Air pollution and greenhouse gas external costs per passenger – car, bus and rail

Emission	Car	Bus	Rail
	cents/pkm		
Air pollution	2.39	1.89	0.04
GHG emissions	1.88	0.78	0.01

Source: TfNSW estimate based on IPART (2014) Cost of Emissions for NSW Ferry Networks and Light Rail and ferry operational data. Indexed from June 2014 prices to June 2019 prices (ABS Series ID A2325806K).

Table 38 Air pollution and greenhouse gas external costs – ferry and light rail

Emission	Light rail upstream electricity generation			Ferry transport operations		
	cents/vkm	cents/pkm (average patronage)	cents/pkm (at capacity)	cents/vkm	cents/km (average patronage)	cents/pkm (at capacity)
Air pollution	41.42	0.64	0.54	955.63	10.06	2.16
GHG emissions	32.69	0.50	0.42	93.83	0.99	0.21

Source: TfNSW estimate based on IPART (2014) Cost of Emissions for NSW Ferry Networks and Light Rail and ferry operational data. Indexed from June 2014 prices to June 2019 prices (ABS Series ID A2325806K).

6.8 Freight vehicle environmental externalities

Table 39 and **Table 40** present externality costs for freight vehicles by externality type, presented in dollars per vehicle-kilometre travelled, based on network-wide average payloads.

As stated above, **TfNSW recommends** air pollution and GHG emissions be calculated using the upper and lower range for congested and free-flow conditions, respectively. For all other externality types, the midpoint estimate should be used.

Table 39 Externality unit costs for freight vehicles (cents per kilometre travelled) – urban

Externality type	Light commercial vehicles	Rigid trucks	Articulated trucks
Air pollution	7.56	16.50	65.82
	(5.60 to 12.44)	(8.00 to 20.19)	(31.93 to 80.54)
GHG emissions	2.35	3.67	14.64
	(2.19 to 2.47)	(1.84 to 6.42)	(7.34 to 25.62)
Noise	1.29	2.75	10.97
	(0.90 to 1.79)	(1.83 to 3.67)	(7.31 to 14.64)
Water pollution	1.13	2.47	9.87
	(0.84 to 1.86)	(0.83 to 3.03)	(3.30 to 12.08)
Nature and landscape	0.84	0.27	1.08
	(0.84 to 1.63)	(0.27 to 0.56)	(1.08 to 2.22)
Urban separation	1.23	1.84	27.34
	(0.73 to 1.74)	(0.92 to 2.76)	(3.67 to 11.00)
Upstream and downstream costs	7.85	14.69	N/A
	(5.60 to 10.09)	(12.85 to 16.52)	

Source: Light and heavy vehicles from Guide to Project Evaluation, Part 4, Project Evaluation Data, Austroads, 2008. Rail from NGTSM, Part 3, Appraisal of initiatives, Australian Transport Council 2006 Values indexed to June 2019 prices (ABS Series ID A2325806K).
Notes: Average load per vehicle is assumed based on ABS 2018 Survey of Motor Vehicle Use.

Table 40 Externality unit costs for freight vehicles (cents per kilometre travelled) – rural

Externality type	Light commercial vehicles	Rigid trucks	Articulated trucks
Air pollution		0.16	0.65
		(0.09 to 0.20)	(0.34 to 0.80)
GHG emissions	2.35	3.65	14.64
	(2.19 to 2.47)	(1.84 to 6.42)	(7.34 to 25.62)
Noise		0.28	1.11
		(0.19 to 0.38)	(0.74 to 1.54)
Water pollution	0.01	0.99	3.95
	(0.01 to 0.02)	(0.50 to 1.21)	(1.99 to 4.83)
Nature and landscape	0.01	0.76	11
	(0.01 to 0.02)	(2.76 to 5.51)	(11.00 to 21.98)
Upstream and downstream costs	7.85	14.69	58.6
	(5.60 to 10.09)	(12.85 to 16.52)	(51.26 to 65.90)

Source: Light and heavy vehicles from Guide to Project Evaluation, Part 4, Project Evaluation Data, Austroads, 2008. Rail from NGTSM, Part 3, Appraisal of initiatives, Australian Transport Council 2006. Values indexed to June 2019 prices (CPI, Australia, all groups).
Notes: Average load per vehicle is assumed based on ABS 2018 Survey of Motor Vehicle Use; Urban separation is not included in rural externality values.

Table 41 Average freight vehicle payloads

Vehicle Type	Average load per trip (kg)	Average load per trip (t)
Light vehicles	359	0.359
Rigid trucks	5879	5.879
Articulated trucks	23451	23.451

Source: ABS, 9208.0 Table 26 Survey of Motor Vehicle Use, Australia, 2018 - NSW values.

Table 42 and **Table 43** present externality costs for freight vehicles by externality type, presented in dollars per 1,000 tones-kilometre travelled. **Equation 5** can be used to convert these figures into vehicle-kilometres travelled unit costs, where more detailed payload information is available:

Equation 5 Freight externality unit conversion

$$Unit\ cost_{ev} = \frac{CT_e \times L_v}{10}$$

Where:

- **Unit Cost$_{ev}$** = the externality unit cost per vehicle type and environmental externality (c/km)
- **CT$_e$** = the cost in $ per 1000 tonne kilometres, by environmental externality
- **L$_v$** = the average payload per vehicle type,

The assumed weight of freight by vehicle type are in **Table 41**. If a more accurate average load value for a particular project is known, the above equation can be used to convert the values in **Table 42** and **Table 43** into cents per kilometres travelled.

Table 42 Externality unit costs for freight vehicles ($ per 1,000 tonne-kilometre travelled) – urban

Externality type	Light vehicle	Heavy vehicle	Rail
Air pollution	210.54 (156.11 to 346.55)	28.07 (13.61 to 34.35)	4.55
GHG emissions	65.58 (60.88 to 68.69)	6.24 (3.13 to 10.92)	0.41
Noise	35.90 (24.99 to 49.96)	4.68 (3.12 to 6.24)	1.93
Water pollution	31.58 (23.41 to 51.92)	4.21 (1.41 to 5.15)	0.14
Nature and Landscape	23.41 (23.41 to 45.28)	0.46 (0.46 to 0.95)	1.10
Urban separation	34.35 (20.29 to 48.40)	3.13 (1.56 to 4.69)	1.10
Upstream and Downstream Costs	218.56 (156.11 to 281.01)	24.99 (21.86 to 28.10)	

Source: Light and heavy vehicles from Guide to Project Evaluation, Part 4, Project Evaluation Data, Austroads, 2008. Rail from NGTSM, Part 3, Appraisal of initiatives, Australian Transport Council 2006. Values indexed to June 2019 prices (ABS Series ID A2325846C).
Notes: Average load per vehicle is assumed based on ABS 2018 Survey of Motor Vehicle Use.

Table 43 Externality unit costs for freight vehicles ($ per 1,000 tonne-kilometre travelled) – rural

Externality type	Light Vehicle	Heavy Vehicle	Rail
Air pollution		0.28 (0.15 to 0.34)	
GHG emissions	65.58 (60.88 to 68.69)	6.24 (3.13 to 10.92)	0.41
Noise		0.47 (0.32 to 0.65)	
Water pollution	0.32 (0.24 to 0.56)	1.69 (0.85 to 2.06)	0.14
Nature and landscape	0.24 (0.24 to 0.45)	4.69 (4.69 to 9.37)	1.10
Upstream and downstream costs	218.56 (156.11 to 281.01)	24.99 (21.86 to 28.10)	

Source: Light and heavy vehicles from Guide to Project Evaluation, Part 4, Project Evaluation Data, Austroads, 2008. Rail from NGTSM, Part 3, Appraisal of initiatives, Australian Transport Council 2006 Values indexed to June 2019 prices (ABS Series ID A2325846C)
Notes: Average load per vehicle is assumed based on ABS 2018 Survey of Motor Vehicle Use

Table 44 presents parameter values of different types of emissions.

Table 44 Unit values for emissions

Emission	$/tonne
Carbon dioxide equivalent (CO2-e)	62.79
Carbon monoxide (CO)	3.95
Oxides of nitrogen (N_{ox})	2,503.55
Particulate matter (PM10)	398,451.75
Total hydrocarbons (THC)	1,254.41

Source: Guide to Project Evaluation, Part 4, Project Evaluation Data, Austroads 2012. Values are indexed from June 2010 prices to June 2019 prices (ABS Series ID A2325846C).

7 Active transport

Active transport refers to physical activity undertaken as a means of transport. The most popular forms of active transport are cycling and walking. The **TfNSW recommended** parameter values for active transport are in **Table 45**.

Table 45 Active transport parameters

Cost / Benefit	Cycling ($/bicycle km)	Walking ($/km)	Recipient
Health benefits	1.22	1.83	Former car and public transport users
Congestion cost savings	0.45	0.45	Former car users
Vehicle operating cost savings	0.21	0.27	Former car users
Accident cost	0.24	0.12	Former car users
Air pollution	0.03	0.03	Former car users
GHG emissions	0.03	0.03	Former car users
Noise	0.01	0.01	Former car users
Water pollution	0.01	0.01	Former car users
Nature and landscape	0.00	0.00	Former car users
Urban separation	0.01	0.01	Former car users
Roadway provision cost savings	0.04	0.04	Former car users
Parking cost savings	0.01	0.01	Former car users
Travel time cost*			

Source: Estimated by Evaluation and Assurance, TfNSW. See notes below for details. Values are in June 2019 dollars (ABS Series ID A2325806K).
* TfNSW does not recommend quantifying a travel time cost or saving for active transport projects.

7.1 Health benefits

An increase in active transport reduces morbidity and mortality. The existing literature suggests that the value of health benefits from cycling ranges from $0.07 to $1.30 (**Table 46**). Health benefits are lower for more active people.

Table 46 Health benefit literature review

Reference	Cycling ($ / km)	Walking ($ / km)
AECOM (2010)	0.07	
Marsden Jacob Associates (2009)	0.44	0.44
WHO (HEAT tool) (2012)	0.96	2.31
New Zealand Transport Authority (2010)	1.22	2.43
PWC (2011)	1.31	1.96
Range	0.072 to 1.309	0.439 to 2.435

Source: Values have been indexed from June 2011 prices to June 2019 prices (ABS Series ID A2325806K).

7.2 Congestion cost savings

This benefit is applicable only when the cycling or walking trip replaces a car trip. It is assumed that both cycling and walking impose no congestion cost compared to motor vehicles.

7.3 Vehicle operating cost savings

This benefit is applicable only when cycling and walking replace car trips. It is a net saving calculated from VOC minus any operating cost for cycling. The operating cost of a bicycle is approximately $0.04/km. No operating cost is incurred from walking.

7.4 Accident cost

Cycling incurs greater accident costs compared to cars, as there are more cycling accidents than vehicle accidents per kilometre travelled. The accident costs per kilometre travelled for car, bus, cycling and walking are estimated in **Table 47**.

Table 47 Crash costs

Crash type	Car	Bus	Cycling	Walking
Average annual no. of crashes	20,683	384	629	1,216
Fatal	64	4	5	28
Injury	10,360	199	621	1,186
Property damage	10,259	181	2	2
Allocated crash cost ($m)	$1,353.67	$28.84	$57.13	$135.57
Million vehicle kilometres travelled (mkvt)	41,153	2,070	209	883
Average cost ($/vkt)	$0.03	$0.01	$0.27	$0.15

Source: Number of crashes based on RMS Road Safety crash statistics 2011-2015. Million vehicle kilometres travelled sourced from 2015/16 Household Travel Survey.

7.5 Environmental cost savings

The same values as **Table 35** are used if the individual walking or cycling is no longer using a passenger car.

7.6 Roadway provision cost savings

Cycling and walking causes less wear-and-tear on roads and requires less space than other vehicles. Footpaths and cycle paths cost less than roads. The roadway provision cost for cars is estimated by the annual roadway provision costs divided by total vehicle kilometres travelled totalling $0.07/km. The roadway provision cost for cycling (cycle lanes/paths) is approximately $0.03/km (NSW Road and Traffic Authority, 2003). This gives a cost saving of $0.04/km for cycling.

7.7 Parking cost savings

This benefit is applicable only when the cycling and walking trip replaces a car trip with a parking cost. Travelling by car may incur parking costs which includes the costs associated with parking facility infrastructure (land) and maintenance. Parking costs vary depending on the location. In the Sydney CBD, metered parking costs can range from $3.70 to $7.00 per hour. While cycling requires provision of bicycle racks for parking, the cost is small compared to parking a car. The recommended parking cost savings when cycling and/or walking trips replace car trips is $0.01/km (NSW Road and Traffic Authority, 2003).

7.8 Travel time costs

Cycling and walking is usually slower than a car or public transport which means that cycling and walking involve a net cost in travel time. However, the travel time is not a key factor for people choosing to walk or cycle. The decision to walk or cycle as a transport mode is often for leisure or to improve health. Therefore, **TfNSW recommends no travel time cost or saving for cycling and walking.**

8 Road damage cost

TfNSW recommends the road damage costs presented in **Table 48** be used in CBA to calculate the benefits of diverting or reducing road traffic as a result of a project or initiative.

Table 48 Unit cost of road maintenance by vehicle types

Vehicle type	Unit costs (cents/vkt)
Cars and motorcycles	4.39
Rigid truck	5.48
Light rigid (LCV)	4.39
Medium rigid	10.08
Heavy rigid	15.14
Articulated trucks	18.70
4 or less axles	14.91
5 axles	16.57
6 or more axles	19.32
Combination vehicles	24.85
Rigid 3 axle plus trailer	16.45
Rigid 4 axle plus trailer	25.61
B-double	25.23
Double road train	28.39
B-triple	35.63
Buses	8.25
2 axle light bus	4.39
Rigid bus	10.22
Articulated bus 3 axle	11.66
Special purpose vehicles	13.75
Sub-total: Light Vehicles	4.39
Sub-total: Heavy Vehicles	15.08
Total: All Vehicles	5.09

Source: Estimated by Evaluation and Assurance, TfNSW. Values are indexed from December 2011 prices to June 2019 prices (ABS Series ID A2325806K).
Note: 46% of total cost is for road repair & maintenance and 54% for road provision (construction).

8.1 Method

The unit cost of road damage was calculated using the process described below. This methodology is based on research by the National Transport Commission (NTC).

Step 1: Collect road expenditure data in NSW and group it into the following categories:

- road serving and operating
- road pavement and shoulder construction
- bridge maintenance and rehabilitation
- road rehabilitation
- road safety and traffic management
- asset extension and improvements
- other items including corporate services, enforcement of heavy vehicle regulations, vehicle registration, driver licensing and debt servicing.

Step 2: Estimate traffic related costs by excluding costs for:

- vehicle registration and driver licensing, which are not directly related to road traffic and its cost has been recovered from registration fees

- debt servicing, which is a funding mechanism and not directly related to road traffic
- local road access and community amenity, which is only partly related to road traffic; with a proportion of costs collected from developers' contributions.

Step 3: Total traffic related costs can be separated into the following groups:

- Vehicle kilometre travelled (vkt): This part of the cost is equally distributed to vkt regardless of vehicle size, mass or axle weight.
- Passenger Car Equivalent (PCU) kilometres: This cost is distributed based on PCU. Therefore, large sized vehicles bear more costs than cars.
- Equivalent Standard Axle (ESA) kilometres: This cost is distributed based on damages caused by vehicle axle weight. Heavier vehicles reduce the serviceability in a much shorter time than light vehicles. It is assumed that damages caused by vehicles are related to the 4th power of their axle weight. The 4th power law describes the relationship between a vehicle's axle weight and road damage.
- Average Gross Mass (AGM) kilometres: This cost is allocated based on gross mass of vehicles.
- Heavy vehicle kilometres travelled: This cost is related to enforcement of heavy vehicle regulations. The cost is distributed based on heavy vehicle vkt.
- Costs that cannot be allocated into any of the above groups are referred to as non-separable items, which are distributed based on vkt for all vehicles. Percentages of cost allocation are sourced from the latest NTC report (National Transport Commission, 2012).

Step 4: Allocate the cost across the following vehicle types:

- cars and motor cycles
- light commercial vehicles
- rigid trucks (2, 3 and 4 axles of different gross mass, with or without a trailer)
- articulated trucks (3, 4, 5 and 6 axles)
- B doubles
- road trains
- buses (2 and 3 axle rigid buses, 3 axle articulated buses)
- Special purpose vehicles (light and heavy).

Vehicle kilometres by vehicle types are sourced from ABS Survey of Motor Vehicle Use (SMVU) 2010. PCU and ESA by vehicle types are sourced from NTC. Average Gross Mass (AGM) is sourced from ARRB report (Vuong & Mathias, 2004).

Step 5: Estimate the unit costs by vehicle types, resulting in the values presented in **Table 48**.

9 Demand elasticity

TfNSW recommends the short-run demand elasticity values in **Table 49.** For long-run demand elasticity, twice the value of short-run elasticities should be used.

Table 49 Short-run elasticity

Attributes	Best estimate – demand response			Typical range
	Peak	Off peak	Overall	
Fares	-0.25	-0.50	-0.35	-0.2 to -0.6
Service level (frequency)	0.25	0.50	0.35	+0.2 to +0.5
In vehicle time	-0.30	-0.50	-0.40	-0.1 to -0.7

Source: NGTSM, Australian Transport Council, 2006.

9.1 Additional information

Elasticity is a measure of a variable's sensitivity to a change in another variable. In transport economics, it usually refers to the change in trips due to changes in the price of a fare or the total travel time. Direct elasticity measures the responsiveness of demand for a particular product to a change in its own price, whereas cross elasticity measures the responsiveness of demand to a change in the price of a substitute or complementary product.

Elasticities are often lower in the short run than in the long run. This is because some changes are not possible to make in a short amount of time. For example, if the train fare during off-peak times reduces, commuters may need time to change their work schedule to take advantage of the reduced price.

Table 50 summarises the direct and cross elasticities of public transport and car use. The ranges of the elasticity values are based on a literature review of transport elasticity particularly focusing on Sydney and Australia. The central values are based on a review undertaken by IPART which used the former rail weekly and bus travel ten (these have now been replaced by Opal) as the fare type.

Table 50 Cross elasticity of demand

Mode	Rail fare cost [5]		Bus fare cost[5]		Car operating cost (Petrol price)[5]		Public transport fare cost[4]		In vehicle time[4]
	Range	Value	Range	Value	Range	Value	Range	Value	Value
Rail	-0.043 to -1.103(2)	-0.250	0.004 to 0.500 (5,1)	0.004	0.009 to 0.190 (4,5)	0.009			
Bus	0.009 to 0.400 (5,1)	0.009	-0.040 to -0.822 (4,5)	-0.383	0.005 to 1.010 (4,5)	0.005			
Car	0.015 to 0.090 (5,1)	0.015	0.020 to 0.007(5,1)	0.007	-0.014 to -0.800 (5,1)	-0.014			-0.17
Public Transport					0.07 to 0.8 (3)		-0.100 to -0.600 (4)	-0.35	

Source: Compiled by Evaluation and Assurance, TfNSW based on:
(1) Transport Elasticities Database, BITRE, 2009
(2) CityRail Fare Elasticities, Booz & Co, 2008
(3) Exploring the impacts of fuel price increases on public transport use in Melbourne, Currie & Phung, 2006
(4) Survey of Public Transport Elasticities, Industry Commission, 1993
(5) Estimation of Public Transport Fare Elasticities in the Sydney Region, IPART, 1996, Table 16, p. 25.

Sydney Trains estimated the demand elasticity values for train travel (**Table 51**). Compared with other studies, the elasticity for in-vehicle time and generalised journey time is high.

Table 51 Demand elasticity estimated by Sydney Trains

Crash type	Peak	Off peak	Overall
Fare (price)	-0.35	-0.42	-0.38
Rail in-vehicle time	-0.63	-0.74	-0.67
Service interval	-0.28	-0.32	-0.30
Generalised journey time	-1.00	-1.16	-1.07

Source: (Douglas Economics, 2008)

10 Public transport project expansion factors

Transport demand modelling is usually undertaken in 1 hour, 2 hour or 3.5 hour peak periods. The estimated levels of demand are then converted into annual numbers by applying expansion and annualisation factors.

TfNSW recommends calculating project-specific expansion factors where data is available. The values presented in **Table 52** provide expansion factors appropriate for use in public transport projects when estimating specific benefit streams in a CBA in an urban area.

TfNSW requires that urban and rural road projects use project-specific expansion and annualisation factors rather than the factors presented in this section. The TfNSW Evaluation and Assurance team can be contacted for assistance.

Table 52 Expansion factor by benefit category - urban

Attributes	Input unit	Expansion AM peak			Annualisation	Type
		1hr to weekday	2hr to weekday	3.5hr to weekday		
Trains*						
Travel time savings	hours	6.84	4.61	3.40	277	Volume
Train crowding	hours			2.0	277	Cost
Station crowding	hours			2.0	277	Cost
Station quality	trips	6.84	4.61	3.40	277	Volume
Vehicle quality	trips	6.84	4.61	3.40	277	Volume
Travel time reliability	hours			2.0	277	Volume
Buses**						
Travel time savings	hours	7.10	4.34	3.19	300	Volume
Bus crowding	hours			2.0	300	Cost
Stop crowding	hours			2.0	300	Cost
Stop and station quality	trips	7.10	4.34	3.19	300	Volume
Vehicle quality	trips	7.10	4.34	3.19	300	Volume
Travel time reliability	hours			2.0	300	Volume
Road***						
Travel time savings	hours	12.45	6.29	4.04	336	Cost
Vehicle operating costs / cost savings	vkt	12.45	6.29	4.04	336	Cost
Crash costs / cost savings	vkt	12.45	6.29	4.04	336	Cost
Environmental impacts	vkt	12.45	6.29	4.04	336	Cost
Travel time reliability	hours	12.45	6.29	4.04	336	Cost

Source: Detailed methodology is provided in Orthongthed et al (2013). Estimated by Evaluation and Assurance, TfNSW, based on the following datasets:
*Trains: A compendium of CityRail travel statistics, 7th edition, June 2010.
**Buses: Sydney Buses boarding data by time of day and weekday of the year in 2010/11. Data were sourced from State Transit Authority (STA).
***Roads: Traffic volume data in 2011 provided by Roads and Maritime Services. These expansion factors are not suitable use in road projects, which require expansion factors to be calculated on a project-specific basis.
Notes: Crowding and reliability benefits are not generally quantified for off-peak time periods, hence the use of a 1.0 expansion factor for the 3.5 hour to weekday period. 1hr and 2hr expansion factors should be calculated on a project-specific basis.

Using **Table 52,** for a travel time savings benefit measured for the 2hr AM peak in Sydney, a factor of 4.61 should be used to expand this to average weekday volumes. A factor of 277 is applied to annualise this figure for a full year.

10.1 Additional information: expansion factors

Table 52 presents the relevant cost expansion factor or volume expansion factor to use. Cost expansion factors are not always the same as volume expansion factors. Cost expansion factors take into account the impacts of congestion, vehicle operating costs, and environmental externalities generated by road use.

The cost expansion factors are lower than the volume expansion factors as the proportion of daily traffic cost is higher than the proportion of traffic volume in the peak periods, for urban areas. In rural regions, the difference between cost and the volume expansion is smaller due to a more even distribution of traffic throughout the day.

10.1.1 Volume expansion factors

Table 53 Volume expansion factors

	Roads	
	Sydney (1)	Rural (2)
From peak 1 hour to weekday	14.31	12.10
	(AM Peak: 07:00 AM - 08:00 AM)	(15:00 PM - 16:00 PM)
From peak 2 hours to weekday	7.21	6.13
	(AM Peak: 07:00 AM - 09:00 AM)	(15:00 PM - 17:00 PM)
From peak 3.5 hours to weekday	4.46	3.61
	(AM Peak: 06:30 AM - 10:00 AM)	(14:30 PM - 18:00 PM)
From week day to year	345	347
	Public transport	
	Train (Sydney) (3)	Bus (Sydney) (4)
From peak 1 hour to weekday	6.84	7.10
	(AM Peak: 8:00 AM - 9:00 AM)	(AM Peak: 7:30 AM - 8:30 AM)
From peak 2 hours to weekday	4.61	4.34
	(AM Peak: 7:30 AM - 9:30 AM)	(AM Peak: 7:00 AM - 9:00 AM)
From peak 3.5 hours to weekday	3.40	3.19
	(AM Peak: 6:00 AM -– 9:30 AM)	(AM Peak: 7:00 AM - 10:30 AM)
From week day to year	277	300

Source: Estimated by Evaluation and Assurance, TfNSW, based on the following datasets:
(1) Sydney roads: Traffic volume data in 2011 provided by Roads and Maritime Services. Expansion factors are based on traffic data at 7 tolled freeway stations, 22 arterial stations and 31 local road stations. Stations are selected for fairly representing traffic conditions in Sydney Inner, Middle and Outer rings.
(2) Rural roads: Traffic volume data in 2011 provided by Roads and Maritime Services. Expansion factors are based on traffic data at 65 arterial stations and 26 local road stations in Hunter, Northern, South West, Southern and Western regions.
(3) Trains (Sydney): Estimated by Sydney Metro from March 2017 Opal data.
(4) Buses (Sydney): Sydney Buses boarding data by time of day and weekday of the year in 2010/11. Data were sourced from State Transit Authority (STA).

The volume expansion factors in **Table 54** have been converted from those in **Table 53** to provide the volume expansion factors in Average Annual Daily Traffic (AADT).

Table 54 Volume expansion factors by Average Annual Daily Traffic

	Roads	
	Sydney	Rural
From peak 1 hour to average weekday (AADT)	13.53	11.50
	(AM Peak: 07:00 AM - 08:00 AM)	(15:00 PM - 16:00 PM)
From peak 2 hours to average weekday (AADT)	6.81	5.83
	(AM Peak: 07:00 AM - 09:00 AM)	(15:00 PM - 17:00 PM)
From peak 3.5 hours to average weekday (AADT)	4.22	3.43
	(AM Peak: 06:30 AM - 10:00 AM)	(14:30 PM - 18:00 PM)
From average week day to year	365	365

Source: Estimated by Evaluation and Assurance, TfNSW.

10.1.2 Cost expansion factors

Cost expansion factors in **Table 55** have been estimated using RMS data from 2011/12. The traffic cost is composed of travel time cost, vehicle operating cost, accident cost and environmental cost. The value of travel time during business hours is greater compared to the peak period due to a higher proportion of business vehicles.

The traffic volume data provided did not differentiate between vehicle types. The cost expansion and volume expansion factors are assumed to be the same for public transport modes (rail, bus and ferry). However, additional crowding costs can be included for peak hours in CBA.

Table 55 Cost expansion factors: road traffic

	Roads (ADT)	
	Sydney (1)	Rural (2)
From peak 1 hour to weekday	12.45 AM Peak: 08:00 AM - 09:00 AM	10.81 16:00 PM - 17:00 PM
From peak 2 hours to weekday	6.29 AM Peak: 07:00 AM - 09:00 AM	5.51 15:00 PM - 17:00 PM
From peak 3.5 hours to weekday	4.04 AM Peak: 06:30 AM - 10:00 AM	3.32 14:30 PM - 18:00 PM
From week day to year	336	349
	Roads (AADT)	
	Sydney (1)	Rural (2)
From peak 1 hour to average day (AADT)	12.56 AM Peak: 08:00 AM - 09:00 AM	10.92 16:00 PM - 17:00 PM
From peak 2 hours to average day (AADT)	6.34 AM Peak: 07:00 AM - 09:00 AM	5.56 15:00 PM - 17:00 PM
From peak 3.5 hours to average day (AADT)	4.07 AM Peak: 06:30 AM - 10:00 AM	3.34 14:30 PM - 18:00 PM
From average day to year	336	350

Source: Detailed methodology is provided in Orthongthed et al (2013). Estimated by Evaluation and Assurance, TfNSW, based on the following datasets:
(1) Sydney: Traffic volume data in 2011 provided by Roads and Maritime Services for each hour and direction. Breakdown of traffic volume by vehicle type was not available. Expansion factors are based on traffic data at 5 tolled freeway stations, 4 arterial stations and 5 local road stations. Stations are selected for fairly representing traffic conditions in Sydney Inner, Middle and Outer rings.
(2) Rural: Traffic volume data in 2011 provided by Roads and Maritime Services for each hour and direction. Expansion factors are based on traffic data at 26 arterial stations and 10 local road stations in Hunter, Northern, South West, Southern and Western regions.

11 Public transport attributes

11.1 Public transport crowding

TfNSW recommended multipliers for train crowding are presented in **Table 56**. These parameters can be used to evaluate transport projects that change on-board crowding, e.g. projects that increase service frequency, introduce new services, or build new links. These multipliers convert time spent in a crowded situation into equivalent IVT minutes. For example, sitting on a crowded train is valued at 1.01 to 1.05 times an uncrowded on-board train time.

Table 56 Train crowding multipliers

Category	TfNSW multiplier	National Guidelines multiplier
Crowded seat	1.01 – 1.05	1.21
Standing	1.04 - 1.87	1.65
Crush standing	2.04 - 2.52	2.11

Source: TfNSW multipliers sourced from Douglas & Jones (2016). ATAP (2018).

Detailed crowding multipliers by mode are included in **Table 57** by percentage of seated capacity. Because of the difference in the amount of standing area per seat between public transport vehicles, crowding multipliers scale at different rates for each vehicle type.

Table 57 Detailed heavy rail, light rail, metro and bus crowding multipliers

Heavy Rail		Light Rail and metro		Bus	
% Seated capacity	Multiplier	% Seated capacity	Multiplier	% Seated capacity	Multiplier
80% - 90%	1.01	80% - 90%	1.01	80% - 90%	1.01
90% - 100%	1.02	90% - 100%	1.02	90% - 100%	1.05
100% - 110%	1.05	100% - 110%	1.04	100% - 110%	1.10
110% - 120%	1.09	110% - 120%	1.06	110% - 120%	1.16
120% - 130%	1.15	120% - 130%	1.09	120% - 130%	1.24
130% - 140%	1.21	130% - 140%	1.12	130% - 140%	1.32
140% - 150%	1.29	140% - 150%	1.15	140% - 150%	1.41
150% - 160%	1.38	150% - 160%	1.18	150% - 160%	1.52
160% - 170%	1.48	160% - 170%	1.21	Over 160%*	2.04 – 2.52
170% - 180%	1.60	170% - 180%	1.25		
180% - 190%	1.72	180% - 190%	1.29		
190% - 200%	1.86	190% - 200%	1.33		
Over 200%*	2.04 - 2.52	200% - 210%	1.37		
		210% - 220%	1.46		
		220% - 230%			
		230% - 240%	1.55		
		240% - 250%			
		250% - 260%	1.65		
		260% - 270%			
		270% - 280%	1.76		
		280% - 290%			
		290% - 300%	1.87		
		Over 300%*	2.04 - 2.52		

Source: Douglas & Jones (2016) * Crush capacity for each vehicle type

Crowding multipliers have not been estimated for the single-deck trains used by Sydney Metro. For single-deck trains, **TfNSW recommends** using light rail crowding multipliers.

Transport demand models used in NSW do not constrain public transport demand to the capacity of the service. This results in patronage above crush capacity in some cases. **TfNSW recommends** that one of the following approaches is used where modelled crowding exceeds the crush capacity threshold:

- Extrapolate the existing crowding function for levels of crowding above the crush capacity threshold
- Apply the maximum crowding factor to all travel occurring over the crush capacity threshold
- Estimate displacement of trips to other travel times or modes using an alternative model, such as the Enhanced Train Crowding Model (ETCM) or another appropriate methodology.

11.2 Station crowding

TfNSW recommends the multipliers for station crowding in **Table 58**.

Four levels of station crowding are used:

- low crowding (crowding level A: max density of 0.31 persons per square metre (psm))
- medium crowding (crowding level B: max density of 0.43 psm to level C: max density of 0.71 psm)
- high crowding (crowding level D: max density of 1.08 psm to level E: max density of 2.13 psm)
- very high crowding (crowding level F: max density of 3.6 psm).

The multipliers in **Table 58** convert waiting and walking in a crowded station into on-board train time. For example, one minute waiting time in a very highly crowded station is equivalent to 3.66 minutes on-board train time. These multipliers can be used to evaluate projects that impact station crowding (e.g. station upgrades, increasing service frequency or introducing new services).

Table 58 Station crowding multipliers

National Guidelines	Station crowding level					
	Low	Medium		High		Very High
Station crowding classification	A	B	C	D	E	F
Waiting	1.00	1.00	1.00	1.02	1.55	3.66
Walking	1.00	1.00	1.00	1.00	1.10	2.77

Source: ATAP (2018).

11.3 Value of bus stop and station quality attributes

TfNSW recommends the values for bus stop and station quality attributes in **Table 59**. Public transport projects often involve the construction or improvement of bus stop and rail station attributes such as seating, information, cleanliness and lighting. Valuation of these attributes is often conducted using In Vehicle Time (IVT) minutes which converts a person's willingness-to-pay for the improvement in the attribute to equivalent time spent travelling on-board the bus, train or light rail.

Table 59 presents the IVT minute values from a 2013 stated preference and quality rating survey on bus, light rail and rail services conducted by Douglas Economics, and the converted dollar value. The values represent a service quality improvement from a customer rating of 40 per cent to 80 per cent (using a scale where 0 per cent corresponds to "very poor" and 100 per cent to "very good"). The 2013 survey showed that the average stop/station rating was 65 per cent, 79 per cent, 62 per cent for bus, light rail and rail respectively with an overall rating of 67 per cent for all modes.

To apply these values in a CBA, the rating in the base case (denoted as A in the equation below) and the project case (denoted as B in the equation below) for a particular mode must first be estimated. The economic benefit can then be estimated as:

Equation 6 Value of stop / station quality

$$\textbf{\textit{Stop quality benefit}} = (\textbf{\textit{entries}} + \textbf{\textit{transfers}} + \textbf{\textit{exits}}) \times \textbf{\textit{uplift}} \times \frac{(\boldsymbol{B} - \boldsymbol{A})}{\mathbf{40\%}}$$

Where:

- **Entries** = stop / station entries
- **Exits** = stop / station exits
- Uplift = the attribute dollar value in **Table 59**
- **A** = the quality rating (out of 100%) in the base case
- **B** = the quality rating (out of 100%) in the project case.

The analysis can be done at an individual attribute level or overall rating level dependent on information availability.

Table 59 Value of bus stop / station quality attributes

Attribute	Sydney 2013 survey					
	IVT minutes			Dollar value of stop/station quality ($)		
	Bus	Light rail	Rail	Bus	Light rail	Rail
Weather protection	0.95	0.53	0.35	0.28	0.16	0.10
Seating	0.69	0.60	0.46	0.20	0.18	0.14
Information	0.86	0.72	0.37	0.25	0.21	0.11
Lighting	0.40	0.53	0.37	0.12	0.16	0.11
Cleanliness & graffiti	0.55	1.30	0.61	0.16	0.38	0.18
Ticket purchase	0.23	0.57	0.60	0.07	0.17	0.18
Platform Surface			0.57			0.17
Platform On/Off			0.40			0.12
Toilet Availability & Cleanliness			0.09			0.03
Staff			0.24			0.07
Retail Facilities			0.11			0.03
Car access facilities			0.08			0.02
Bus access facilities			0.07			0.02
Attribute sum	3.7	4.3	4.3	1.09	1.26	1.28
Overall rating	3.0	3.2	3.4	0.89	0.95	1.00

Source: Douglas Economics (2014) Passenger service quality values for bus, LRT and rail in inner Sydney, report to Bureau of Transport Statistics, TfNSW, August 2014.
Note: The values in the table represent the quality improvement from a rating score of 40% to 80%. The value of each attribute can be used if the individual attributes are known. Otherwise, the 'overall rating' value can be used for a 'package' of improvements or if the individual attribute is unknown.

11.4 Value of vehicle quality attributes

TfNSW recommends the values for vehicle quality attributes in **Table 60.**

Table 60 shows the value of vehicle quality attributes such as improvements to outside appearance, seat availability and heating and air-conditioning in terms of IVT minutes and dollar value. The average vehicle rating was 57 per cent, 71 per cent, 62 per cent for bus, light rail and rail respectively with an overall rating of 63 per cent for all modes in the 2013 survey. The economic benefit can be calculated using the method below:

Equation 7 Value of vehicle quality

$$\boldsymbol{Vehicle\ quality\ benefit = boardings\ \times uplift \times \frac{(B - A)}{40\%}}$$

Where:

- **Boardings** = vehicle entries
- Uplift = the attribute dollar value in **Table 60**
- **A** = the quality rating (out of 100%) in the base case
- **B** = the quality rating (out of 100%) in the project case.

Table 60 Value of vehicle quality attributes

Attribute	Sydney 2013 survey							
	IVT minutes				Dollar value of vehicle quality ($)			
	Bus	Light Rail	Rail	All	Bus	Light Rail	Rail	All
Outside appearance	0.18	0.50	0.70	0.47	$0.05	$0.15	$0.21	$0.14
Ease of on/off	0.20	0.41	0.17	0.27	$0.06	$0.12	$0.05	$0.08
Seat availability & comfort	0.33	0.31	0.52	0.37	$0.10	$0.09	$0.15	$0.11
Space for personal belongings	0.01	0.14	0.07	0.04	$0.00	$0.04	$0.02	$0.01
Smoothness & quietness of ride	0.35	0.43	0.24	0.38	$0.10	$0.13	$0.07	$0.11
Heating & air-conditioning	0.29	0.31	0.53	0.38	$0.09	$0.09	$0.16	$0.11
Lighting	0.14	0.27	0.24	0.21	$0.04	$0.08	$0.07	$0.06
Inside cleanliness & graffiti	0.44	0.19	0.34	0.37	$0.13	$0.06	$0.10	$0.11
On-board information & announcements	0.14	0.11	0.36	0.22	$0.04	$0.03	$0.11	$0.06
Ability to use computer & internet	0.03	0.00	0.10	0.01	$0.01	$0.00	$0.03	$0.003
Bus driver/on-board train staff	0.42	0.49	0.00	0.50	$0.12	$0.14	$0.00	$0.15
Environment: noise & emissions	0.28	0.42	0.29	0.37	$0.08	$0.12	$0.09	$0.11
Attribute sum	2.8	3.6	3.6	3.6	$0.83	$1.06	$1.05	$1.06
Overall rating	2.2	2.2	2.8	2.5	$0.65	$0.65	$0.83	$0.74

Source: Douglas Economics (2014) Passenger service quality values for bus, LRT and rail in inner Sydney, report to Bureau of Transport Statistics, TfNSW, August 2014. Prices have been indexed to May 2019 prices (ABS, AWE, SA, Full Time Adult Ordinary Earnings, NSW).
Note: The values represent the quality improvement from a rating score of 40% to 80%. The value of each attribute can be used if the individual attributes are known. Otherwise, the 'overall rating' value can be used for a 'package' of improvements or if the individual attribute is unknown. A trip time of 25 minutes is assumed.

11.5 Value of quality attributes when switching modes

Travellers that switch mode may benefit from access to a service which is perceived as being of higher quality than the one previously used.

Two types of preferences have been estimated: quality and intrinsic. Intrinsic preference is the residual preference after subtracting quality differences. **TfNSW recommends** the ‘intrinsic mode preference’ values in **Table 62** be used to estimate the additional benefit for travellers switching from bus to light rail and heavy rail. **TfNSW does not recommend** estimating a vehicle quality benefit for users switching from car to public transport.

Table 61 Modal preference per trip

Attribute	Estimated modal preference per 25 minute trip					
	IVT minutes			Dollar value of stop/station quality ($)		
	Bus to light rail	Bus to Rail	Rail to light rail	Bus to light rail	Bus to Rail	Rail to light rail
Quality modal preference	2.10	0.10	2.00	0.60	0.03	0.58
Intrinsic modal preference	2.80	2.50	0.30	0.81	0.72	0.09
Gross modal preference	4.90	2.60	2.30	1.41	0.75	0.66

Source: Developing a Suite of Demand Parameters for Inner Sydney Public Transport, Douglas & Jones, November 2016, ATRF. Table 11 (p.17).

Table 62 Modal preference per hour of travel

Attribute	Estimated modal preference per hour of travel					
	IVT minutes			Dollar value of stop/station quality ($)		
	Bus to light rail	Bus to Rail	Rail to light rail	Bus to light rail	Bus to Rail	Rail to light rail
Quality modal preference	5.04	0.24	4.80	1.45	0.07	1.38
Intrinsic modal preference	6.72	6.00	0.72	1.93	1.73	0.21
Gross modal preference	11.76	6.24	5.52	3.39	1.80	1.59

Source: Developing a Suite of Demand Parameters for Inner Sydney Public Transport, Douglas & Jones, November 2016, ATRF.

11.6 Travel time reliability

When travel times are unreliable, travellers will include buffer times to their journey. **TfNSW recommends additional buffer time built into a journey (because of travel time variability) be treated *equally as costly* as the time spent traveling.**

Travel time reliability is defined as the consistency and dependability of travel times for a given trip. It can also be thought of as the variability in journey times. Statistical range measures provide information on the range of travel time variability that transport users experience. One of these is the use of the standard deviation statistic.

Travel time reliability can be assessed using the buffer time, which is an additional time allowance a traveller includes due to trip variability. For example, a travel route has an average travel time of 60 minutes and standard deviation of 10 minutes. Assuming a normal distribution, if a trip-maker needs 95 per cent confidence to arrive at the destination on time, the departure time would need to be 20 minutes earlier (two standard deviations). However, the actual travel time is mostly likely to be 60 minutes in that the trip-maker will arrive 20 minutes earlier, which attracts additional waiting time cost.

The valuation of travel time reliability attempts to value the buffer time that the travellers have budgeted before departure. It is worth noting that in this framework, the values of travel time reliability do not include other logistic costs such as worker's cost at warehouses waiting for loading or unloading freight vehicles.

Travel time reliability depends on many factors including road capacity, traffic accidents, road work, weather, traffic controls, special events and traffic fluctuations. This means that the travel time reliability, as measured by standard deviation, is constantly changing.

Table 63 summarises various studies of the value of travel time variability. Empirical evidences indicate that the valuation of travel time reliability varies. The relativity of the value of travel time variability to the value of in-vehicle travel time ranges from 0.10 to 3.23. **TfNSW recommends that the reliability ratio is equal to 1.** That is, the value of travel time reliability should be set at the same value as in-vehicle travel time.

Table 63 Value of travel time reliability

Study	Mode	Country	Reliability factor
Hollander (2006)	Bus	UK	0.10
Bhat and Sardesai (2006)	Multi-modes	US	0.27
Brownstone and Small (2005)	Car	US	0.40
Hensher (2001)	Car	NZ	0.57
Lam and Small (2011)	Car	US	0.66
Small et all (2005)	Car	US	0.91
Batley and Ibnez (2009)	Rail	UK	2.06
Small et al. (1999)	Car	US	3.23
Reliability ratio recommended by TfNSW	**Multi-modes**		**1.00**

Source: TfNSW Evaluation & Assurance (2019).

12 Asset life and residual value

12.1 Asset life

TfNSW recommends the economic life of assets presented in **Table 64**. **TfNSW recommends** that residual value is calculated using the straight line depreciation method.

Often information is available on the useful life of assets in TfNSW financial statements. However, these values will relate to each entity's accounting treatment for depreciation purposes, and may or may not be suitable for use in a CBA.

Table 64 Economic life of assets

Asset class	Economic life (years)
Network infrastructure	
Rail extensions, busways	70
Earthworks	50-150
Bridges - concrete	120
Bridges - timber	40
tunnels	100
Culverts	100-120
Rail track	50-100
Turnouts	15-50
Ballast	60
Sleepers – concrete	50
Sleepers - timber	20
Road pavements – concrete	60-80
Road pavement – asphalt	30-40
Bus priority schemes	20
Nodal infrastructures	
Stations – rail/light rail	50
Bus stops	20
Ferry wharves	40
Interchanges, commuter parking facilities	50
System infrastructure	
Deports, buildings (miscellaneous)	40-50
Plant and equipment (miscellaneous)	12
Control centres (IT systems, excl. buildings)	5
Rail signals and communications	20
Fleet and rolling stock	
Bus	15
Rolling stock	35

Source: ATAP (2018), TfNSW.

Some assets have an economic life that is shorter than the appraisal period. Where this is the case, the costs of the replacement of that asset should be included in the CBA in the final year of the asset's economic life.

12.2 Residual value

Residual value refers to the components of the project that have significant life remaining at the end of the appraisal period. **TfNSW recommends** that residual value is calculated using the straight line depreciation method:

Equation 8 Straight line depreciation

$$\textbf{Residual value} = K \times \frac{(\textbf{Asset life} - \textbf{Appraisal period})}{\textbf{Asset life}}$$

Where:

- **K** = the capital cost
- **Asset life** = useful life / economic life of the asset
- **Appraisal period** = the appraisal period used for the CBA.

The residual value is treated as accruing in the final year of the appraisal for the purposes of discounting.

The full capital cost should be included when calculating the residual value, including labour, materials, plant, equipment, and other fees or management costs. Only including physical components (such as infrastructure or raw materials) will understate the residual value of the asset.

13 People with a disability

Lifts improve train station accessibility for people with a disability. Parameter values for the installation of a lift are:

- $0.71 for passengers without a disability
- $3.29 for passengers that have mobility challenges. Passengers that have mobility challenges may include elderly people, those with heavy luggage, bicycles and strollers
- $4.30 for passengers using a wheelchair.

Table 65 Benefits of rail station lift to passengers

	People without a disability ($ / train trip)	Mobility challenged (mild disabilities) ($ / train trip)	People using a wheelchair ($ / train trip)
Sydney Station Survey 1997	$0.71	$2.76	
UK survey 2009	$0.07	$0.88	$1.60
UK survey 2007	$0.59	$3.63	
Sydney Observation Survey		$3.82	$4.30
Recommended value (based on SP survey of Sydney Trains)	**$0.71**	**$3.29**	**$4.30**

Sources:
(1) Sydney surveys from Douglas (2011) Estimating the user benefit of rail station lift, ATRF 2011.
(2) UK survey 2009 from Duckenfield et al (2010) Measuring the benefits of the access for all programme, European Transport Conference 2010.
(3) UK survey 2007 from Maynard, A, (2007) Monetising the benefits of disabled access in transport appraisal, 2007 Conference Transport Canada.
December 2011 prices indexed to March 2019 prices (ABS Series ID A2325806K).

14 Option value

Option value refers to an individual's willingness-to-pay (WTP) to have the option of another mode of transport, even if they may not use it. For example, a car driver benefits from having the option of a bus service available in case the car unexpectedly breaks down.

There is limited research into the monetary values of options in NSW. Therefore, **TfNSW recommends** that option values are only included as a benefit as part of sensitivity testing. **Table 66** provides indicative monetary values for option values based on a UK study.

The following factors need to be considered when estimating option value:

- The catchment area: this should consider the number of households that are likely to be affected by the project. A catchment area of 2km is appropriate for minor stations while a catchment of 5km is suggested for main stations.
- Alternative transport solutions in the area: if a train service is added to an area where public transport does not exist in the Base Case, the full option value is used. If there is already an existing bus service, the option value is lower and is the difference between the train and bus option values.

Table 66 Option value ($ / household per annum)

New Service Type	Option value only ($ / household per annum)	Option value and Non-use value*($ / household per annum)	Value of mixed mode package($ / household per annum)
Introduce train service where no public transport exists	$298	$497	
Introduce bus service where no public transport exists	$163	$272	
Introduce both bus and train service where no public transport exists	$298	$497	$769
Introduce train service where bus exists	$135	$226	

Source: UK DfT 2012, Transport Analysis Guidelines. Values converted to AUD from GBP (average 2010 exchange rate) then indexed from December 2010 to June 2019 prices (ABS Series ID A2325806K).
Notes: *Non-use value refers to the value placed on the existence of a service regardless of any possibility of future use of the individual.

15 Cost estimation

A robust CBA needs comprehensive and accurate cost estimates that are able to be easily and clearly traced, replicated and updated. These expenses are generally estimated by a quantity surveyor, construction economist, or cost manager.

The standard for cost estimation can be found in the Cost Estimation Guidance by the Australian Government of Department of Infrastructure, Transport, Cities and Regional Development (DITCRD). For large projects, especially those seeking federal funding, DITCRD's cost estimation guidance should be followed and requires highly accurate estimates, including probabilistic cost estimation and itemised costing from first principles.

15.1 Difference between costings in a financial appraisal and a cost-benefit analysis

The cost estimates used in a CBA differ from the cost estimates used in a financial appraisal. CBA uses real costs, discounted to present values using the social discount rate. Financial appraisals tend to report costs in nominal dollars and may use a different discount rate to the CBA.

Resource costs are used in a CBA and do not include taxes and subsidies. Taxes and subsidies are transfer payments due to government policy decision and do not impact the underlying level of benefits and costs of an initiative to the NSW community. Rather, they impact how these benefits and costs are shared by the NSW community.

Cost escalation is also treated differently in a CBA. Prices in a CBA are generally in real terms, that is, no escalation takes place. Escalation should not be included unless the prices of specific inputs or outputs are expected to move at a rate significantly different from the general inflation rate. That is, if prices of project components move at a different rate.

15.1.1 Level of accuracy

The NSW Government recommends the use of probabilistic modelling approaches to be informed by actual experience of project managers, service delivery officers, legal or other experts who are able to identify and place a value on salient risks.

In practice, the accuracy of project estimates should increase during the decision making process in keeping with available information about the project options. At the planning stage, estimates are likely to be less accurate than final out-turn costs. While early estimates may not be as accurate as final cost, planning estimates are generally accurate in relative terms, so they provide a reasonable basis for the ranking and initial screening of options.

The cost of gaining greater accuracy should also be considered. For early stage investigations and unfunded transport projects the amounts spent on accurate cost estimations should be enough to support an informed choice and not necessarily be definitive.

For projects not seeking federal funding, **where possible TfNSW recommends that expected value should be used for the CBA as a preference over the P50 value but cost estimates at P50 value can be used in the CBA.** The project risk profile, life cycle phase, delivery strategy and the expertise available to the project team also need to be considered in deciding on the accuracy of cost estimates.

Cost estimates in a CBA should be clear in stating the level of coverage, completeness and accuracy involved, with particular care exercised in the public release of cost estimates that are preliminary or likely to be revised.

15.2 Indicative operation and maintenance costs

Operation and maintenance costs are expenses associated with the maintenance and administration of the project or initiative on a day-to-day basis, after it is built. The figures from **Table 67 to Table 76** *should only be used strategically.* For example, they can be used to calculate the cost of network wide changes, where indicative costs are needed. For the majority of projects, **Section 15** does not provide adequate consideration of project-specific factors to be used in cost estimation.

15.2.1 Heavy rail

Operating and maintenance cost parameter values for suburban and intercity trains are presented in **Table 67**. Although average costs are presented, it is noted that rolling stock maintenance, presentation and cleaning costs are higher for suburban trains compared to intercity trains; while power, traction and crew costs are lower for suburban trains.

Marginal costs are often more relevant in an economic evaluation because comparisons are between the base case and the project case. Marginal cost can be estimated by removing fixed costs. For example, rolling stock presentation and cleaning are often fixed costs because they incur independently of the number of kilometres travelled. High level benchmark station maintenance and operating costs are included in **Table 68**.

Table 67 Train operating and maintenance costs

Cost description	$ per car km	
	Average cost	Marginal cost
Power/traction	$0.26	$0.26
Rollingstock routine maintenance	$0.35	$0.35
Rollingstock presentation / cleaning*	$0.17	
Rollingstock major periodic maintenance*	$0.98	
Infrastructure routine maintenance	$0.98	$0.98
Infrastructure major periodic maintenance*	$1.55	
Crew	$1.38	$1.38
Total recurrent costs	$5.68	$2.97

Source: Railcorp Operating and Maintenance cost analysis, June 2015.
*These items are not marginal costs.
Crew costs are indexed from June 2015 to June 2015 wages (ABS Series ID A2599999R). All other costs are indexed from June 2015 prices to June 2019 prices (ABS Series ID A2325806K).
Note: Values are indicative, they should only be used strategically.

Table 68 Station operating and maintenance costs

Cost description	$m / year	
	Surface station	Underground station
Station operating and maintenance (range)	$0.64 ($0.63 - $0.80)	$1.07 ($1.07 - $1.61)

Source: Railcorp Operating and Maintenance cost analysis, June 2015. Values indexed to June 2019 prices (ABS Series ID A2325806K).
Note: Values are indicative, they should only be used strategically.

15.2.2 Rail freight

Table 69 presents indicative values. The values are suitable for CBA as they exclude tax.

Freight rail operating costs can vary widely depending on a range of factors. Some of the factors that may affect below rail operating costs include tonnage carried, axle loads, line speed, age and type of infrastructure and rolling stock characteristics. The factors that may affect above rail costs include type of rolling stock, condition of asset, level of usage, gradient, curvature, speed limits, axle load, payload and number of wagons.

Given the wide variability in freight rail operations the costs are provided in a range (i.e. low, medium and high). The below rail fixed maintenance costs are provided as annualised average costs for the coal network and the interstate freight network.

Users should exercise judgment when choosing the most appropriate value noting the following on the items provided in **Table 69**:

- **Items 1a and 1b:** These are the fixed costs of track maintenance for the coal and inter-state network. They cover the costs of track maintenance over three distinct phases:
    - immediately after construction – inspection and routine maintenance
    - after 5 years – inspection and routine maintenance, regular rail regrinding and resurfacing
    - after 10 years – Major Periodic Maintenance.
- **Item 3:** Rail track variable maintenance costs vary with the volume of the load carried. These costs include grinding, ballast cleaning etc.
- **Item 4:** Major Periodic Maintenance (MPM) covers re-sleepering and laying ballast. They are typically incurred every 10 years. However, heavy usage may result in more frequent MPM.
- **Item 5:** This is the cost of new rolling stock including locomotives and wagons purchased. The economic life of rolling stock is assumed to be 35 years.
- **Item 6:** Refit costs are the cost of refitting locomotives and wagons depending on usage. Assume these occur every 10 years for locomotives and 15 years for wagons. It should be noted that locomotive and wagon refit costs can vary significantly between 15 per cent and 50 per cent of the cost of a new unit.
- **Items 7 and 8:** If no refurbishment or half-life fit out costs are available, use costs in Items 7 and 8. Alternatively, Items 7b and 8b are per km values which may be used if detailed maintenance costs are not available. **To avoid double counting, if items 7 and 8 are used, item 6 should be excluded.**
- **Item 9:** To estimate fuel costs multiply the fuel consumption rate in Item 9 with the resource price of fuel (market wholesale price for diesel fuel less 10 per cent GST and excise taxes). This will provide the fuel cost per locomotive km. Fuel cost will vary significantly with load, terrain and distance travelled.
- **Item 10:** This provides the hourly cost of a two person crew which can be used to estimate crew costs for each trip or over one year making assumptions about working hours and working conditions.

Table 69 Freight operating and maintenance costs – above and below rail

	Cost component	Low	Medium	High
Below Rail Costs	Item 1a – rail track fixed maintenance cost by volume ($ / track km) – Coal network			
	1 – 10 million ton per annum (mtpa)	$11,329.42	$16,994.13	$28,323.56
	10 – 30 mtpa	$16,994.13	$28,323.56	$45,317.69
	30 mtpa and above	$22,658.85	$28,323.56	$56,647.12
	Item 1b – rail track fixed maintenance cost by volume ($ / track km) – Inter-state network			
	Inter-state network	$21,525.90	$26,057.67	$36,254.15
	Item 2 – network control and corporate overheads ($ / track km)*	$6.80	$10.20	$13.60
	Item 3 – rail track variable maintenance costs ($ / '000 gtk)	$1.22	$2.27	$3.40
	Item 4 – major periodic maintenance ($ / track km) – assume every 5 or 10 years based on usage	$11,329.42	$28,323.56	$56,647.12
Above Rail Costs	Rolling stock – upfront capex			
	Item 5a – locomotive ($m per DC 3000 hp locomotive)	$4.31	$4.42	$4.53
	Item 5b – locomotive ($m per AC 4500 hp locomotive)	$5.44	$5.55	$5.66
	Item 5c – wagon ($ per wagon)	$90,635.39	$135,953.08	$181,270.77
	Re-fit costs			
	Item 6a – DC 3000 hp locomotive ($m)	$1.36	$1.47	$1.59
	Item 6b – AC locomotive ($m)	$1.70	$1.81	$1.93
	Item 6c – wagon re-fit cost ($ per wagon)	$9,063.54	$33,988.27	$90,635.39
	Rolling stock – Maintenance costs (annualised average costs)			
	Item 7a – locomotive maintenance ($ per loco per year), assuming 250,000km per year operations, and including scheduled, unscheduled, wheels, component change out (CCO) and maintenance facility charge	$396,529.81	$453,176.93	$509,824.05
	Item 7b – locomotive maintenance ($ per locomotive km)		$1.98	
	Item 8a – wagon maintenance ($ per wagon per year), assuming 250,000km per year operations, and including scheduled, unscheduled, wheels, component change out (CCO) and maintenance facility charge	$14,161.78	$16,994.13	$21,242.67
	Item 8b – wagon maintenance ($ per km per wagon)	$0.06	$0.07	$0.08
	Fuel and crew costs			
	Item 9 – fuel consumption (L / locomotive km)	3 (flat or empty train)	5 (loaded train or Mixed terrain)	8 (hilly or bulk coal or steel)
	Item 10 – crewing cost (standard 2 person crew per hour)	$291.59	$338.25	$384.90

Source: Infrastructure Advisory Services (2013). Values have been indexed to June 2019 prices (ABS Series ID A2325806K). Values for Crewing cost have been indexed from December 2012 to June 2019 wages (ABS Series ID A2599999R).
Note: Values are indicative, they should only be used strategically.

15.2.3 Light rail

Table 70 presents the operating and maintenance cost parameters for light rail, with cost breakdown by track, station and train.

Table 70 Operating and maintenance costs – light rail

Cost item	Cost	Unit
Light rail vehicle	3.5 to 5.1	$m / per light rail vehicle
Track maintenance cost		
Fixed: track and right of way	12,379	$ / track km
Fixed: electric overhead	11,605	$ / track km
Variable: track and right of way	0.62	$ / train km
Variable: signals & communications	12.44	$ / train km
Variable: electric overhead	0.15	$ / train km
Station		
Station staff	24.76	$ / train hour
Station maintenance	15,474	$ / station per year
Train		
Driver	46.43	$ / train hour
Maintenance	1.39	$ / train hour
Customer services and ticketing	23.83	$ / train hour
Cleaning	13,927	$ / train-year
Materials and overheads	60,489	$ / train-year

Source: North West Transport Link Economic Appraisal by Douglas Economics (Jan 2006). Values have been indexed from December 2005 to June 2019 (ABS Series ID A84994877K).
Notes: Values are indicative, they should only be used strategically.

15.2.4 Transitway and Metrobus

Table 71 presents the operating and maintenance parameters for Metrobus and Transitway buses.

Table 71 Operating costs – buses

Cost item	Unit cost	Unit type
Total non-labour costs	$1.69	$ / bus km
Labour cost	$54.40	$ / bus hour

Source: TfNSW analysis. Values have been indexed from March 2015 prices to June 2019 prices (ABS Series ID A2325806K).
Notes: **(1)** Cost per revenue and dedicated school bus kilometre is an average of Sydney Transit Authority (STA) figures for a standard bus. Cost cover all running costs of a service variation excluding labour for a weekday between hours of 0559 and 2359. Dead running costs has been loaded to revenue and school bus kilometres by a factor of 1.259. **(2)** Values are indicative, they should only be used strategically.

15.2.5 Bus depots

Table 72 presents a list of operating and capital costs in a bus depot proposal.

Table 72 Operating and capital costs – bus depots

Cost item	Unit cost	Unit
Depot operating costs		
Employee related	34,710	$ / bus lot
Other operating costs	1,815	$ / bus lot
Maintenance costs	1,689	$ / bus lot
Administration	2,447	$ / bus lot
Rent		
Imputed rent	5,366 – 21.463	$ / bus lot
Bus		
Road repair and maintenance	0.04	$ / bus km
Crash cost	0.01	$ / bus km
Road congestion	0.83	$ / bus km
Air pollution	0.38	$ / bus km
GHG emissions	0.16	$ / bus km
Noise	0.03	$ / bus km
Water pollution	0.06	$ / bus km
Nature and landscape	0.00	$ / bus km
Urban separation	0.03	$ / bus km
Upstream and downstream	0.23	$ / bus km
Bus cost by type		
Category 1	65,604	$ / bus
Category 2	120,274	$ / bus
Category 3	371,755	$ / bus
Category 4	404,557	$ / bus
Articulated bus	754,443 to 820,047	$ / bus
Double deck bus	754,443	$ / bus

Source: Estimated by Evaluation and Assurance, TfNSW.
Notes: **(1)** Imputed rent depends largely on land value and location. **(2)** Refer to Table 24 for Road congestion and Table 35 for environmental costs (e.g. air pollution, GHG emissions). **(3)** Road repair and maintenance costs account for 46% of total repair, maintenance and provision cost – refer to Table 68. **(4)** Bus categories 1,2,3 and 4 correspond to 13 to 18 passengers, 19 to 24 passengers, 25 to 41 passengers and 42 + passengers respectively.
* Values have been indexed from June 2016 prices to June 2019 prices (ABS Series ID A2325806K).
** Values have been indexed from June 2014 prices to June 2019 prices (ABS Series ID A2325806K).
Note: Values are indicative, they should only be used strategically.

15.2.6 Ferry services

Table 73 presents the costs of ferry services, vessels and wharves. The ferry fleet includes different vessel types that have different capacities and operating costs.

Table 73 Operating and capital costs – ferry services

Cost item	Cost	Unit type
Vessel costs		
River Cat ferry	$5,401,000	per vessel
Manly class	$27,004,000	per vessel
Wharf costs		
Ferry wharf (commuter upgrade)	$6,481,000	per wharf
Ferry wharf (recreational) upgrade	$1,620,000	per wharf
New ferry wharf	$7,561,000	per wharf
Boat ramp upgrade	$432,000	per ramp
Operating costs		
Harbour rate (Parramatta and Inner harbour)	$906	per service hour
Freshwater rate	$1,189	per service hour

Source: Estimated by Evaluation and Assurance, TfNSW based on costings supplied to NSW Treasury in 2015. Values have been indexed from March 2015 prices to June 2019 prices (ABS Series ID A2325806K).
Note: Values are indicative, they should only be used strategically.

15.2.7 Local infrastructure costs

Table 74 represents the median cost of delivering the infrastructure item and should be used as a guide.

Table 74 Infrastructure benchmark costs

Infrastructure type	Detail description	Benchmark base cost ($ / unit)	Unit
New sub-arterial road	New 3 lane flexible pavement road	9,908	m
	New 4 lane flexible pavement road	11,506	m
Sub-arterial road widening	Flexible pavement	7,020	m
	Rigid pavement	7,219	m
New rural road	New 2 lane, flexible pavement road	2,610	m
Rural road widening	Widening flexible pavement by 1 lane	3,972	m
Guide posts/safety barriers/pedestrian fencing	Metal guide posts	62 - 115	each
	Guardrail safety barriers	230 – 379	m
	Steel pedestrian fencing	821 - 1436	m
Traffic calming on 2 lane road	Flat top road hump	34,719	each
	Concrete road hump	9,268	each
New concrete footpath adjacent to traffic lane	1.2m wide footpath	254	m
	2.2m wide footpath	613	m
	2.5m wide footpath	752	m
Removal of old footpath and replace with new	1.2m wide footpath	287	m
	2.2m wide footpath	640	m
	2.5m wide footpath	776	m
Unsignalised intersection	“T” intersection	19,906	each
	4 way intersection	33,405	each
Signalised intersection	“T” intersection	246,054	each
	4 way intersection	293,044	each
Roundabout	4 leg roundabout with 2 approach lanes-greenfield	38,576	each
	4 leg roundabout with 2 approach lanes-brownfield (existing traffic)	112,493	each
	4 leg roundabout and pavement with 2 approach lanes-greenfield	371,433	each
Pedestrian crossing	Spanning 2 lanes including pedestrian refuge	6,172	each
Bus stop	Including enclosure, seating and signage	19,690	each
Street Lighting	Including post with 4.5m outreach- 10.5m high	11,311	each
	Including post with 4.5m outreach- 12m high	17,275	each
On road cycleway	2.2m wide lane without kerb separation	263	m
	2.2m wide lane with kerb separation	334	m
Pedestrian underpass	Under rail line	171,860	m
Road pavement resurfacing	Milling and filling of road pavement	109	m2
Cycleway facilities	Stainless steel bicycle racks	1,260	each
Pedestrian/cycle overpass with anti-throw screens and covered walkway	Pedestrian Bridge	34,082	m
	Cycle overbridge	35,942	m
Single lane, on road cycleway, surface treatment and signage	Without kerb separation	263	m
	With kerb separation	334	m
Carpark	At grade carpark	7,082	space
	Multi-storey	38,266	space

Source: IPART Report on Local Infrastructure Benchmark Costs, Final Report, April 2014. Values indexed from June 2013 prices to June 2019 prices (ABS Series ID A2325806K). **Note:** Values are indicative, they should only be used strategically.

Table 75 Infrastructure reference costs

Infrastructure type	Detail description	Benchmark base cost ($ / unit)	Unit
Road bridge over railway, waterway or grade separation	Single span bridge 9.4m wide X 19m (lower bound)	1,084,296	each
	Single span bridge 25m wide X 34m (upper bound) with ramps	7,274,439	each
Intersection state / local road	Intersection with perpendicular junction, widening for turning, profiling & removal of 1.2m width asphalt carriageway for local road tie-in, traffic mitigation measures, 100mm asphalt paving, rework at pavement interface, signage.	67,466	each
	Above plus acceleration-deceleration lane off and on, stormwater pipe	354,797	each
Additional cost for road maintenance attributed to mining activity	Lower bound (10% acceleration)	12,479	km
	Upper Bound (30% acceleration)	48,134	km

Source: IPART Report on Local Infrastructure Benchmark Costs, Final Report, April 2014. Values indexed from June 2013 prices to June 2019 prices (ABS Series ID A2325806K).
Note: Values are indicative, they should only be used strategically.

15.2.8 Average fare by mode

Table 76 provides the average fares for train, bus, ferry and light rail; estimated from Opal data.

Table 76 Fare by public transport mode ($/trip)

Card type	Train	Bus	Ferry	Light rail
Adult	$3.98	$2.12	$3.98	$1.52
Child / Youth	$1.93	$1.08	$1.93	$0.90
Concession	$2.07	$1.05	$2.07	$0.74
Senior	$0.75	$0.73	$0.75	$0.42
Weighted Average	$2.49	$1.71	$3.31	$1.27

Source: Data provided by TfNSW Customer Services. Based on Opal trip data only from September quarter 2016 to June quarter 2017. Increased for 2017 and 2018 Opal price increases.
Notes: GST on ticket price is excluded. Values are indicative, they should only be used strategically.

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Appendix A Value of travel time – additional information

TfNSW recommends the values of travel time (VTT) times in Section 2. The following is additional information on VTT.

A.1 Value of travel time approach

The TfNSW recommended VTT is in line with the ATAP values and based on the Austroads method. The Austroads method of calculating the VTT follows the willingness-to-pay (WTP) approach and is linked to a person's productivity and earnings. Austroads recommended the following valuation principles:

- Private travel time is valued at 40 per cent of the seasonally adjusted full time Average Weekly Earnings (AWE) for Australia, assuming a 38-hour working week. This rate is applicable for travel modes of private car, motorcycle, bicycle, walking and public transport for commuting and recreational trip purposes.
- Business travel time is valued at 128 per cent of the seasonally adjusted full time AWE for Australia, applicable for all business trips. This is because businesses pay tax as well as wages. It is assumed that time spent travelling for business purposes is unproductive and therefore foregone working time (Austroads, 2012).

Below are some reasons for the lower VTT for private travel compared to business travel:

- The traveller's WTP is based on after-tax income.
- A worker's after-tax income is shared by household members. The WTP is then related to household disposable income and the number of persons in the household.
- For most people, the marginal disutility of travel is lower than that of work. In Sydney, the average work trip duration is 35 minutes (one way), and the daily travel time per capita is 79 minutes (Bureau of Transport Statistics, TfNSW, 2013). Most people seem to enjoy a certain amount of personal travel, about 30 minutes per day, and dislike travelling more than 90 minutes per day (Mokhtarian & Salomon, 2001). The benefit of small reductions in travel time, say from 34 minutes to 30 minutes, would be marginal or negligible for many people.

In general, however, the VTT reflects the willingness of travellers to trade time for money. Willingness to pay depends on additional factors including the value and urgency attached to the journey purpose and comfort of the trip. Therefore, VTT values are arguably better determined from revealed preference and stated preference data.

A.2 Value of travel time – used in transport demand modelling

TfNSW undertook the Value of Travel Time Study in 2015-2016 (**Table 77**). This study used stated preference surveys to estimate the VTT for several modes of travel.

The values in **Table 77** are behavioural values and could be used in transport demand models (not economic evaluations). Transport demand models use different values of time for different segments of the NSW community in order to estimate their travel behaviour. For example, transport demand models differentiate travellers by behavioural characteristics, such as income (with higher income earners assumed to have a higher value of time), trip purpose, and time of day.

Table 77 Value of travel time by mode – TfNSW 2015-16 survey

Mode	Mode share %	Personal income ($000 p.a.)	Value of travel time ($/hr)	
			Non income standardised	Income standardised
Car	85.40	68	16.87	16.58
Train	6.70	48	14.70	16.50
Bus	7.40	41	8.42	10.94
Ferry	0.40	75	16.35	15.16
Light Rail	0.10	69	22.52	22.04
Public transport	14.60	46	11.60	13.67
All	100.00	64	16.10	16.16

Source: 2015/16 TfNSW Value of Travel Time Study. Values indexed to May 2019 AWE (ABS Series ID A84994877K).

When valuing the benefit of travel time savings in a CBA, the purpose is to inform decisions on resource allocation. This differs from the transport modeller's objective of predicting behaviour. For this reason, the VTT savings is assumed to be consistent across modes and segments of the community. If a higher VTT was used for road travel compared to public transport, resource allocation would preference road projects, all else being equal. Similarly, if a higher VTT was used for higher income earners, transport initiatives in high socioeconomic areas would be preferred over lower socioeconomic areas, all else being equal.

The key finding of the 2015-2016 study is that the estimated VTT weighted by mode share is very close to $17.72 per person hour (the TfNSW recommended VTT for private travel). The TfNSW recommended VTT is an equity (or resource) value for use in CBA of road and public transport initiatives.

A.3 Value of travel time – Sydney Trains method

In 2010, Sydney Trains (formerly RailCorp) engaged Douglas Economics to update the value of rail travel time used in economic evaluations. This study was updated in 2013. The values were estimated by stated preference market research that asked passengers to choose between two hypothetical rail journeys varying in travel time, fare and departure time. The overall value of on-board train time was estimated at $16.72 ($15.38 in November 2018 values) per hour with a peak value of $14.95 ($15.36) and an off-peak value of $14.03 ($15.41), as shown in **Table 78. Table 79** compares the VTT from the Sydney Trains survey and that recommended by ATAP.

Table 78 Value of on-board train time ($/hr)

Time period	Short <25 min	Medium 26 – 29 min	Long >60 min	All	Overall
Peak	15.26	16.72	13.06	14.95	16.72
Off peak	14.81	13.55	13.89	14.03	

Source: Service Quality Values for Sydney Rail, Report to Railcorp by Douglas Economics, October 2016. Values indexed from November 2016 AWE to May 2019 AWE (ABS Series ID A84994877K).

Table 79 Value of on-board train time - comparisons

Source	Value of time ($/hr)	Difference from ATAP value (%)
Sydney Trains concession fare	8.88	-49.91
Sydney Trains non-concession fare	18.31	3.36
Sydney Trains overall	15.77	-10.98
ATAP - private trips	17.72	

Source: Service Quality Values of Rail Transport in Sydney, Report to Railcorp by Douglas Economics, August 2015 values indexed to May 2019 AWE ((ABS Series ID A84994877K).

The difference between the Sydney Trains and ATAP VTT (which is recommended by TfNSW) can be explained by the following factors:

- The ATAP value is anchored at 40 per cent of AWE, while the Sydney Trains value is based on stated preference surveys of train users. The value of stated preference surveys can be affected by many factors such as sampling, income, trip purpose and general consumer sentiments at the time of the survey.
- Various surveys on the VTT have indicated that the VTT for public transport is lower than car travel. Abrantes and Wardman (2010), having undertaken meta-analysis of UK values of travel time of 1,749 valuations in 226 studies from 1980 to 2008, reported that the VTT of bus users was 35 per cent below that of car users, and the VTT of rail users was 15 per cent below car travel. Bus users tend to have lower VTT in stated preference surveys. However, bus travel is less comfortable than car travel, suggesting bus users are willing-to-pay a higher cost to cut bus travel time.
- The lower VTT for train users can be largely attributed to the lower value of private leisure. Based on the 2014/15 Household Travel Survey undertaken by Bureau of Transport Statistics, business trips represent 6 per cent of total train trips on weekdays, or 5 per cent in the 3 hour morning peak (6:30AM - 9:00AM) on weekdays.

Appendix B Vehicle classification

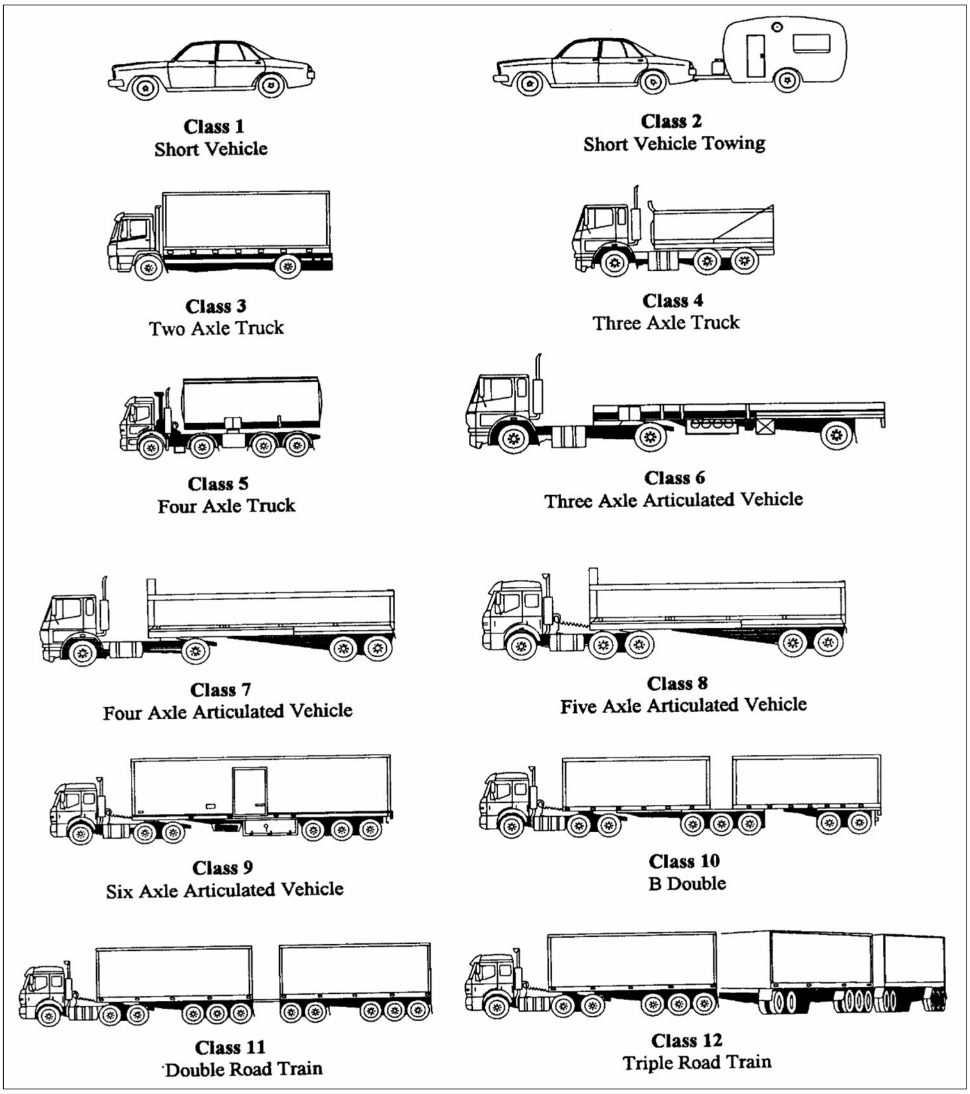
A number of vehicle classification systems are used in this document and by other state and federal guidance documents. This section provides an overview of the different vehicle types and a concordance between classifications. More detail can be found on the Austroads website.

Table 80 Vehicle Classifications

<table>
<tr><th colspan="2">Demand Category*</th><th>Vehicle class</th><th>Vehicle name / category</th></tr>
<tr><td rowspan="3">Light Vehicle (LV)</td><td>Car</td><td rowspan="2">1</td><td>Small Car
Medium Car
Large Car</td></tr>
<tr><td>Light Commercial Vehicle (LCV)</td><td>Courier Van-Utility / Light Commercial Vehicle**
4WD Petrol</td></tr>
<tr><td>N/A***</td><td>2</td><td>Trailer
Caravan</td></tr>
<tr><td rowspan="10">Heavy Vehicle (HV)</td><td rowspan="3">Rigid</td><td>3</td><td>Light Rigid</td></tr>
<tr><td>4</td><td>Medium Rigid</td></tr>
<tr><td>5</td><td>Heavy Rigid</td></tr>
<tr><td rowspan="7">Articulated</td><td>6</td><td>Three Axle Articulated</td></tr>
<tr><td>7</td><td>Four Axle Articulated</td></tr>
<tr><td>8</td><td>Five Axle Articulated</td></tr>
<tr><td>9</td><td>Six Axle Articulated</td></tr>
<tr><td>10</td><td>B Double
Heavy Truck + Trailer</td></tr>
<tr><td>11</td><td>Double Road Train
Medium Articulated + Trailer</td></tr>
<tr><td>12</td><td>Triple Road Train
Heavy Truck + three trailers</td></tr>
</table>

Source: TfNSW Evaluation & Assurance, based on Austroads (2018) Guide to Pavement Technology Part 4K: Selection and Design of Sprayed Seals, Appendix B Austroads.
* These categories are used by demand models such as PTPM and STM.
** Light Commercial Vehicle as per Austroads AP-R264-05 (2005a); Courier Van-Utility as per ARRB RC2062 (2002) for Austroads.
*** Trailers and caravans are generally not separately modelled in strategic demand models.

Figure 2 Austroads typical configurations



Source: Austroads (2018) Guide to Pavement Technology Part 4K: Selection and Design of Sprayed Seals, Appendix B Austroads.

Appendix C Parameters for use with strategic demand models

Table 81 provides parameter values for use with PTPM's economic output module.

Table 81 Parameters for use with PTPM – C1

Row number	PTPM Output	Unit	Period	Economic parameter
Public Transport Travel Time Savings				
Row 290	Commute	hours (Δ)	3.5h AM	$17.72
Row 291	Business	hours (Δ)	3.5h AM	$57.48
Row 292	Education	hours (Δ)	3.5h AM	$17.72
Row 293	Other	hours (Δ)	3.5h AM	$17.72
Road User Travel Time Savings (1)				
Row 497	VHT - Car continuous	hours (Δ)	2h AM	$35.76
Row 498	VHT - Car new (incl. ROH)	hours (Δ)	2h AM	$35.76
Vehicle Operating Costs – Resource Costs (2)				
Row 477	< 10 kph	km	2h AM	$1.1458
Row 478	10-20 kph	km	2h AM	$0.4962
Row 479	20-30 kph	km	2h AM	$0.3662
Row 480	30-40 kph	km	2h AM	$0.3106
Row 481	40-50 kph	km	2h AM	$0.2796
Row 482	50-60 kph	km	2h AM	$0.2599
Row 483	60-70 kph	km	2h AM	$0.2463
Row 484	70-80 kph	km	2h AM	$0.2363
Row 485	80-90 kph	km	2h AM	$0.2287
Row 486	90-100 kph	km	2h AM	$0.2226
Vehicle Operating Costs – Perceived Costs (3)				
Row 477	< 10 kph	km	2h AM	$0.3595
Row 478	10-20 kph	km	2h AM	$0.3595
Row 479	20-30 kph	km	2h AM	$0.3595
Row 480	30-40 kph	km	2h AM	$0.3595
Row 481	40-50 kph	km	2h AM	$0.3595
Row 482	50-60 kph	km	2h AM	$0.3595
Row 483	60-70 kph	km	2h AM	$0.3595
Row 484	70-80 kph	km	2h AM	$0.3595
Row 485	80-90 kph	km	2h AM	$0.3595
Row 486	90-100 kph	km	2h AM	$0.3595
Urban road congestion (4)				
Row 487	Total	km	2h AM	$0.4366
Road Safety Benefit				
Row 487	Total	km	2h AM	$0.0716
Environmental Externalities				
Row 477	< 10 kph	km	2h AM	$0.1340
Row 478	10-20 kph	km	2h AM	$0.1340
Row 479	20-30 kph	km	2h AM	$0.1340
Row 480	30-40 kph	km	2h AM	$0.1340
Row 481	40-50 kph	km	2h AM	$0.1340
Row 482	50-60 kph	km	2h AM	$0.1261
Row 483	60-70 kph	km	2h AM	$0.1261
Row 484	70-80 kph	km	2h AM	$0.1261
Row 485	80-90 kph	km	2h AM	$0.1261
Row 486	90-100 kph	km	2h AM	$0.1261
Active Transport Health Externalities				
Row 149	Walk time (access, egress and interchange)	hours	3.5h AM	$0.3652
Road Damage Costs				
Row 487	Total	km	2h AM	$0.0439

Source: Evaluation & Assurance (2019)

(1) Private / Business purpose split calculated from 2012/13 NSW Household Travel Survey.
(2) TfNSW Depreciation-adjusted VOC model results for 'Medium Car' used for resource costs.
(3) Flat perceived costs from PTPM used – for further information on calculating VOC benefits, refer to *Transport for NSW Technical Note on Vehicle Operating Costs* (2019).
(4) Not to be calculated in combination with road user travel time savings and vehicle operating costs.

Appendix D Rural vehicle operating cost tables

This appendix contains the VOC tables for rural vehicle operating costs calculated at 75 per cent payload, estimated using the equations contained in **section 3.2.2.**

These VOCs have been calculated based on the ATAP VOC model.

Table 82 to **Table 97** presents the VOC for rural (uninterrupted travel or free flow) travel for each vehicle type by speed; for each road surface condition (very good, good, fair, poor), gradient (0 per cent, 4 per cent, 6 per cent, 8 per cent) and road curvature (straight, curvy, very curvy). **Table 98** presents the fuel consumption for vehicles on a typical road with good road surface conditions and 4 per cent gradient at varying levels of curvature (straight, curvy, very curvy).

Further details can be found in Australian Transport Assessment and Planning PV2 Road Parameter Values (2016).

There is also the Rural Vehicle Operating Cost and Fuel Consumption Excel Tool where CBA practitioners can insert their own inputs into the ATAP VOC model.

Table 82 Vehicle operating costs for rural roads (cents/km) – D1

IRI = 1, NRM = 25; Gradient = 0%; Curvature = Straight (20 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	28.0	24.7	23.3	22.7	22.5	22.5	22.8	23.2	23.8	24.5
Medium Car	38.9	33.9	31.6	30.4	29.8	29.7	29.8	30.1	30.5	31.2
Large Car	52.2	45.3	42.0	40.2	39.3	38.8	38.7	38.9	39.2	39.7
Courier Van-Utility	40.1	35.8	33.8	32.9	32.6	32.6	32.9	33.4	34.1	34.9
4WD Mid-Size Petrol	43.3	39.1	37.2	36.3	36.0	36.1	36.5	37.0	37.8	38.7
Light Rigid	50.9	47.0	45.6	45.3	45.6	46.5	47.7	49.3	51.1	53.3
Medium Rigid	66.5	59.4	56.4	55.1	54.9	55.3	56.2	57.5	59.2	61.2
Heavy Rigid	82.1	71.4	67.0	65.6	65.8	67.1	69.4	72.4	76.1	80.4
Heavy Bus	128.4	112.9	105.7	101.9	100.1	99.3	99.4	100.2	101.4	103.1
Artic 4 Axle	108.5	96.0	91.2	89.9	90.6	92.8	96.2	100.5	105.7	111.8
Artic 5 Axle	119.5	106.0	100.6	98.9	99.3	101.1	104.2	108.2	113.0	118.7
Artic 6 Axle	128.8	114.5	108.8	106.8	107.0	108.8	111.8	115.7	120.5	126.2
Rigid + 5 Axle Dog	136.3	123.5	118.5	117.1	117.7	119.8	123.1	127.4	132.6	138.5
B-Double	151.2	135.7	129.4	127.1	127.1	128.7	131.6	135.5	140.3	145.9
Twin steer+5 Axle Dog	150.4	135.6	129.7	127.6	127.8	129.6	132.6	136.6	141.5	147.2
A-Double	182.0	163.8	156.1	152.9	152.4	153.5	156.0	159.6	164.1	169.4
B Triple	212.6	190.1	180.2	175.6	174.0	174.4	176.1	179.0	182.9	187.6
A B Combination	205.4	186.2	178.0	174.6	173.9	174.9	177.4	180.9	185.5	190.9
A-Triple	232.4	211.0	201.7	197.7	196.5	197.3	199.5	202.9	207.3	212.6
Double B-Double	233.6	213.0	204.1	200.3	199.4	200.3	202.7	206.3	210.8	216.3

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 1, NRM = 25; Gradient = 0%; Curvature = Curvy/Hilly/Winding (120 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	27.9	24.7	23.3	22.7	22.5	22.5	22.8	23.2	23.8	24.5
Medium Car	38.8	33.9	31.6	30.4	29.9	29.7	29.8	30.0	30.5	31.1
Large Car	52.1	45.3	42.1	40.3	39.3	38.9	38.7	38.8	39.1	39.6
Courier Van-Utility	40.1	35.8	33.8	32.9	32.6	32.7	33.0	33.5	34.3	35.2
4WD Mid-Size Petrol	43.3	39.1	37.2	36.4	36.1	36.2	36.6	37.2	38.0	38.9
Light Rigid	50.8	47.0	45.6	45.3	45.7	46.5	47.7	49.3	51.1	53.2
Medium Rigid	66.6	59.4	56.5	55.3	55.2	55.8	56.9	58.5	60.4	62.8
Heavy Rigid	82.3	71.4	67.1	65.8	66.3	68.0	70.6	74.2	78.4	83.3
Heavy Bus	128.6	112.8	105.7	102.1	100.5	100.1	100.6	101.8	103.6	105.9
Artic 4 Axle	108.5	96.1	91.5	90.4	91.5	94.0	97.8	102.5	108.3	114.9
Artic 5 Axle	119.3	106.0	100.7	99.2	99.7	101.8	105.0	109.2	114.4	120.3
Artic 6 Axle	128.5	114.5	108.9	107.1	107.5	109.4	112.6	116.8	121.8	127.8
Rigid + 5 Axle Dog	136.4	123.5	118.7	117.6	118.6	121.2	125.1	130.0	135.9	142.8
B-Double	151.1	135.7	129.5	127.5	128.0	130.1	133.5	138.1	143.6	150.1
Twin steer+5 Axle Dog	150.3	135.6	129.9	128.1	128.8	131.1	134.7	139.5	145.2	151.8
A-Double	182.1	163.8	156.3	153.6	153.6	155.4	158.8	163.3	169.0	175.6
B Triple	212.5	190.1	180.4	176.3	175.2	176.2	178.8	182.6	187.5	193.4
A B Combination	205.8	186.4	178.4	175.6	175.6	177.7	181.3	186.2	192.3	199.4
A-Triple	232.8	211.3	202.4	199.0	198.7	200.5	204.0	208.9	215.0	222.1
Double B-Double	234.1	213.3	204.8	201.7	201.6	203.8	207.5	212.7	219.0	226.5

IRI = 1, NRM = 25; Gradient = 0%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	27.8	24.7	23.4	22.8	22.6	22.6	22.9	23.3	23.8	24.5
Medium Car	38.6	33.9	31.7	30.6	30.0	29.8	29.8	30.1	30.5	31.0
Large Car	51.9	45.3	42.2	40.5	39.5	39.0	38.8	38.8	39.1	39.4
Courier Van-Utility	40.0	35.7	33.9	33.1	32.9	33.1	33.6	34.4	35.3	36.5
4WD Mid-Size Petrol	43.2	39.1	37.3	36.6	36.4	36.7	37.3	38.1	39.2	40.5
Light Rigid	50.8	47.1	45.7	45.5	46.0	47.0	48.4	50.2	52.3	54.7
Medium Rigid	66.9	59.5	56.8	56.2	57.0	58.7	61.2	64.3	67.9	72.2
Heavy Rigid	82.5	71.3	67.6	67.4	69.3	72.9	77.8	83.9	91.0	99.1
Heavy Bus	128.5	112.7	106.0	103.4	103.1	104.4	106.8	110.2	114.5	119.6
Artic 4 Axle	108.7	96.2	92.7	93.4	96.8	102.4	109.6	118.4	128.7	140.4
Artic 5 Axle	119.1	105.9	101.5	101.2	103.5	107.6	113.3	120.3	128.6	138.0
Artic 6 Axle	128.4	114.4	109.7	109.3	111.5	115.6	121.4	128.5	136.9	146.5
Rigid + 5 Axle Dog	136.5	123.5	119.9	120.8	124.7	130.8	138.8	148.5	159.8	172.5
B-Double	151.2	135.6	130.7	130.9	134.2	139.9	147.6	157.0	167.9	180.5
Twin steer+5 Axle Dog	150.5	135.6	131.1	131.7	135.4	141.5	149.5	159.4	170.9	183.9
A-Double	182.3	163.7	157.8	157.9	161.9	168.6	177.6	188.7	201.7	216.5
B Triple	212.6	189.9	181.9	180.7	183.6	189.5	197.8	208.3	220.7	234.8
A B Combination	206.3	186.3	180.4	181.2	186.3	194.7	205.8	219.3	235.0	252.9
A-Triple	233.6	211.3	204.7	205.7	211.4	220.7	233.0	248.0	265.4	285.3
Double B-Double	235.0	213.3	207.2	208.6	214.8	224.6	237.6	253.2	271.4	292.1

Table 83 Vehicle operating costs for rural roads (cents/km) – D2

IRI = 1, NRM = 25; Gradient = 4%; Curvature = Straight (20 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	28.2	25.0	23.6	22.9	22.7	22.8	23.0	23.4	24.0	24.7
Medium Car	39.3	34.3	32.0	30.8	30.2	30.0	30.1	30.3	30.8	31.3
Large Car	52.7	45.8	42.5	40.7	39.8	39.3	39.1	39.2	39.5	40.0
Courier Van-Utility	41.8	37.4	35.3	34.3	33.8	33.6	33.7	34.0	34.5	35.1
4WD Mid-Size Petrol	44.2	40.0	38.1	37.2	36.8	36.8	37.1	37.5	38.2	38.9
Light Rigid	54.6	50.2	48.4	47.8	47.9	48.5	49.4	50.6	52.1	53.9
Medium Rigid	74.4	66.9	63.5	61.8	61.0	60.9	61.1	61.7	62.6	63.7
Heavy Rigid	107.3	96.1	90.9	88.1	86.6	86.0	85.9	86.2	86.9	87.9
Heavy Bus	147.7	133.2	125.7	121.0	117.5	114.7	112.3	110.2	108.1	106.2
Artic 4 Axle	144.9	130.1	123.7	120.8	119.9	120.4	121.8	124.0	126.9	130.3
Artic 5 Axle	161.7	146.6	139.8	136.5	135.3	135.3	136.2	137.9	140.1	143.0
Artic 6 Axle	173.9	158.4	151.3	147.7	146.1	145.7	146.3	147.5	149.3	151.5
Rigid + 5 Axle Dog	201.0	186.5	180.0	176.8	175.5	175.4	176.1	177.5	179.5	182.0
B-Double	219.1	202.5	194.7	190.4	188.1	187.0	186.7	187.0	187.8	189.0
Twin steer+5 Axle Dog	220.5	204.3	196.8	193.0	191.2	190.6	191.0	192.0	193.6	195.6
A-Double	272.0	252.7	243.0	237.2	233.3	230.6	228.5	226.9	225.6	224.5
B Triple	306.8	283.6	271.6	264.0	258.5	254.2	250.4	247.1	243.9	240.9
A B Combination	319.2	298.0	287.1	280.3	275.4	271.5	268.3	265.4	262.8	260.3
A-Triple	366.8	342.6	330.0	322.0	316.1	311.4	307.4	303.7	300.2	296.9
Double B-Double	373.0	349.1	336.9	329.2	323.7	319.4	315.9	312.7	309.8	307.1

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 1, NRM = 25; Gradient = 4%; Curvature = Curvy/Hilly/Winding (120 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	28.2	25.0	23.6	23.0	22.7	22.8	23.0	23.4	24.0	24.6
Medium Car	39.2	34.3	32.0	30.8	30.2	30.0	30.1	30.3	30.7	31.3
Large Car	52.6	45.8	42.6	40.8	39.8	39.3	39.1	39.2	39.4	39.8
Courier Van-Utility	41.8	37.3	35.3	34.3	33.8	33.6	33.7	34.0	34.4	35.0
4WD Mid-Size Petrol	44.2	40.0	38.1	37.2	36.9	36.9	37.2	37.7	38.3	39.1
Light Rigid	54.4	50.2	48.5	47.8	47.9	48.3	49.1	50.2	51.5	53.1
Medium Rigid	74.3	67.0	63.7	62.0	61.2	61.0	61.1	61.6	62.3	63.3
Heavy Rigid	107.2	96.2	91.0	88.2	86.8	86.1	86.0	86.3	86.9	87.8
Heavy Bus	147.7	133.2	125.7	121.0	117.6	114.9	112.6	110.5	108.6	106.7
Artic 4 Axle	144.6	130.7	124.4	121.4	120.1	120.0	120.7	122.1	124.0	126.4
Artic 5 Axle	161.5	147.2	140.7	137.3	135.8	135.3	135.7	136.7	138.1	140.0
Artic 6 Axle	173.7	159.1	152.2	148.6	146.8	146.0	146.0	146.6	147.7	149.1
Rigid + 5 Axle Dog	201.1	187.1	180.8	177.8	176.6	176.5	177.3	178.7	180.7	183.2
B-Double	219.3	203.0	195.4	191.5	189.5	188.7	188.7	189.5	190.7	192.4
Twin steer+5 Axle Dog	220.6	204.9	197.7	194.1	192.5	192.1	192.6	193.8	195.6	197.9
A-Double	272.2	253.2	243.9	238.5	235.1	232.9	231.4	230.4	229.9	229.6
B Triple	307.0	284.2	272.6	265.3	260.2	256.1	252.8	249.9	247.2	244.7
A B Combination	319.3	298.8	288.2	281.7	277.0	273.4	270.3	267.7	265.3	263.0
A-Triple	366.9	343.5	331.3	323.4	317.7	313.0	308.9	305.2	301.6	298.1
Double B-Double	373.1	350.0	338.2	330.8	325.5	321.4	317.9	314.8	312.0	309.4

IRI = 1, NRM = 25; Gradient = 4%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	28.1	25.0	23.7	23.0	22.8	22.9	23.1	23.5	24.0	24.6
Medium Car	39.0	34.3	32.1	30.9	30.3	30.1	30.1	30.3	30.7	31.1
Large Car	52.4	45.8	42.7	40.9	39.9	39.4	39.2	39.1	39.3	39.6
Courier Van-Utility	41.7	37.3	35.4	34.4	34.0	33.9	34.1	34.5	35.0	35.7
4WD Mid-Size Petrol	44.1	39.9	38.1	37.4	37.2	37.3	37.8	38.5	39.4	40.5
Light Rigid	54.3	50.3	48.6	48.0	48.0	48.4	49.2	50.2	51.4	52.8
Medium Rigid	74.1	67.3	64.2	62.6	62.0	61.9	62.1	62.7	63.5	64.6
Heavy Rigid	107.0	96.6	91.7	89.1	87.7	87.1	87.1	87.4	88.1	89.0
Heavy Bus	147.7	133.3	126.1	121.6	118.6	116.4	114.6	113.2	111.9	110.8
Artic 4 Axle	144.3	131.3	125.4	122.6	121.4	121.2	121.8	123.1	124.8	127.0
Artic 5 Axle	161.1	147.9	141.8	138.5	136.8	136.1	136.0	136.5	137.4	138.6
Artic 6 Axle	173.4	159.8	153.3	149.9	148.0	147.1	146.9	147.1	147.8	148.8
Rigid + 5 Axle Dog	201.1	187.6	181.9	179.4	178.8	179.5	181.0	183.4	186.4	190.0
B-Double	219.3	203.6	196.5	193.1	191.8	191.8	192.7	194.4	196.7	199.6
Twin steer+5 Axle Dog	220.6	205.5	198.8	195.8	194.8	195.0	196.3	198.3	201.0	204.3
A-Double	272.2	253.8	245.1	240.5	238.1	237.1	237.0	237.5	238.7	240.4
B Triple	306.9	284.8	273.8	267.2	262.9	259.8	257.5	255.8	254.5	253.4
A B Combination	319.2	299.5	289.5	283.5	279.5	276.5	274.2	272.4	270.9	269.5
A-Triple	366.8	344.4	332.8	325.4	319.9	315.5	311.7	308.2	304.9	301.7
Double B-Double	372.9	350.9	339.7	332.8	327.9	324.1	321.1	318.4	316.0	313.8

Table 84 Vehicle operating costs for rural roads (cents/km) – D3

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 1, NRM = 25; Gradient = 6%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	28.7	25.5	24.1	23.4	23.1	23.2	23.4	23.7	24.2	24.8
Medium Car	40.0	35.0	32.6	31.4	30.8	30.5	30.5	30.7	31.0	31.5
Large Car	53.3	46.5	43.2	41.4	40.4	39.9	39.7	39.7	39.9	40.3
Courier Van-Utility	43.7	39.6	37.6	36.4	35.7	35.3	35.0	34.9	34.8	34.8
4WD Mid-Size Petrol	46.2	41.8	39.8	38.8	38.2	38.1	38.1	38.4	38.8	39.3
Light Rigid	58.5	54.2	52.3	51.4	51.2	51.3	51.7	52.4	53.3	54.3
Medium Rigid	82.1	74.5	71.0	69.2	68.4	68.1	68.2	68.7	69.4	70.4
Heavy Rigid	128.6	117.2	111.7	108.4	106.4	105.1	104.3	103.8	103.6	103.5
Heavy Bus	163.7	149.8	142.1	136.8	132.5	128.6	124.9	121.3	117.5	113.6
Artic 4 Axle	174.6	159.7	152.4	148.3	145.8	144.2	143.3	142.9	142.8	143.0
Artic 5 Axle	196.4	181.0	173.7	169.8	167.5	166.3	165.9	165.9	166.4	167.3
Artic 6 Axle	212.1	196.3	188.7	184.5	182.0	180.7	180.0	179.9	180.2	180.9
Rigid + 5 Axle Dog	253.0	237.5	230.2	226.3	224.2	223.3	223.1	223.5	224.4	225.7
B-Double	274.7	256.8	248.2	243.2	240.1	238.2	237.1	236.4	236.2	236.3
Twin steer+5 Axle Dog	277.7	260.4	252.2	247.8	245.3	244.0	243.6	243.7	244.4	245.5
A-Double	343.4	321.6	310.6	303.8	299.2	295.8	293.1	290.9	289.0	287.4
B Triple	381.4	355.1	341.4	332.5	325.9	320.6	315.8	311.5	307.2	303.1
A B Combination	406.6	381.6	370.3	364.7	362.3	361.8	362.8	365.0	368.1	372.0
A-Triple	468.9	440.8	429.3	425.3	425.5	428.7	434.1	441.5	450.5	461.1
Double B-Double	478.8	451.4	440.9	437.9	439.5	444.3	451.6	461.0	472.4	485.5

IRI = 1, NRM = 25; Gradient = 6%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	28.7	25.5	24.1	23.4	23.2	23.2	23.3	23.7	24.2	24.8
Medium Car	39.9	35.0	32.7	31.4	30.8	30.5	30.5	30.7	31.0	31.4
Large Car	53.2	46.5	43.2	41.5	40.4	39.9	39.6	39.6	39.8	40.1
Courier Van-Utility	43.6	39.6	37.6	36.5	35.7	35.3	35.0	34.8	34.7	34.7
4WD Mid-Size Petrol	46.1	41.8	39.8	38.8	38.3	38.1	38.2	38.4	38.8	39.3
Light Rigid	58.4	54.2	52.4	51.5	51.2	51.2	51.5	52.0	52.7	53.6
Medium Rigid	82.0	74.6	71.2	69.4	68.5	68.1	68.2	68.5	69.0	69.8
Heavy Rigid	128.7	117.3	111.8	108.7	106.8	105.6	104.9	104.6	104.5	104.6
Heavy Bus	163.7	149.7	142.1	136.7	132.4	128.5	124.8	121.1	117.4	113.4
Artic 4 Axle	174.9	160.6	153.7	149.9	147.7	146.4	145.8	145.7	145.9	146.5
Artic 5 Axle	196.8	181.8	174.9	171.3	169.6	168.9	169.1	169.8	171.1	172.7
Artic 6 Axle	212.6	197.1	189.8	186.1	184.2	183.4	183.5	184.2	185.5	187.1
Rigid + 5 Axle Dog	253.3	238.4	231.6	228.2	226.6	226.2	226.6	227.7	229.3	231.3
B-Double	275.0	257.8	249.6	245.1	242.5	241.0	240.4	240.3	240.7	241.5
Twin steer+5 Axle Dog	278.1	261.5	253.8	249.8	247.8	247.1	247.3	248.2	249.7	251.6
A-Double	343.7	322.8	312.4	306.1	301.9	298.9	296.7	294.9	293.5	292.3
B Triple	381.6	356.4	343.2	334.7	328.4	323.2	318.7	314.5	310.5	306.5
A B Combination	407.2	383.3	372.8	368.0	366.5	367.1	369.3	372.7	377.2	382.6
A-Triple	469.7	442.9	432.7	429.9	431.6	436.4	443.7	453.1	464.4	477.5
Double B-Double	479.6	453.6	444.5	443.0	446.3	453.0	462.4	474.3	488.4	504.5

IRI = 1, NRM = 25; Gradient = 6%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	28.6	25.5	24.1	23.5	23.2	23.2	23.4	23.7	24.2	24.8
Medium Car	39.8	35.0	32.7	31.5	30.9	30.6	30.6	30.7	31.0	31.4
Large Car	53.0	46.5	43.3	41.6	40.6	40.0	39.7	39.7	39.8	40.1
Courier Van-Utility	43.6	39.6	37.7	36.6	35.9	35.4	35.2	35.0	34.9	34.9
4WD Mid-Size Petrol	46.0	41.8	39.8	38.9	38.5	38.4	38.6	39.0	39.5	40.2
Light Rigid	58.3	54.4	52.6	51.7	51.3	51.3	51.5	51.8	52.3	52.9
Medium Rigid	81.8	74.8	71.6	69.9	69.0	68.6	68.5	68.8	69.2	69.8
Heavy Rigid	128.8	117.6	112.4	109.6	108.1	107.4	107.3	107.6	108.3	109.2
Heavy Bus	163.7	149.8	142.3	137.2	133.1	129.5	126.2	122.9	119.5	116.1
Artic 4 Axle	174.8	161.3	155.0	151.7	150.0	149.2	149.2	149.8	150.7	152.1
Artic 5 Axle	196.8	182.5	176.1	173.1	172.0	172.1	173.0	174.7	177.0	179.8
Artic 6 Axle	212.6	197.7	191.0	187.9	186.7	186.8	187.9	189.7	192.1	195.0
Rigid + 5 Axle Dog	253.4	239.2	233.1	230.4	229.7	230.2	231.8	234.1	237.1	240.7
B-Double	275.0	258.6	251.1	247.3	245.5	244.9	245.3	246.4	248.1	250.3
Twin steer+5 Axle Dog	278.2	262.3	255.3	252.1	251.0	251.4	252.8	255.0	257.9	261.5
A-Double	343.7	323.9	314.1	308.4	304.7	302.3	300.5	299.3	298.5	298.0
B Triple	381.5	357.6	345.0	336.9	330.8	325.8	321.4	317.2	313.2	309.2
A B Combination	407.4	384.8	375.3	371.6	371.3	373.1	376.7	381.7	388.0	395.4
A-Triple	470.1	444.9	436.2	435.0	438.5	445.3	454.9	466.9	481.1	497.4
Double B-Double	480.1	455.8	448.2	448.6	454.0	463.2	475.4	490.4	508.0	527.9

Table 85 Vehicle operating costs for rural roads (cents/km) – D4

IRI = 1, NRM = 25; Gradient = 8%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	29.8	26.6	25.1	24.4	24.0	23.9	24.0	24.2	24.6	25.0
Medium Car	41.3	36.4	34.0	32.7	32.0	31.6	31.4	31.4	31.5	31.7
Large Car	54.9	48.0	44.7	42.8	41.7	41.0	40.7	40.5	40.5	40.7
Courier Van-Utility	45.8	42.0	40.0	38.8	38.0	37.3	36.8	36.3	35.9	35.5
4WD Mid-Size Petrol	48.4	44.3	42.3	41.2	40.5	40.1	39.8	39.7	39.6	39.7
Light Rigid	63.2	58.9	56.9	55.8	55.3	55.0	55.0	55.2	55.5	55.9
Medium Rigid	90.3	82.9	79.4	77.5	76.4	75.9	75.7	75.7	76.0	76.4
Heavy Rigid	153.1	140.9	134.8	131.2	128.7	127.0	125.7	124.7	123.8	123.1
Heavy Bus	181.6	167.7	159.6	153.4	148.0	142.7	137.4	131.9	126.0	119.7
Artic 4 Axle	208.7	191.8	183.6	178.7	175.7	173.7	172.4	171.6	171.1	170.8
Artic 5 Axle	235.2	218.5	210.4	205.8	203.1	201.5	200.6	200.2	200.3	200.7
Artic 6 Axle	255.1	237.8	229.4	224.7	221.7	219.9	218.8	218.3	218.1	218.2
Rigid + 5 Axle Dog	311.4	293.8	285.8	281.8	280.1	279.9	280.6	282.2	284.4	287.2
B-Double	336.7	316.5	306.9	301.8	299.1	297.8	297.5	298.0	299.0	300.6
Twin steer+5 Axle Dog	342.3	322.7	313.7	309.1	306.9	306.2	306.5	307.7	309.6	312.1
A-Double	422.9	397.9	387.3	382.9	382.0	383.5	386.8	391.6	397.6	404.8
B Triple	463.8	434.0	421.1	415.3	413.6	414.5	417.5	422.0	427.9	435.0
A B Combination	504.0	478.3	471.2	473.2	480.9	493.0	508.8	527.9	550.2	575.4
A-Triple	584.3	558.0	554.9	563.7	580.7	604.3	633.6	668.3	708.0	752.6
Double B-Double	599.0	574.0	572.4	583.0	602.1	628.1	660.3	698.2	741.5	790.1

Use this page to look up VOC values for the following highlighted road conditions

Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 1, NRM = 25; Gradient = 8%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	29.7	26.6	25.1	24.4	24.0	23.9	24.0	24.2	24.5	24.8
Medium Car	41.2	36.4	34.1	32.8	32.0	31.6	31.3	31.3	31.3	31.5
Large Car	54.8	48.0	44.7	42.9	41.7	41.0	40.6	40.4	40.4	40.5
Courier Van-Utility	45.8	42.0	40.1	38.8	38.0	37.3	36.8	36.3	35.9	35.4
4WD Mid-Size Petrol	48.4	44.3	42.3	41.2	40.5	40.1	39.8	39.6	39.6	39.6
Light Rigid	63.1	59.0	57.0	55.9	55.3	55.0	54.9	54.9	55.0	55.2
Medium Rigid	90.2	83.0	79.6	77.7	76.5	75.9	75.6	75.5	75.6	75.8
Heavy Rigid	153.1	141.1	135.1	131.6	129.3	127.6	126.5	125.6	125.0	124.5
Heavy Bus	181.5	167.7	159.6	153.4	148.0	142.7	137.4	131.8	125.9	119.6
Artic 4 Axle	209.1	193.4	185.7	181.1	178.2	176.2	174.9	173.9	173.3	172.9
Artic 5 Axle	235.6	219.8	212.2	208.1	205.7	204.5	203.9	204.0	204.4	205.3
Artic 6 Axle	255.6	239.1	231.3	226.9	224.5	223.1	222.6	222.6	223.0	223.8
Rigid + 5 Axle Dog	312.1	295.4	288.2	284.9	283.9	284.4	285.9	288.4	291.6	295.5
B-Double	337.3	318.1	309.3	304.9	302.7	302.1	302.6	303.8	305.7	308.3
Twin steer+5 Axle Dog	342.9	324.4	316.1	312.2	310.6	310.6	311.8	313.8	316.6	320.1
A-Double	423.8	400.2	390.7	387.5	387.9	390.8	395.6	402.1	410.0	419.3
B Triple	464.7	436.5	424.9	420.4	420.1	422.6	427.3	433.8	441.9	451.4
A B Combination	505.3	481.6	476.4	480.5	490.7	505.6	524.6	547.4	573.7	603.3
A-Triple	586.2	562.5	562.0	573.8	594.2	621.8	655.7	695.5	740.9	791.8
Double B-Double	600.9	578.6	579.7	593.4	616.2	646.5	683.5	726.9	776.3	831.6

IRI = 1, NRM = 25; Gradient = 8%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	29.6	26.6	25.2	24.5	24.1	23.9	23.9	24.1	24.3	24.6
Medium Car	41.1	36.4	34.1	32.8	32.1	31.6	31.3	31.1	31.1	31.1
Large Car	54.6	48.1	44.8	43.0	41.8	41.1	40.6	40.2	40.1	40.0
Courier Van-Utility	45.8	42.0	40.1	38.9	38.1	37.5	37.0	36.6	36.2	35.8
4WD Mid-Size Petrol	48.3	44.3	42.4	41.3	40.7	40.3	40.1	40.0	40.0	40.1
Light Rigid	63.0	59.1	57.2	56.1	55.4	55.0	54.7	54.6	54.5	54.6
Medium Rigid	90.1	83.2	79.9	78.0	76.8	76.1	75.7	75.5	75.4	75.5
Heavy Rigid	153.2	141.5	135.9	132.8	130.9	129.9	129.3	129.2	129.4	129.8
Heavy Bus	181.5	167.8	159.8	153.7	148.4	143.3	138.1	132.7	127.0	120.9
Artic 4 Axle	209.2	194.7	187.5	183.4	180.8	179.0	177.9	177.1	176.7	176.4
Artic 5 Axle	235.6	220.8	213.9	210.3	208.5	207.9	208.1	208.8	210.1	211.8
Artic 6 Axle	255.5	240.0	232.9	229.2	227.5	226.9	227.2	228.2	229.7	231.6
Rigid + 5 Axle Dog	312.2	296.7	290.3	287.9	287.9	289.4	292.1	295.8	300.5	305.9
B-Double	337.4	319.4	311.5	307.8	306.5	306.8	308.2	310.5	313.6	317.4
Twin steer+5 Axle Dog	343.0	325.7	318.4	315.3	314.7	315.8	318.0	321.3	325.5	330.5
A-Double	424.1	402.1	393.9	392.0	393.8	398.3	404.9	413.4	423.6	435.3
B Triple	465.1	438.7	428.4	425.4	426.7	431.0	437.6	446.3	456.8	469.0
A B Combination	506.1	484.6	481.7	488.5	501.8	520.4	543.6	571.1	602.6	638.0
A-Triple	587.6	566.7	569.5	585.1	610.2	643.1	683.1	729.8	782.9	842.3
Double B-Double	602.4	583.0	587.5	605.4	633.0	669.0	712.5	763.2	820.8	885.1

Table 86 Vehicle operating costs for rural roads (cents/km) – D5

IRI = 3, NRM = 78; Gradient = 0%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	29.5	26.2	24.8	24.2	24.0	24.0	24.3	24.7	25.3	26.0
Medium Car	40.8	35.8	33.5	32.3	31.7	31.5	31.6	31.9	32.4	33.1
Large Car	54.4	47.5	44.2	42.5	41.5	41.1	40.9	41.1	41.4	41.9
Courier Van-Utility	43.5	39.1	37.2	36.3	35.9	36.0	36.3	36.8	37.5	38.3
4WD Mid-Size Petrol	46.6	42.3	40.5	39.6	39.3	39.4	39.7	40.3	41.0	41.9
Light Rigid	55.6	51.8	50.4	50.0	50.4	51.3	52.5	54.0	55.9	58.1
Medium Rigid	71.4	64.3	61.3	60.1	59.8	60.2	61.1	62.4	64.1	66.1
Heavy Rigid	93.5	82.8	78.5	77.0	77.2	78.5	80.8	83.8	87.5	91.8
Heavy Bus	143.4	127.9	120.7	117.0	115.1	114.4	114.5	115.2	116.5	118.1
Artic 4 Axle	124.8	112.3	107.5	106.2	107.0	109.2	112.5	116.8	122.1	128.1
Artic 5 Axle	137.0	123.5	118.1	116.4	116.7	118.6	121.6	125.7	130.5	136.2
Artic 6 Axle	148.0	133.7	128.0	126.0	126.2	128.0	131.0	134.9	139.7	145.4
Rigid + 5 Axle Dog	155.5	142.6	137.6	136.2	136.9	139.0	142.3	146.5	151.7	157.7
B-Double	174.9	159.5	153.1	150.8	150.9	152.5	155.4	159.3	164.1	169.7
Twin steer+5 Axle Dog	172.6	157.9	151.9	149.9	150.1	151.9	154.8	158.8	163.7	169.5
A-Double	212.4	194.1	186.4	183.3	182.7	183.8	186.3	189.9	194.4	199.7
B Triple	248.7	226.2	216.3	211.8	210.1	210.5	212.2	215.1	219.0	223.7
A B Combination	240.2	221.0	212.8	209.4	208.7	209.8	212.2	215.8	220.3	225.7
A-Triple	272.0	250.6	241.3	237.3	236.1	236.9	239.1	242.5	246.9	252.2
Double B-Double	273.5	252.9	244.0	240.2	239.3	240.2	242.6	246.2	250.8	256.2

Use this page to look up VOC values for the following highlighted road conditions

Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 3, NRM = 78; Gradient = 0%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	29.4	26.3	24.9	24.2	24.0	24.1	24.3	24.7	25.3	26.0
Medium Car	40.7	35.8	33.5	32.3	31.8	31.6	31.7	31.9	32.4	33.0
Large Car	54.4	47.5	44.3	42.6	41.6	41.1	41.0	41.1	41.4	41.9
Courier Van-Utility	43.5	39.2	37.2	36.3	36.0	36.1	36.4	36.9	37.7	38.6
4WD Mid-Size Petrol	46.6	42.3	40.5	39.6	39.4	39.5	39.8	40.4	41.2	42.2
Light Rigid	55.6	51.8	50.4	50.1	50.5	51.3	52.5	54.0	55.9	58.0
Medium Rigid	71.5	64.4	61.4	60.2	60.1	60.7	61.8	63.4	65.3	67.7
Heavy Rigid	93.7	82.7	78.5	77.2	77.6	79.4	82.0	85.5	89.8	94.7
Heavy Bus	143.6	127.9	120.7	117.1	115.5	115.1	115.6	116.8	118.6	120.9
Artic 4 Axle	124.9	112.5	107.9	106.8	107.8	110.4	114.1	118.9	124.7	131.3
Artic 5 Axle	136.9	123.6	118.4	116.8	117.4	119.4	122.6	126.9	132.0	138.0
Artic 6 Axle	147.9	133.8	128.2	126.4	126.9	128.8	132.0	136.1	141.2	147.1
Rigid + 5 Axle Dog	155.6	142.7	137.9	136.8	137.8	140.4	144.3	149.2	155.1	162.0
B-Double	175.0	159.6	153.4	151.4	151.9	154.0	157.4	162.0	167.5	174.0
Twin steer+5 Axle Dog	172.7	158.0	152.2	150.5	151.2	153.5	157.1	161.8	167.6	174.2
A-Double	212.5	194.2	186.7	183.9	183.9	185.8	189.2	193.7	199.3	205.9
B Triple	248.8	226.3	216.7	212.5	211.4	212.5	215.0	218.8	223.8	229.7
A B Combination	240.5	221.1	213.2	210.3	210.4	212.5	216.1	221.0	227.0	234.1
A-Triple	272.3	250.8	241.9	238.5	238.2	240.0	243.5	248.4	254.4	261.6
Double B-Double	273.9	253.1	244.6	241.4	241.4	243.6	247.3	252.5	258.8	266.3

IRI = 3, NRM = 78; Gradient = 0%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	29.3	26.3	24.9	24.3	24.1	24.2	24.4	24.8	25.3	26.0
Medium Car	40.6	35.8	33.7	32.5	32.0	31.7	31.8	32.0	32.4	33.0
Large Car	54.2	47.6	44.5	42.8	41.8	41.3	41.1	41.2	41.4	41.8
Courier Van-Utility	43.5	39.2	37.3	36.5	36.4	36.6	37.1	37.8	38.8	39.9
4WD Mid-Size Petrol	46.5	42.4	40.6	39.9	39.7	40.0	40.6	41.5	42.5	43.8
Light Rigid	55.6	51.8	50.5	50.3	50.8	51.8	53.2	55.0	57.1	59.4
Medium Rigid	71.8	64.4	61.7	61.2	62.0	63.7	66.1	69.2	72.9	77.2
Heavy Rigid	94.1	82.8	79.1	78.9	80.9	84.4	89.3	95.4	102.5	110.6
Heavy Bus	143.8	127.9	121.3	118.6	118.3	119.6	122.0	125.5	129.7	134.8
Artic 4 Axle	125.3	112.8	109.2	110.0	113.4	118.9	126.2	135.0	145.3	156.9
Artic 5 Axle	137.0	123.8	119.4	119.1	121.4	125.5	131.2	138.2	146.5	155.9
Artic 6 Axle	148.0	134.1	129.3	128.9	131.1	135.3	141.0	148.2	156.6	166.2
Rigid + 5 Axle Dog	156.0	142.9	139.3	140.3	144.2	150.3	158.3	167.9	179.2	191.9
B-Double	175.3	159.8	154.9	155.1	158.4	164.1	171.7	181.1	192.1	204.6
Twin steer+5 Axle Dog	173.1	158.2	153.8	154.3	158.0	164.1	172.2	182.0	193.5	206.6
A-Double	213.1	194.4	188.5	188.7	192.6	199.3	208.3	219.4	232.5	247.3
B Triple	249.2	226.6	218.6	217.3	220.2	226.1	234.5	244.9	257.3	271.5
A B Combination	241.4	221.3	215.4	216.3	221.4	229.8	240.9	254.4	270.1	288.0
A-Triple	273.4	251.1	244.6	245.5	251.2	260.5	272.8	287.8	305.3	325.1
Double B-Double	275.1	253.4	247.3	248.7	254.9	264.8	277.7	293.3	311.6	332.2

Table 87 Vehicle operating costs for rural roads (cents/km) – D6

IRI = 3, NRM = 78; Gradient = 4%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr) 20	30	40	50	60	70	80	90	100	110
Small Car	29.7	26.5	25.1	24.4	24.2	24.3	24.5	24.9	25.5	26.2
Medium Car	41.2	36.2	33.9	32.7	32.1	31.9	32.0	32.2	32.7	33.2
Large Car	54.9	48.0	44.7	43.0	42.0	41.5	41.3	41.4	41.7	42.2
Courier Van-Utility	45.2	40.7	38.6	37.6	37.1	37.0	37.1	37.4	37.8	38.4
4WD Mid-Size Petrol	47.4	43.2	41.3	40.4	40.1	40.1	40.3	40.8	41.4	42.2
Light Rigid	59.2	54.8	53.1	52.5	52.6	53.1	54.0	55.3	56.8	58.5
Medium Rigid	79.2	71.7	68.3	66.6	65.8	65.7	65.9	66.5	67.4	68.5
Heavy Rigid	118.4	107.3	102.0	99.3	97.8	97.1	97.0	97.4	98.1	99.1
Heavy Bus	162.8	148.3	140.8	136.1	132.6	129.8	127.5	125.3	123.3	121.3
Artic 4 Axle	161.4	146.7	140.3	137.4	136.5	136.9	138.3	140.5	143.4	146.9
Artic 5 Axle	179.7	164.5	157.7	154.5	153.2	153.2	154.1	155.8	158.1	160.9
Artic 6 Axle	193.6	178.0	170.9	167.4	165.8	165.4	166.0	167.2	169.0	171.2
Rigid + 5 Axle Dog	220.5	206.0	199.5	196.3	195.0	194.9	195.6	197.0	199.0	201.5
B-Double	243.3	226.7	218.9	214.6	212.3	211.2	210.9	211.2	212.0	213.3
Twin steer+5 Axle Dog	243.3	227.1	219.6	215.8	214.0	213.5	213.8	214.8	216.4	218.4
A-Double	302.7	283.3	273.7	267.9	264.0	261.3	259.2	257.6	256.3	255.2
B Triple	343.3	320.1	308.1	300.5	295.0	290.7	286.9	283.6	280.4	277.3
A B Combination	354.0	332.8	322.0	315.1	310.2	306.4	303.1	300.3	297.6	295.1
A-Triple	406.4	382.1	369.5	361.5	355.7	351.0	346.9	343.3	339.8	336.4
Double B-Double	412.8	388.9	376.7	369.0	363.5	359.2	355.7	352.5	349.6	346.9

Use this page to look up VOC values for the following highlighted road conditions

Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 3, NRM = 78; Gradient = 4%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr) 20	30	40	50	60	70	80	90	100	110
Small Car	29.7	26.5	25.1	24.5	24.3	24.3	24.5	24.9	25.5	26.1
Medium Car	41.1	36.2	33.9	32.7	32.1	31.9	32.0	32.2	32.6	33.2
Large Car	54.9	48.1	44.8	43.1	42.1	41.6	41.4	41.4	41.7	42.1
Courier Van-Utility	45.1	40.7	38.7	37.6	37.2	37.0	37.1	37.4	37.8	38.4
4WD Mid-Size Petrol	47.4	43.2	41.3	40.5	40.1	40.1	40.4	40.9	41.6	42.4
Light Rigid	59.1	54.9	53.2	52.5	52.6	53.0	53.8	54.9	56.2	57.8
Medium Rigid	79.1	71.9	68.5	66.8	66.0	65.8	66.0	66.4	67.2	68.1
Heavy Rigid	118.4	107.3	102.2	99.4	97.9	97.2	97.1	97.4	98.1	99.0
Heavy Bus	162.8	148.3	140.8	136.1	132.7	130.0	127.7	125.6	123.7	121.8
Artic 4 Axle	161.0	147.1	140.9	137.8	136.6	136.5	137.2	138.5	140.4	142.8
Artic 5 Axle	179.3	165.0	158.4	155.1	153.5	153.1	153.5	154.4	155.9	157.8
Artic 6 Axle	193.2	178.6	171.7	168.1	166.3	165.5	165.5	166.1	167.2	168.6
Rigid + 5 Axle Dog	220.3	206.4	200.1	197.1	195.8	195.8	196.5	198.0	200.0	202.5
B-Double	243.3	227.0	219.4	215.4	213.4	212.6	212.7	213.4	214.7	216.4
Twin steer+5 Axle Dog	243.2	227.4	220.2	216.6	215.0	214.6	215.1	216.3	218.1	220.4
A-Double	302.6	283.6	274.3	268.9	265.5	263.3	261.8	260.8	260.3	260.0
B Triple	343.2	320.4	308.8	301.5	296.3	292.3	289.0	286.1	283.4	280.9
A B Combination	353.8	333.3	322.8	316.2	311.5	307.9	304.9	302.2	299.8	297.5
A-Triple	406.2	382.7	370.5	362.7	356.9	352.3	348.2	344.4	340.8	337.3
Double B-Double	412.6	389.5	377.7	370.3	365.0	360.8	357.4	354.3	351.5	348.8

IRI = 3, NRM = 78; Gradient = 4%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr) 20	30	40	50	60	70	80	90	100	110
Small Car	29.6	26.6	25.2	24.6	24.4	24.4	24.6	25.0	25.5	26.2
Medium Car	41.0	36.2	34.0	32.9	32.3	32.1	32.1	32.3	32.6	33.1
Large Car	54.7	48.1	45.0	43.3	42.3	41.7	41.5	41.5	41.6	41.9
Courier Van-Utility	45.1	40.8	38.8	37.8	37.4	37.3	37.5	37.9	38.5	39.2
4WD Mid-Size Petrol	47.4	43.2	41.4	40.7	40.5	40.6	41.1	41.8	42.7	43.8
Light Rigid	59.0	55.0	53.3	52.7	52.7	53.2	53.9	54.9	56.1	57.6
Medium Rigid	78.9	72.1	69.0	67.5	66.8	66.7	67.0	67.5	68.4	69.4
Heavy Rigid	118.1	107.7	102.8	100.2	98.9	98.3	98.2	98.5	99.2	100.2
Heavy Bus	162.8	148.4	141.2	136.7	133.7	131.5	129.7	128.3	127.0	125.9
Artic 4 Axle	160.7	147.7	141.8	138.9	137.7	137.6	138.2	139.4	141.2	143.4
Artic 5 Axle	178.8	165.6	159.5	156.2	154.5	153.8	153.7	154.2	155.1	156.3
Artic 6 Axle	192.8	179.2	172.8	169.3	167.4	166.5	166.3	166.6	167.2	168.2
Rigid + 5 Axle Dog	220.2	206.8	201.0	198.5	197.9	198.6	200.2	202.5	205.5	209.1
B-Double	243.1	227.4	220.3	217.0	215.6	215.6	216.5	218.2	220.6	223.4
Twin steer+5 Axle Dog	243.0	227.9	221.2	218.2	217.2	217.4	218.7	220.7	223.4	226.7
A-Double	302.5	284.0	275.4	270.8	268.4	267.4	267.2	267.8	269.0	270.6
B Triple	343.0	320.9	309.9	303.3	299.0	295.9	293.7	291.9	290.6	289.5
A B Combination	353.6	333.9	324.0	318.0	313.9	311.0	308.7	306.9	305.3	304.0
A-Triple	405.9	383.6	372.0	364.5	359.1	354.7	350.9	347.4	344.1	340.9
Double B-Double	412.3	390.3	379.1	372.2	367.3	363.5	360.5	357.8	355.4	353.2

Table 88 Vehicle operating costs for rural roads (cents/km) – D7

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 3, NRM = 78; Gradient = 6%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	30.2	27.0	25.6	24.9	24.6	24.7	24.9	25.2	25.7	26.3
Medium Car	41.8	36.9	34.5	33.3	32.7	32.4	32.4	32.6	32.9	33.4
Large Car	55.5	48.7	45.5	43.7	42.7	42.1	41.9	41.9	42.1	42.5
Courier Van-Utility	47.1	43.0	41.0	39.8	39.1	38.7	38.4	38.2	38.2	38.2
4WD Mid-Size Petrol	49.4	45.0	43.0	42.0	41.5	41.3	41.3	41.6	42.0	42.5
Light Rigid	63.2	58.9	57.0	56.1	55.9	56.0	56.5	57.1	58.0	59.0
Medium Rigid	86.9	79.3	75.8	74.1	73.2	72.9	73.1	73.5	74.3	75.2
Heavy Rigid	139.8	128.4	122.9	119.7	117.7	116.4	115.5	115.0	114.8	114.7
Heavy Bus	179.0	165.0	157.4	152.1	147.7	143.9	140.2	136.5	132.8	128.8
Artic 4 Axle	192.1	177.1	169.8	165.7	163.2	161.6	160.7	160.3	160.2	160.4
Artic 5 Axle	215.2	199.9	192.6	188.6	186.3	185.2	184.7	184.8	185.3	186.1
Artic 6 Axle	232.8	216.9	209.3	205.1	202.7	201.3	200.7	200.6	200.9	201.5
Rigid + 5 Axle Dog	273.5	258.0	250.7	246.8	244.8	243.8	243.7	244.1	245.0	246.2
B-Double	299.9	282.1	273.4	268.5	265.4	263.5	262.3	261.7	261.4	261.5
Twin steer+5 Axle Dog	301.8	284.5	276.3	271.8	269.3	268.0	267.6	267.8	268.4	269.5
A-Double	375.4	353.6	342.6	335.9	331.3	327.9	325.2	323.0	321.1	319.4
B Triple	419.2	393.0	379.2	370.4	363.8	358.4	353.7	349.3	345.1	341.0
A B Combination	443.2	418.2	406.8	401.2	398.8	398.4	399.4	401.5	404.6	408.6
A-Triple	510.5	482.4	471.0	466.9	467.1	470.3	475.7	483.1	492.1	502.7
Double B-Double	520.8	493.4	482.9	479.9	481.5	486.3	493.5	503.0	514.3	527.5

IRI = 3, NRM = 78; Gradient = 6%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	30.2	27.0	25.6	24.9	24.7	24.7	24.9	25.2	25.7	26.3
Medium Car	41.8	36.9	34.6	33.4	32.7	32.4	32.4	32.6	32.9	33.3
Large Car	55.5	48.7	45.5	43.7	42.7	42.2	41.9	41.9	42.1	42.4
Courier Van-Utility	47.0	43.0	41.0	39.9	39.1	38.7	38.4	38.2	38.1	38.1
4WD Mid-Size Petrol	49.3	45.0	43.0	42.0	41.5	41.3	41.4	41.6	42.0	42.6
Light Rigid	63.1	59.0	57.1	56.2	55.9	55.9	56.2	56.7	57.4	58.3
Medium Rigid	86.8	79.4	76.0	74.2	73.3	73.0	73.0	73.3	73.9	74.6
Heavy Rigid	139.8	128.5	123.0	119.9	118.0	116.8	116.1	115.8	115.7	115.8
Heavy Bus	178.9	165.0	157.3	152.0	147.7	143.8	140.1	136.4	132.6	128.7
Artic 4 Axle	191.9	177.6	170.8	166.9	164.7	163.5	162.9	162.7	163.0	163.6
Artic 5 Axle	215.2	200.3	193.3	189.8	188.0	187.3	187.5	188.2	189.5	191.2
Artic 6 Axle	232.8	217.2	210.0	206.3	204.4	203.6	203.7	204.4	205.7	207.3
Rigid + 5 Axle Dog	273.5	258.6	251.8	248.3	246.7	246.3	246.7	247.8	249.4	251.4
B-Double	299.8	282.6	274.4	269.9	267.3	265.9	265.2	265.2	265.6	266.4
Twin steer+5 Axle Dog	301.7	285.0	277.3	273.4	271.4	270.7	270.9	271.8	273.2	275.2
A-Double	375.3	354.4	344.0	337.7	333.5	330.5	328.3	326.5	325.1	323.9
B Triple	419.1	393.9	380.7	372.2	365.8	360.7	356.2	352.0	347.9	343.9
A B Combination	443.2	419.3	408.9	404.1	402.6	403.2	405.4	408.8	413.3	418.7
A-Triple	510.8	484.0	473.8	471.1	472.7	477.5	484.8	494.2	505.5	518.6
Double B-Double	521.1	495.1	485.9	484.5	487.8	494.4	503.9	515.8	529.9	546.0

IRI = 3, NRM = 78; Gradient = 6%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	30.1	27.1	25.7	25.0	24.8	24.8	24.9	25.3	25.7	26.3
Medium Car	41.7	36.9	34.7	33.5	32.9	32.6	32.5	32.6	32.9	33.3
Large Car	55.3	48.8	45.7	43.9	42.9	42.3	42.1	42.0	42.2	42.4
Courier Van-Utility	47.0	43.0	41.1	40.0	39.3	38.9	38.6	38.4	38.3	38.3
4WD Mid-Size Petrol	49.3	45.0	43.1	42.2	41.8	41.7	41.9	42.3	42.8	43.5
Light Rigid	63.0	59.1	57.3	56.4	56.1	56.0	56.2	56.5	57.0	57.7
Medium Rigid	86.6	79.7	76.4	74.7	73.8	73.4	73.4	73.6	74.0	74.6
Heavy Rigid	139.9	128.7	123.5	120.7	119.2	118.5	118.4	118.7	119.4	120.3
Heavy Bus	178.9	165.1	157.5	152.4	148.3	144.8	141.4	138.1	134.8	131.3
Artic 4 Axle	191.8	178.2	171.9	168.6	166.9	166.2	166.2	166.7	167.7	169.0
Artic 5 Axle	215.1	200.8	194.4	191.4	190.3	190.4	191.3	193.0	195.3	198.1
Artic 6 Axle	232.7	217.7	211.1	207.9	206.8	206.9	207.9	209.7	212.1	215.1
Rigid + 5 Axle Dog	273.4	259.2	253.0	250.4	249.6	250.2	251.8	254.1	257.1	260.7
B-Double	299.7	283.3	275.8	272.0	270.2	269.7	270.0	271.1	272.8	275.0
Twin steer+5 Axle Dog	301.6	285.7	278.7	275.5	274.5	274.8	276.2	278.4	281.4	284.9
A-Double	375.1	355.4	345.6	339.9	336.2	333.7	332.0	330.8	330.0	329.5
B Triple	418.9	394.9	382.4	374.2	368.1	363.1	358.7	354.6	350.6	346.6
A B Combination	443.3	420.7	411.3	407.6	407.2	409.1	412.7	417.7	423.9	431.3
A-Triple	511.1	485.9	477.1	476.0	479.4	486.3	495.9	507.9	522.1	538.4
Double B-Double	521.4	497.1	489.5	489.9	495.3	504.5	516.7	531.7	549.3	569.3

Table 89 Vehicle operating costs for rural roads (cents/km) – D8

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 3, NRM = 78; Gradient = 8%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.3	28.1	26.6	25.9	25.5	25.4	25.5	25.7	26.0	26.5
Medium Car	43.2	38.3	35.9	34.6	33.9	33.4	33.3	33.2	33.3	33.6
Large Car	57.1	50.3	46.9	45.1	43.9	43.3	42.9	42.7	42.8	42.9
Courier Van-Utility	49.2	45.4	43.4	42.2	41.4	40.7	40.2	39.7	39.3	38.9
4WD Mid-Size Petrol	51.7	47.6	45.6	44.4	43.7	43.3	43.0	42.9	42.9	42.9
Light Rigid	68.0	63.6	61.6	60.6	60.0	59.8	59.8	60.0	60.3	60.7
Medium Rigid	95.1	87.8	84.2	82.3	81.2	80.7	80.5	80.5	80.8	81.2
Heavy Rigid	164.3	152.1	146.0	142.4	139.9	138.2	136.9	135.8	135.0	134.3
Heavy Bus	197.0	183.2	175.1	168.9	163.5	158.2	152.9	147.3	141.5	135.2
Artic 4 Axle	227.1	210.3	202.0	197.2	194.2	192.2	190.8	190.0	189.5	189.3
Artic 5 Axle	255.1	238.3	230.2	225.7	222.9	221.3	220.4	220.1	220.1	220.5
Artic 6 Axle	276.8	259.5	251.1	246.3	243.4	241.6	240.5	239.9	239.7	239.9
Rigid + 5 Axle Dog	333.4	315.7	307.7	303.8	302.1	301.8	302.5	304.1	306.3	309.1
B-Double	363.4	343.2	333.6	328.5	325.8	324.5	324.2	324.7	325.8	327.3
Twin steer+5 Axle Dog	367.9	348.3	339.3	334.7	332.5	331.8	332.2	333.4	335.2	337.7
A-Double	457.0	432.0	421.3	416.9	416.1	417.6	420.9	425.6	431.7	438.9
B Triple	503.8	474.0	461.1	455.3	453.6	454.5	457.5	462.0	467.9	475.1
A B Combination	542.9	517.2	510.2	512.1	519.8	531.9	547.7	566.8	589.1	614.3
A-Triple	628.7	602.5	599.4	608.2	625.2	648.7	678.0	712.7	752.4	797.1
Double B-Double	643.9	618.9	617.2	627.8	646.9	673.0	705.2	743.1	786.4	835.0

IRI = 3, NRM = 78; Gradient = 8%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.2	28.1	26.6	25.9	25.5	25.4	25.5	25.7	25.9	26.3
Medium Car	43.1	38.3	36.0	34.7	33.9	33.4	33.2	33.2	33.2	33.4
Large Car	57.1	50.3	47.0	45.1	44.0	43.3	42.9	42.7	42.6	42.7
Courier Van-Utility	49.2	45.4	43.5	42.3	41.4	40.7	40.2	39.7	39.3	38.9
4WD Mid-Size Petrol	51.6	47.6	45.6	44.5	43.8	43.3	43.1	42.9	42.9	42.9
Light Rigid	67.9	63.7	61.7	60.7	60.1	59.7	59.6	59.6	59.8	60.0
Medium Rigid	95.0	87.8	84.4	82.5	81.3	80.7	80.4	80.3	80.4	80.7
Heavy Rigid	164.3	152.2	146.2	142.7	140.4	138.8	137.6	136.7	136.1	135.6
Heavy Bus	197.0	183.2	175.0	168.9	163.4	158.2	152.8	147.3	141.3	135.1
Artic 4 Axle	227.1	211.4	203.6	199.1	196.2	194.2	192.8	191.9	191.2	190.8
Artic 5 Axle	255.0	239.1	231.6	227.4	225.1	223.8	223.3	223.3	223.8	224.6
Artic 6 Axle	276.7	260.2	252.4	248.1	245.6	244.3	243.7	243.7	244.2	245.0
Rigid + 5 Axle Dog	333.4	316.8	309.5	306.3	305.3	305.7	307.3	309.7	313.0	316.8
B-Double	363.4	344.3	335.5	331.0	328.9	328.3	328.7	330.0	331.9	334.4
Twin steer+5 Axle Dog	367.9	349.4	341.1	337.2	335.7	335.7	336.8	338.9	341.7	345.1
A-Double	457.2	433.6	424.2	420.9	421.3	424.2	429.0	435.5	443.4	452.7
B Triple	504.1	475.9	464.2	459.8	459.5	462.0	466.7	473.2	481.2	490.7
A B Combination	543.5	519.8	514.7	518.8	528.9	543.9	562.9	585.7	611.9	641.6
A-Triple	629.9	606.2	605.7	617.5	638.0	665.5	699.4	739.2	784.7	835.6
Double B-Double	645.1	622.7	623.8	637.6	660.4	690.7	727.7	771.0	820.4	875.7

IRI = 3, NRM = 78; Gradient = 8%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.2	28.1	26.7	26.0	25.6	25.5	25.5	25.6	25.8	26.1
Medium Car	43.0	38.3	36.1	34.8	34.0	33.5	33.2	33.0	33.0	33.0
Large Car	56.9	50.4	47.1	45.3	44.1	43.4	42.9	42.6	42.4	42.3
Courier Van-Utility	49.2	45.4	43.5	42.3	41.5	40.9	40.4	40.0	39.6	39.3
4WD Mid-Size Petrol	51.6	47.6	45.7	44.6	44.0	43.6	43.4	43.3	43.3	43.4
Light Rigid	67.8	63.9	61.9	60.9	60.2	59.8	59.5	59.4	59.3	59.3
Medium Rigid	94.9	88.0	84.7	82.8	81.6	80.9	80.5	80.3	80.2	80.3
Heavy Rigid	164.2	152.5	146.9	143.8	142.0	140.9	140.4	140.2	140.4	140.8
Heavy Bus	196.9	183.2	175.2	169.2	163.9	158.8	153.6	148.2	142.5	136.4
Artic 4 Axle	227.0	212.5	205.4	201.2	198.6	196.9	195.7	194.9	194.5	194.3
Artic 5 Axle	254.8	240.0	233.1	229.5	227.7	227.1	227.3	228.0	229.3	231.0
Artic 6 Axle	276.5	261.0	253.9	250.2	248.5	247.9	248.2	249.2	250.7	252.6
Rigid + 5 Axle Dog	333.5	317.9	311.5	309.1	309.1	310.6	313.3	317.1	321.7	327.2
B-Double	363.4	345.4	337.5	333.8	332.5	332.8	334.2	336.5	339.6	343.4
Twin steer+5 Axle Dog	367.9	350.6	343.2	340.2	339.6	340.7	342.9	346.2	350.4	355.4
A-Double	457.4	435.4	427.2	425.3	427.1	431.6	438.2	446.7	456.8	468.5
B Triple	504.3	477.9	467.7	464.7	465.9	470.2	476.9	485.5	496.0	508.2
A B Combination	544.2	522.7	519.8	526.6	539.9	558.5	581.7	609.2	640.7	676.1
A-Triple	631.1	610.3	613.0	628.7	653.7	686.6	726.6	773.3	826.4	885.8
Double B-Double	646.4	627.0	631.5	649.3	677.0	713.0	756.5	807.2	864.8	929.1

Table 90 Vehicle operating costs for rural roads (cents/km) – D9

IRI = 5, NRM = 131; Gradient = 0%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.1	27.9	26.5	25.8	25.6	25.7	26.0	26.4	27.0	27.7
Medium Car	42.9	37.9	35.6	34.4	33.8	33.7	33.8	34.1	34.5	35.2
Large Car	57.0	50.1	46.8	45.0	44.1	43.6	43.5	43.6	44.0	44.5
Courier Van-Utility	47.6	43.2	41.3	40.4	40.0	40.0	40.3	40.8	41.5	42.4
4WD Mid-Size Petrol	50.5	46.2	44.3	43.5	43.2	43.3	43.6	44.2	44.9	45.8
Light Rigid	61.1	57.3	55.8	55.5	55.9	56.7	58.0	59.5	61.4	63.5
Medium Rigid	77.1	70.1	67.0	65.8	65.5	65.9	66.8	68.1	69.8	71.8
Heavy Rigid	105.0	94.3	90.0	88.5	88.7	90.1	92.3	95.3	99.0	103.3
Heavy Bus	159.4	143.9	136.7	132.9	131.0	130.3	130.4	131.1	132.4	134.1
Artic 4 Axle	141.4	128.9	124.1	122.8	123.5	125.7	129.0	133.4	138.6	144.6
Artic 5 Axle	154.8	141.3	135.9	134.2	134.6	136.4	139.5	143.5	148.4	154.0
Artic 6 Axle	167.5	153.2	147.5	145.5	145.8	147.5	150.5	154.4	159.3	164.9
Rigid + 5 Axle Dog	174.7	161.8	156.9	155.4	156.1	158.2	161.5	165.8	170.9	176.9
B-Double	198.9	183.4	177.1	174.8	174.8	176.4	179.3	183.2	188.0	193.6
Twin steer+5 Axle Dog	195.1	180.4	174.4	172.4	172.6	174.3	177.3	181.3	186.2	191.9
A-Double	242.8	224.6	216.8	213.7	213.1	214.3	216.7	220.3	224.8	230.2
B Triple	285.2	262.8	252.9	248.3	246.7	247.1	248.8	251.7	255.6	260.3
A B Combination	275.0	255.8	247.6	244.1	243.4	244.5	246.9	250.5	255.0	260.4
A-Triple	311.5	290.2	280.9	276.8	275.7	276.5	278.7	282.1	286.5	291.7
Double B-Double	313.3	292.6	283.7	279.9	279.0	279.9	282.3	285.9	290.5	295.9

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 5, NRM = 131; Gradient = 0%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.1	27.9	26.5	25.9	25.7	25.7	26.0	26.4	27.0	27.7
Medium Car	42.8	37.9	35.6	34.5	33.9	33.7	33.8	34.1	34.5	35.1
Large Car	56.9	50.1	46.9	45.1	44.2	43.7	43.6	43.7	44.0	44.4
Courier Van-Utility	47.6	43.2	41.3	40.4	40.1	40.2	40.5	41.0	41.8	42.7
4WD Mid-Size Petrol	50.5	46.2	44.4	43.5	43.3	43.4	43.7	44.3	45.1	46.1
Light Rigid	61.1	57.3	55.9	55.6	55.9	56.8	58.0	59.5	61.4	63.5
Medium Rigid	77.2	70.1	67.1	65.9	65.8	66.4	67.5	69.1	71.0	73.4
Heavy Rigid	105.2	94.3	90.0	88.7	89.2	90.9	93.5	97.0	101.3	106.2
Heavy Bus	159.5	143.8	136.7	133.1	131.4	131.1	131.6	132.8	134.6	136.8
Artic 4 Axle	141.4	129.0	124.4	123.3	124.3	126.9	130.6	135.4	141.2	147.8
Artic 5 Axle	154.8	141.5	136.3	134.7	135.2	137.3	140.5	144.8	149.9	155.8
Artic 6 Axle	167.5	153.4	147.8	146.0	146.5	148.4	151.6	155.7	160.8	166.7
Rigid + 5 Axle Dog	174.8	161.9	157.1	156.0	157.0	159.7	163.5	168.5	174.4	181.2
B-Double	199.0	183.5	177.4	175.4	175.8	177.9	181.4	185.9	191.5	197.9
Twin steer+5 Axle Dog	195.2	180.5	174.7	173.0	173.7	176.0	179.6	184.3	190.1	196.7
A-Double	242.9	224.6	217.1	214.4	214.4	216.3	219.6	224.2	229.8	236.4
B Triple	285.4	263.0	253.3	249.1	248.1	249.1	251.6	255.5	260.4	266.3
A B Combination	275.2	255.8	247.9	245.0	245.1	247.1	250.7	255.6	261.7	268.8
A-Triple	311.7	290.3	281.3	277.9	277.6	279.5	283.0	287.8	293.9	301.0
Double B-Double	313.5	292.7	284.2	281.0	281.0	283.1	286.9	292.1	298.4	305.9

IRI= 5, NRM =131; Gradient = 0%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.0	28.0	26.6	26.0	25.8	25.8	26.1	26.5	27.0	27.7
Medium Car	42.7	38.0	35.8	34.7	34.1	33.9	33.9	34.2	34.6	35.1
Large Car	56.8	50.2	47.1	45.4	44.4	43.9	43.7	43.8	44.0	44.4
Courier Van-Utility	47.6	43.3	41.4	40.6	40.5	40.7	41.2	41.9	42.9	44.0
4WD Mid-Size Petrol	50.5	46.3	44.5	43.8	43.7	43.9	44.5	45.4	46.4	47.7
Light Rigid	61.1	57.3	56.0	55.8	56.3	57.3	58.7	60.5	62.6	64.9
Medium Rigid	77.5	70.1	67.4	66.9	67.7	69.4	71.8	74.9	78.6	82.8
Heavy Rigid	105.6	94.4	90.7	90.5	92.4	96.0	100.9	106.9	114.1	122.2
Heavy Bus	159.8	143.9	137.3	134.7	134.4	135.6	138.1	141.5	145.8	150.8
Artic 4 Axle	141.9	129.4	125.8	126.6	130.0	135.5	142.8	151.6	161.9	173.5
Artic 5 Axle	155.0	141.8	137.4	137.1	139.4	143.5	149.2	156.2	164.5	173.9
Artic 6 Axle	167.7	153.8	149.1	148.6	150.9	155.0	160.8	167.9	176.3	185.9
Rigid + 5 Axle Dog	175.3	162.3	158.7	159.6	163.5	169.6	177.6	187.3	198.6	211.3
B-Double	199.5	183.9	179.0	179.2	182.5	188.2	195.9	205.2	216.2	228.7
Twin steer+5 Axle Dog	195.8	180.9	176.4	177.0	180.7	186.8	194.8	204.7	216.2	229.2
A-Double	243.7	225.0	219.1	219.3	223.2	229.9	238.9	250.1	263.1	277.9
B Triple	286.1	263.4	255.4	254.2	257.1	263.0	271.3	281.7	294.1	308.3
A B Combination	276.2	256.1	250.2	251.1	256.2	264.6	275.7	289.2	304.9	322.8
A-Triple	313.0	290.7	284.2	285.1	290.8	300.1	312.4	327.4	344.9	364.7
Double B-Double	314.8	293.1	287.0	288.4	294.6	304.5	317.4	333.1	351.3	371.9

Table 91 Vehicle operating costs for rural roads (cents/km) – D10

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99’/km)	Curvy (100-299’/km)	Very curvy (300’+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 5, NRM = 131; Gradient = 4%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.4	28.2	26.7	26.1	25.9	25.9	26.2	26.6	27.1	27.8
Medium Car	43.3	38.3	36.0	34.8	34.2	34.0	34.1	34.3	34.8	35.3
Large Car	57.5	50.6	47.3	45.5	44.5	44.0	43.9	44.0	44.3	44.7
Courier Van-Utility	49.2	44.7	42.7	41.6	41.2	41.0	41.1	41.4	41.9	42.4
4WD Mid-Size Petrol	51.3	47.1	45.2	44.3	43.9	43.9	44.2	44.6	45.3	46.1
Light Rigid	64.6	60.2	58.5	57.9	58.0	58.5	59.5	60.7	62.2	64.0
Medium Rigid	84.9	77.4	73.9	72.2	71.5	71.3	71.5	72.1	73.0	74.1
Heavy Rigid	129.8	118.7	113.4	110.6	109.2	108.5	108.4	108.8	109.5	110.5
Heavy Bus	178.7	164.3	156.8	152.0	148.6	145.8	143.4	141.3	139.2	137.2
Artic 4 Axle	178.2	163.4	157.0	154.1	153.2	153.7	155.1	157.3	160.2	163.6
Artic 5 Axle	197.9	182.7	175.9	172.7	171.4	171.4	172.3	174.0	176.3	179.1
Artic 6 Axle	213.5	197.9	190.8	187.3	185.7	185.3	185.9	187.1	188.8	191.1
Rigid + 5 Axle Dog	240.0	225.5	219.0	215.8	214.5	214.3	215.1	216.5	218.4	220.9
B-Double	267.6	250.9	243.1	238.9	236.6	235.5	235.2	235.5	236.3	237.5
Twin steer+5 Axle Dog	266.2	249.9	242.5	238.7	236.9	236.3	236.6	237.6	239.2	241.3
A-Double	333.3	314.0	304.3	298.5	294.6	291.9	289.8	288.2	286.9	285.8
B Triple	380.1	356.9	344.9	337.3	331.8	327.4	323.7	320.3	317.2	314.1
A B Combination	388.6	367.4	356.5	349.7	344.8	340.9	337.7	334.9	332.2	329.7
A-Triple	445.7	421.4	408.9	400.8	395.0	390.3	386.3	382.6	379.1	375.7
Double B-Double	452.2	428.3	416.1	408.4	402.9	398.6	395.1	391.9	389.0	386.3

IRI = 5, NRM = 131; Gradient = 4%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.4	28.2	26.8	26.1	25.9	26.0	26.2	26.6	27.1	27.8
Medium Car	43.2	38.3	36.0	34.9	34.3	34.0	34.1	34.3	34.7	35.3
Large Car	57.4	50.6	47.4	45.6	44.6	44.1	43.9	44.0	44.2	44.6
Courier Van-Utility	49.2	44.8	42.7	41.7	41.2	41.0	41.1	41.4	41.9	42.4
4WD Mid-Size Petrol	51.3	47.1	45.2	44.3	44.0	44.0	44.3	44.8	45.5	46.3
Light Rigid	64.5	60.3	58.6	58.0	58.0	58.4	59.2	60.3	61.6	63.2
Medium Rigid	84.7	77.5	74.1	72.4	71.6	71.4	71.6	72.0	72.8	73.7
Heavy Rigid	129.8	118.7	113.5	110.8	109.3	108.6	108.5	108.8	109.4	110.4
Heavy Bus	178.8	164.3	156.8	152.1	148.6	145.9	143.6	141.6	139.6	137.7
Artic 4 Axle	177.6	163.7	157.5	154.5	153.2	153.1	153.8	155.2	157.1	159.5
Artic 5 Axle	197.3	183.0	176.4	173.1	171.6	171.1	171.5	172.4	173.9	175.8
Artic 6 Axle	212.9	198.3	191.4	187.8	186.0	185.2	185.2	185.8	186.9	188.3
Rigid + 5 Axle Dog	239.6	225.6	219.3	216.3	215.1	215.0	215.8	217.2	219.2	221.7
B-Double	267.3	251.0	243.4	239.4	237.4	236.6	236.7	237.4	238.7	240.4
Twin steer+5 Axle Dog	265.8	250.0	242.8	239.3	237.6	237.2	237.8	239.0	240.8	243.1
A-Double	333.0	314.0	304.7	299.3	295.9	293.6	292.2	291.2	290.7	290.4
B Triple	379.7	357.0	345.3	338.1	332.9	328.9	325.6	322.6	320.0	317.4
A B Combination	388.2	367.7	357.1	350.6	345.9	342.3	339.2	336.6	334.2	331.9
A-Triple	445.3	421.8	409.6	401.8	396.0	391.3	387.3	383.5	379.9	376.4
Double B-Double	451.7	428.7	416.9	409.4	404.1	400.0	396.6	393.5	390.7	388.0

IRI=5, NRM =131; Gradient = 4%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.3	28.2	26.9	26.3	26.0	26.1	26.3	26.7	27.2	27.8
Medium Car	43.1	38.4	36.2	35.0	34.4	34.2	34.2	34.4	34.8	35.2
Large Car	57.3	50.7	47.6	45.9	44.9	44.3	44.1	44.1	44.2	44.5
Courier Van-Utility	49.2	44.8	42.9	41.9	41.5	41.4	41.6	42.0	42.5	43.2
4WD Mid-Size Petrol	51.3	47.1	45.3	44.6	44.4	44.5	45.0	45.7	46.6	47.7
Light Rigid	64.4	60.4	58.8	58.2	58.2	58.6	59.3	60.3	61.6	63.0
Medium Rigid	84.5	77.7	74.6	73.1	72.4	72.3	72.5	73.1	74.0	75.0
Heavy Rigid	129.5	119.0	114.1	111.5	110.2	109.6	109.5	109.9	110.5	111.5
Heavy Bus	178.7	164.4	157.1	152.7	149.7	147.4	145.7	144.2	143.0	141.9
Artic 4 Axle	177.2	164.2	158.3	155.4	154.2	154.1	154.7	155.9	157.7	159.9
Artic 5 Axle	196.7	183.5	177.4	174.1	172.4	171.7	171.7	172.1	173.0	174.2
Artic 6 Axle	212.4	198.8	192.4	188.9	187.0	186.1	185.9	186.2	186.8	187.8
Rigid + 5 Axle Dog	239.3	225.9	220.1	217.7	217.1	217.7	219.3	221.6	224.7	228.3
B-Double	267.0	251.3	244.2	240.8	239.5	239.5	240.4	242.1	244.4	247.3
Twin steer+5 Axle Dog	265.4	250.4	243.7	240.7	239.7	239.9	241.2	243.2	245.9	249.2
A-Double	332.7	314.3	305.7	301.1	298.7	297.6	297.5	298.1	299.3	300.9
B Triple	379.4	357.3	346.3	339.8	335.4	332.4	330.1	328.4	327.0	326.0
A B Combination	387.9	368.2	358.3	352.3	348.2	345.3	343.0	341.1	339.6	338.3
A-Triple	444.9	422.6	411.0	403.5	398.1	393.7	389.9	386.4	383.1	379.8
Double B-Double	451.4	429.4	418.2	411.2	406.3	402.6	399.5	396.9	394.5	392.3

Table 92 Vehicle operating costs for rural roads (cents/km) – D11

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 5, NRM =131; Gradient = 6%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.9	28.7	27.2	26.5	26.3	26.3	26.5	26.9	27.4	28.0
Medium Car	44.0	39.0	36.6	35.4	34.8	34.5	34.5	34.7	35.0	35.5
Large Car	58.1	51.3	48.0	46.2	45.2	44.7	44.5	44.5	44.7	45.1
Courier Van-Utility	51.1	47.0	45.0	43.9	43.2	42.7	42.5	42.3	42.2	42.3
4WD Mid-Size Petrol	53.2	48.8	46.8	45.8	45.3	45.1	45.2	45.4	45.8	46.4
Light Rigid	68.7	64.3	62.4	61.6	61.4	61.5	61.9	62.6	63.5	64.5
Medium Rigid	92.6	85.0	81.5	79.7	78.9	78.6	78.7	79.2	79.9	80.9
Heavy Rigid	151.3	139.9	134.3	131.1	129.1	127.8	127.0	126.5	126.3	126.2
Heavy Bus	195.1	181.1	173.5	168.1	163.8	160.0	156.3	152.6	148.8	144.9
Artic 4 Axle	209.5	194.5	187.2	183.1	180.6	179.0	178.1	177.7	177.6	177.8
Artic 5 Axle	234.1	218.7	211.4	207.4	205.2	204.0	203.5	203.6	204.1	205.0
Artic 6 Axle	253.3	237.5	229.9	225.7	223.2	221.9	221.2	221.1	221.5	222.1
Rigid + 5 Axle Dog	293.7	278.2	270.9	267.1	265.0	264.1	263.9	264.3	265.2	266.5
B-Double	325.0	307.1	298.5	293.5	290.5	288.5	287.4	286.7	286.5	286.6
Twin steer+5 Axle Dog	325.6	308.3	300.1	295.6	293.1	291.8	291.4	291.6	292.2	293.3
A-Double	407.1	385.3	374.3	367.6	362.9	359.5	356.9	354.7	352.8	351.1
B Triple	457.1	430.9	417.1	408.3	401.7	396.3	391.6	387.2	383.0	378.8
A B Combination	479.1	454.1	442.8	437.2	434.7	434.3	435.3	437.5	440.6	444.5
A-Triple	551.5	523.4	511.9	507.9	508.1	511.3	516.7	524.1	533.1	543.7
Double B-Double	562.0	534.6	524.0	521.1	522.7	527.4	534.7	544.1	555.5	568.6

IRI = 5, NRM = 131; Gradient = 6%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.8	28.7	27.3	26.6	26.3	26.3	26.5	26.9	27.3	27.9
Medium Car	43.9	39.0	36.7	35.5	34.8	34.6	34.5	34.7	35.0	35.4
Large Car	58.1	51.3	48.1	46.3	45.3	44.7	44.5	44.5	44.7	45.0
Courier Van-Utility	51.1	47.1	45.1	43.9	43.2	42.7	42.4	42.3	42.2	42.1
4WD Mid-Size Petrol	53.2	48.9	46.9	45.9	45.4	45.2	45.3	45.5	45.9	46.4
Light Rigid	68.6	64.4	62.6	61.7	61.4	61.4	61.7	62.2	62.9	63.7
Medium Rigid	92.4	85.1	81.7	79.9	79.0	78.6	78.6	78.9	79.5	80.3
Heavy Rigid	151.3	139.9	134.4	131.3	129.4	128.2	127.5	127.2	127.1	127.2
Heavy Bus	195.0	181.1	173.4	168.1	163.7	159.9	156.2	152.5	148.7	144.8
Artic 4 Axle	209.0	194.7	187.8	184.0	181.8	180.6	180.0	179.8	180.1	180.7
Artic 5 Axle	233.7	218.8	211.9	208.3	206.5	205.9	206.0	206.8	208.0	209.7
Artic 6 Axle	253.1	237.5	230.3	226.5	224.6	223.9	224.0	224.7	225.9	227.6
Rigid + 5 Axle Dog	293.4	278.5	271.7	268.2	266.7	266.2	266.6	267.7	269.3	271.4
B-Double	324.5	307.4	299.2	294.6	292.0	290.6	290.0	289.9	290.3	291.1
Twin steer+5 Axle Dog	325.2	308.5	300.8	296.8	294.9	294.2	294.4	295.3	296.7	298.6
A-Double	406.7	385.8	375.4	369.1	364.9	361.9	359.6	357.9	356.4	355.3
B Triple	456.6	431.4	418.2	409.7	403.4	398.2	393.7	389.5	385.5	381.5
A B Combination	478.9	455.0	444.5	439.8	438.2	438.8	441.0	444.4	448.9	454.3
A-Triple	551.4	524.7	514.4	511.7	513.4	518.2	525.4	534.8	546.2	559.2
Double B-Double	561.9	535.9	526.8	525.3	528.6	535.3	544.7	556.6	570.7	586.8

IRI =5, NRM =131; Gradient = 6%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	31.8	28.7	27.3	26.7	26.4	26.4	26.6	26.9	27.4	28.0
Medium Car	43.8	39.1	36.8	35.6	35.0	34.7	34.7	34.8	35.1	35.5
Large Car	57.9	51.4	48.2	46.5	45.5	44.9	44.7	44.6	44.8	45.0
Courier Van-Utility	51.1	47.1	45.2	44.1	43.4	42.9	42.7	42.5	42.4	42.4
4WD Mid-Size Petrol	53.2	48.9	47.0	46.0	45.6	45.6	45.8	46.1	46.7	47.4
Light Rigid	68.5	64.5	62.8	61.9	61.5	61.5	61.6	62.0	62.5	63.1
Medium Rigid	92.2	85.3	82.0	80.3	79.4	79.0	79.0	79.2	79.6	80.2
Heavy Rigid	151.2	140.0	134.8	132.0	130.5	129.8	129.7	130.0	130.7	131.6
Heavy Bus	195.0	181.1	173.6	168.5	164.4	160.9	157.5	154.2	150.8	147.4
Artic 4 Axle	208.7	195.2	188.9	185.6	183.9	183.1	183.1	183.7	184.6	186.0
Artic 5 Axle	233.5	219.1	212.8	209.8	208.6	208.7	209.7	211.4	213.7	216.5
Artic 6 Axle	252.8	237.8	231.2	228.0	226.9	227.0	228.0	229.8	232.2	235.2
Rigid + 5 Axle Dog	293.1	278.9	272.8	270.1	269.4	270.0	271.5	273.8	276.8	280.5
B-Double	324.2	307.9	300.3	296.5	294.8	294.2	294.6	295.7	297.4	299.6
Twin steer+5 Axle Dog	324.9	309.0	302.0	298.8	297.8	298.1	299.5	301.7	304.7	308.2
A-Double	406.4	386.6	376.8	371.1	367.4	365.0	363.2	362.0	361.2	360.7
B Triple	456.3	432.3	419.8	411.6	405.6	400.6	396.1	392.0	388.0	384.0
A B Combination	478.8	456.2	446.7	443.1	442.7	444.6	448.2	453.2	459.4	466.8
A-Triple	551.5	526.4	517.6	516.4	519.9	526.7	536.4	548.4	562.6	578.8
Double B-Double	562.1	537.7	530.2	530.6	536.0	545.1	557.4	572.4	589.9	609.9

Table 93 Vehicle operating costs for rural roads (cents/km) – D12

IRI = 5, NRM = 131; Gradient = 8%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	32.9	29.7	28.2	27.5	27.1	27.0	27.1	27.3	27.7	28.1
Medium Car	45.3	40.3	38.0	36.7	35.9	35.5	35.3	35.3	35.4	35.7
Large Car	59.7	52.8	49.5	47.6	46.5	45.8	45.4	45.3	45.3	45.4
Courier Van-Utility	53.3	49.5	47.5	46.3	45.5	44.8	44.3	43.8	43.4	43.0
4WD Mid-Size Petrol	55.5	51.4	49.4	48.3	47.6	47.2	46.9	46.8	46.7	46.8
Light Rigid	73.5	69.2	67.1	66.1	65.5	65.3	65.3	65.5	65.8	66.2
Medium Rigid	100.8	93.4	89.9	88.0	86.9	86.3	86.1	86.2	86.4	86.9
Heavy Rigid	175.7	163.6	157.5	153.9	151.4	149.7	148.4	147.3	146.5	145.8
Heavy Bus	213.3	199.5	191.4	185.2	179.8	174.5	169.2	163.6	157.8	151.5
Artic 4 Axle	245.3	228.4	220.2	215.4	212.3	210.3	209.0	208.2	207.7	207.4
Artic 5 Axle	274.7	257.9	249.8	245.3	242.5	240.9	240.0	239.7	239.7	240.1
Artic 6 Axle	298.2	280.9	272.5	267.7	264.8	262.9	261.8	261.3	261.1	261.3
Rigid + 5 Axle Dog	354.6	337.0	329.0	325.1	323.4	323.1	323.8	325.4	327.6	330.4
B-Double	389.6	369.4	359.9	354.8	352.0	350.7	350.4	350.9	352.0	353.6
Twin steer+5 Axle Dog	393.0	373.4	364.4	359.8	357.6	356.9	357.2	358.4	360.3	362.8
A-Double	490.3	465.3	454.6	450.2	449.4	450.9	454.2	458.9	465.0	472.2
B Triple	543.4	513.6	500.6	494.9	493.2	494.1	497.0	501.6	507.5	514.6
A B Combination	580.8	555.1	548.0	550.0	557.7	569.8	585.6	604.7	627.0	652.2
A-Triple	671.9	645.7	642.6	651.4	668.4	691.9	721.3	755.9	795.7	840.3
Double B-Double	687.4	662.4	660.8	671.4	690.5	716.5	748.7	786.6	830.0	878.6

Use this page to look up VOC values for the following highlighted road conditions

Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 5, NRM = 131; Gradient = 8%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	32.9	29.7	28.3	27.5	27.2	27.0	27.1	27.3	27.6	28.0
Medium Car	45.2	40.4	38.0	36.7	36.0	35.5	35.3	35.3	35.3	35.5
Large Car	59.6	52.8	49.5	47.7	46.5	45.8	45.4	45.2	45.2	45.3
Courier Van-Utility	53.3	49.5	47.6	46.3	45.5	44.8	44.3	43.8	43.4	42.9
4WD Mid-Size Petrol	55.5	51.5	49.5	48.3	47.6	47.2	46.9	46.8	46.7	46.8
Light Rigid	73.4	69.2	67.2	66.2	65.6	65.2	65.1	65.1	65.3	65.5
Medium Rigid	100.7	93.5	90.0	88.1	87.0	86.3	86.0	85.9	86.0	86.3
Heavy Rigid	175.7	163.6	157.7	154.1	151.8	150.2	149.0	148.2	147.5	147.0
Heavy Bus	213.3	199.5	191.3	185.2	179.7	174.5	169.1	163.5	157.6	151.3
Artic 4 Axle	244.8	229.1	221.4	216.8	213.9	211.9	210.6	209.6	209.0	208.6
Artic 5 Axle	274.2	258.3	250.8	246.6	244.3	243.0	242.5	242.5	243.0	243.8
Artic 6 Axle	297.7	281.2	273.4	269.0	266.6	265.2	264.7	264.7	265.1	265.9
Rigid + 5 Axle Dog	354.3	337.7	330.4	327.1	326.1	326.6	328.2	330.6	333.8	337.7
B-Double	389.2	370.1	361.3	356.8	354.7	354.1	354.5	355.8	357.7	360.2
Twin steer+5 Axle Dog	392.6	374.1	365.8	361.9	360.3	360.3	361.5	363.5	366.3	369.8
A-Double	490.0	466.5	457.0	453.7	454.1	457.0	461.8	468.3	476.2	485.5
B Triple	543.2	515.0	503.4	498.9	498.6	501.1	505.8	512.3	520.4	529.9
A B Combination	580.9	557.2	552.1	556.1	566.3	581.2	600.3	623.0	649.3	678.9
A-Triple	672.7	649.0	648.5	660.3	680.7	708.3	742.2	782.0	827.4	878.3
Double B-Double	688.1	665.7	666.8	680.6	703.4	733.7	770.7	814.0	863.4	918.7

IRI =5, NRM =131; Gradient = 8%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	32.8	29.8	28.4	27.6	27.3	27.1	27.1	27.2	27.4	27.7
Medium Car	45.1	40.5	38.2	36.9	36.1	35.6	35.3	35.2	35.1	35.2
Large Car	59.5	52.9	49.7	47.9	46.7	45.9	45.4	45.1	45.0	44.9
Courier Van-Utility	53.3	49.5	47.6	46.4	45.6	45.0	44.5	44.1	43.7	43.3
4WD Mid-Size Petrol	55.5	51.5	49.6	48.5	47.8	47.5	47.3	47.2	47.2	47.3
Light Rigid	73.3	69.3	67.4	66.3	65.7	65.2	65.0	64.8	64.8	64.8
Medium Rigid	100.5	93.6	90.3	88.4	87.2	86.5	86.1	85.9	85.8	85.9
Heavy Rigid	175.5	163.9	158.2	155.1	153.3	152.2	151.7	151.5	151.7	152.1
Heavy Bus	213.2	199.5	191.5	185.5	180.2	175.0	169.9	164.5	158.7	152.7
Artic 4 Axle	244.6	230.1	223.0	218.8	216.2	214.5	213.3	212.6	212.1	211.9
Artic 5 Axle	273.9	259.0	252.1	248.6	246.8	246.2	246.3	247.1	248.4	250.1
Artic 6 Axle	297.3	281.8	274.7	271.0	269.3	268.7	269.0	270.0	271.5	273.4
Rigid + 5 Axle Dog	354.2	338.6	332.2	329.8	329.8	331.3	334.0	337.8	342.4	347.9
B-Double	389.0	371.0	363.1	359.4	358.2	358.4	359.8	362.2	365.3	369.1
Twin steer+5 Axle Dog	392.4	375.1	367.7	364.7	364.1	365.1	367.4	370.7	374.9	379.9
A-Double	490.1	468.1	459.9	457.9	459.8	464.2	470.9	479.4	489.5	501.2
B Triple	543.3	516.9	506.6	503.6	504.9	509.2	515.8	524.5	535.0	547.1
A B Combination	581.4	559.9	557.0	563.8	577.1	595.7	618.9	646.4	677.9	713.3
A-Triple	673.6	652.8	655.5	671.2	696.2	729.1	769.1	815.8	868.9	928.3
Double B-Double	689.2	669.8	674.3	692.2	719.8	755.8	799.3	850.0	907.6	971.9

Table 94 Vehicle operating costs for rural roads (cents/km) – D13

IRI = 7, NRM = 184; Gradient = 0%; Curvature = Straight (20 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	32.9	29.7	28.3	27.6	27.4	27.5	27.8	28.2	28.8	29.5
Medium Car	45.2	40.2	37.9	36.7	36.2	36.0	36.1	36.4	36.9	37.5
Large Car	59.9	53.0	49.7	47.9	47.0	46.5	46.4	46.5	46.9	47.4
Courier Van-Utility	52.3	48.0	46.0	45.1	44.8	44.8	45.1	45.6	46.3	47.1
4WD Mid-Size Petrol	55.0	50.7	48.9	48.0	47.7	47.8	48.1	48.7	49.4	50.3
Light Rigid	67.3	63.5	62.0	61.7	62.1	62.9	64.2	65.7	67.6	69.7
Medium Rigid	83.6	76.5	73.5	72.3	72.0	72.4	73.3	74.6	76.3	78.3
Heavy Rigid	116.7	106.0	101.6	100.2	100.4	101.7	104.0	107.0	110.7	115.0
Heavy Bus	176.2	160.7	153.5	149.8	147.9	147.2	147.3	148.0	149.2	150.9
Artic 4 Axle	158.1	145.6	140.8	139.5	140.2	142.4	145.8	150.1	155.3	161.4
Artic 5 Axle	173.0	159.4	154.1	152.3	152.7	154.6	157.6	161.6	166.5	172.2
Artic 6 Axle	187.4	173.1	167.3	165.4	165.6	167.4	170.3	174.3	179.1	184.8
Rigid + 5 Axle Dog	194.0	181.2	176.2	174.8	175.4	177.5	180.8	185.1	190.3	196.3
B-Double	223.0	207.5	201.2	198.9	198.9	200.5	203.4	207.3	212.1	217.7
Twin steer+5 Axle Dog	217.8	203.0	197.1	195.0	195.2	197.0	200.0	204.0	208.9	214.6
A-Double	273.3	255.1	247.4	244.2	243.6	244.8	247.3	250.8	255.3	260.7
B Triple	322.3	299.9	290.0	285.4	283.8	284.1	285.9	288.8	292.7	297.4
A B Combination	309.6	290.4	282.2	278.8	278.1	279.1	281.6	285.1	289.7	295.1
A-Triple	351.1	329.7	320.4	316.4	315.2	316.0	318.2	321.6	326.0	331.3
Double B-Double	352.8	332.1	323.2	319.4	318.5	319.4	321.8	325.4	330.0	335.4

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 7, NRM = 184; Gradient = 0%; Curvature = Curvy/Hilly/Winding (120 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	32.9	29.7	28.3	27.7	27.5	27.5	27.8	28.2	28.8	29.4
Medium Car	45.2	40.3	38.0	36.8	36.2	36.0	36.1	36.4	36.8	37.4
Large Car	59.8	53.0	49.8	48.0	47.1	46.6	46.4	46.5	46.8	47.3
Courier Van-Utility	52.3	48.0	46.1	45.2	44.9	44.9	45.2	45.8	46.5	47.4
4WD Mid-Size Petrol	55.0	50.7	48.9	48.0	47.8	47.9	48.2	48.8	49.6	50.6
Light Rigid	67.3	63.5	62.1	61.8	62.2	63.0	64.2	65.7	67.6	69.7
Medium Rigid	83.7	76.5	73.5	72.4	72.2	72.8	74.0	75.5	77.5	79.8
Heavy Rigid	116.8	105.9	101.6	100.3	100.8	102.5	105.2	108.7	112.9	117.9
Heavy Bus	176.4	160.7	153.5	149.9	148.3	147.9	148.4	149.6	151.4	153.7
Artic 4 Axle	158.1	145.7	141.1	140.0	141.0	143.6	147.3	152.1	157.8	164.4
Artic 5 Axle	172.9	159.6	154.4	152.8	153.4	155.4	158.7	162.9	168.0	174.0
Artic 6 Axle	187.3	173.3	167.7	165.9	166.3	168.2	171.4	175.6	180.6	186.6
Rigid + 5 Axle Dog	194.1	181.2	176.4	175.3	176.3	179.0	182.8	187.8	193.7	200.5
B-Double	223.0	207.6	201.4	199.4	199.9	202.0	205.4	210.0	215.5	222.0
Twin steer+5 Axle Dog	217.8	203.1	197.4	195.6	196.3	198.6	202.2	207.0	212.7	219.3
A-Double	273.4	255.1	247.6	244.9	244.9	246.8	250.1	254.6	260.3	266.9
B Triple	322.4	300.0	290.3	286.1	285.1	286.1	288.7	292.5	297.4	303.3
A B Combination	309.8	290.4	282.4	279.6	279.6	281.7	285.3	290.2	296.3	303.4
A-Triple	351.1	329.7	320.7	317.3	317.0	318.9	322.4	327.2	333.3	340.4
Double B-Double	352.9	332.1	323.5	320.4	320.4	322.5	326.3	331.4	337.8	345.2

IRI =7, NRM =184; Gradient = 0%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)										
Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	32.8	29.8	28.4	27.8	27.6	27.6	27.9	28.3	28.8	29.5
Medium Car	45.1	40.3	38.1	37.0	36.4	36.2	36.3	36.5	36.9	37.5
Large Car	59.7	53.1	50.0	48.3	47.3	46.8	46.6	46.7	46.9	47.3
Courier Van-Utility	52.3	48.0	46.2	45.4	45.2	45.4	45.9	46.7	47.6	48.8
4WD Mid-Size Petrol	55.0	50.8	49.0	48.3	48.2	48.5	49.0	49.9	50.9	52.2
Light Rigid	67.3	63.5	62.2	62.0	62.5	63.5	64.9	66.7	68.8	71.1
Medium Rigid	84.0	76.6	73.9	73.3	74.1	75.8	78.2	81.3	85.0	89.3
Heavy Rigid	117.2	106.0	102.3	102.1	104.0	107.6	112.5	118.5	125.7	133.8
Heavy Bus	176.6	160.8	154.1	151.5	151.2	152.4	154.9	158.3	162.6	167.7
Artic 4 Axle	158.6	146.1	142.5	143.2	146.7	152.2	159.4	168.3	178.5	190.2
Artic 5 Axle	173.1	160.0	155.6	155.3	157.5	161.7	167.3	174.3	182.6	192.0
Artic 6 Axle	187.6	173.6	168.9	168.5	170.7	174.8	180.6	187.7	196.1	205.7
Rigid + 5 Axle Dog	194.6	181.6	178.0	178.9	182.8	188.9	196.9	206.6	217.8	230.6
B-Double	223.5	207.9	203.1	203.2	206.5	212.2	219.9	229.3	240.3	252.8
Twin steer+5 Axle Dog	218.4	203.5	199.0	199.6	203.3	209.4	217.4	227.3	238.8	251.8
A-Double	274.2	255.5	249.6	249.8	253.7	260.4	269.4	280.5	293.5	308.3
B Triple	323.1	300.4	292.4	291.2	294.1	300.0	308.3	318.8	331.2	345.3
A B Combination	310.7	290.7	284.8	285.6	290.7	299.1	310.2	323.7	339.4	357.3
A-Triple	352.3	330.0	323.5	324.4	330.1	339.4	351.7	366.7	384.2	404.0
Double B-Double	354.1	332.5	326.4	327.8	334.0	343.8	356.7	372.4	390.6	411.3

Table 95 Vehicle operating costs for rural roads (cents/km) – D14

IRI = 7, NRM = 184; Gradient = 4%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	33.2	30.0	28.5	27.9	27.7	27.7	28.0	28.4	28.9	29.6
Medium Car	45.6	40.6	38.3	37.1	36.5	36.3	36.4	36.7	37.1	37.7
Large Car	60.4	53.4	50.2	48.4	47.4	46.9	46.8	46.9	47.1	47.6
Courier Van-Utility	53.9	49.5	47.4	46.4	45.9	45.7	45.8	46.1	46.6	47.2
4WD Mid-Size Petrol	55.8	51.6	49.7	48.8	48.4	48.4	48.7	49.2	49.8	50.6
Light Rigid	70.8	66.4	64.6	64.0	64.1	64.7	65.6	66.9	68.4	70.1
Medium Rigid	91.3	83.8	80.4	78.7	77.9	77.7	78.0	78.6	79.4	80.5
Heavy Rigid	141.5	130.3	125.0	122.3	120.8	120.1	120.1	120.4	121.1	122.1
Heavy Bus	195.5	181.1	173.6	168.8	165.4	162.6	160.2	158.0	156.0	154.0
Artic 4 Axle	195.1	180.4	174.0	171.1	170.2	170.6	172.0	174.2	177.1	180.6
Artic 5 Axle	216.3	201.1	194.3	191.1	189.8	189.8	190.8	192.4	194.7	197.5
Artic 6 Axle	233.6	218.0	210.9	207.4	205.8	205.4	206.0	207.2	208.9	211.2
Rigid + 5 Axle Dog	259.4	244.9	238.4	235.2	233.9	233.8	234.5	235.9	237.9	240.3
B-Double	291.8	275.2	267.3	263.1	260.8	259.7	259.4	259.7	260.5	261.7
Twin steer+5 Axle Dog	289.0	272.8	265.4	261.6	259.8	259.2	259.5	260.5	262.1	264.2
A-Double	363.8	344.5	334.8	329.0	325.2	322.4	320.3	318.7	317.4	316.3
B Triple	417.2	394.0	382.0	374.4	368.9	364.5	360.8	357.4	354.2	351.2
A B Combination	423.0	401.8	390.9	384.0	379.1	375.3	372.1	369.2	366.6	364.0
A-Triple	484.8	460.5	448.0	439.9	434.1	429.4	425.4	421.7	418.2	414.8
Double B-Double	491.2	467.3	455.1	447.4	441.9	437.7	434.1	430.9	428.1	425.3

Use this page to look up VOC values for the following highlighted road conditions

Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 7, NRM = 184; Gradient = 4%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	33.1	30.0	28.6	27.9	27.7	27.7	28.0	28.4	28.9	29.6
Medium Car	45.6	40.6	38.4	37.2	36.6	36.4	36.4	36.7	37.1	37.6
Large Car	60.3	53.5	50.2	48.5	47.5	47.0	46.8	46.9	47.1	47.5
Courier Van-Utility	53.9	49.5	47.4	46.4	45.9	45.8	45.9	46.1	46.6	47.2
4WD Mid-Size Petrol	55.8	51.6	49.7	48.8	48.5	48.5	48.8	49.3	50.0	50.8
Light Rigid	70.7	66.5	64.7	64.1	64.1	64.6	65.4	66.5	67.8	69.4
Medium Rigid	91.1	83.9	80.5	78.8	78.0	77.8	78.0	78.4	79.2	80.1
Heavy Rigid	141.3	130.3	125.1	122.3	120.9	120.2	120.1	120.4	121.0	121.9
Heavy Bus	195.5	181.1	173.6	168.8	165.4	162.7	160.4	158.3	156.4	154.5
Artic 4 Axle	194.5	180.6	174.3	171.3	170.0	169.9	170.6	172.0	173.9	176.3
Artic 5 Axle	215.6	201.3	194.7	191.4	189.8	189.4	189.8	190.7	192.2	194.1
Artic 6 Axle	232.9	218.2	211.3	207.8	205.9	205.1	205.2	205.7	206.8	208.3
Rigid + 5 Axle Dog	258.9	244.9	238.6	235.6	234.4	234.3	235.1	236.5	238.5	241.0
B-Double	291.4	275.1	267.5	263.5	261.5	260.7	260.8	261.5	262.8	264.5
Twin steer+5 Axle Dog	288.5	272.8	265.6	262.0	260.4	260.0	260.5	261.7	263.5	265.8
A-Double	363.4	344.4	335.1	329.7	326.3	324.0	322.6	321.6	321.1	320.8
B Triple	416.6	393.9	382.3	375.0	369.8	365.8	362.5	359.5	356.9	354.3
A B Combination	422.4	401.9	391.3	384.8	380.1	376.5	373.4	370.8	368.4	366.1
A-Triple	484.2	460.7	448.5	440.7	434.9	430.3	426.2	422.4	418.9	415.3
Double B-Double	490.6	467.6	455.7	448.3	443.0	438.9	435.4	432.4	429.6	426.9

IRI =7, NRM =184; Gradient = 4%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	33.1	30.0	28.7	28.1	27.8	27.9	28.1	28.5	29.0	29.6
Medium Car	45.5	40.7	38.5	37.4	36.8	36.5	36.5	36.7	37.1	37.6
Large Car	60.2	53.6	50.5	48.7	47.7	47.2	47.0	46.9	47.1	47.4
Courier Van-Utility	53.9	49.5	47.6	46.6	46.2	46.1	46.3	46.7	47.3	47.9
4WD Mid-Size Petrol	55.8	51.6	49.8	49.1	48.9	49.0	49.5	50.2	51.1	52.2
Light Rigid	70.6	66.6	64.9	64.3	64.3	64.8	65.5	66.5	67.7	69.2
Medium Rigid	90.9	84.1	81.0	79.4	78.8	78.6	78.9	79.5	80.3	81.4
Heavy Rigid	141.0	130.5	125.6	123.0	121.7	121.1	121.0	121.4	122.0	123.0
Heavy Bus	195.5	181.1	173.9	169.5	166.4	164.2	162.4	161.0	159.7	158.6
Artic 4 Axle	193.9	180.9	175.0	172.1	170.9	170.8	171.4	172.6	174.4	176.5
Artic 5 Axle	214.8	201.7	195.5	192.2	190.5	189.8	189.8	190.2	191.1	192.3
Artic 6 Axle	232.2	218.6	212.1	208.7	206.8	205.9	205.6	205.9	206.6	207.6
Rigid + 5 Axle Dog	258.4	245.0	239.2	236.8	236.2	236.8	238.4	240.8	243.8	247.4
B-Double	290.9	275.2	268.1	264.8	263.4	263.4	264.4	266.0	268.4	271.3
Twin steer+5 Axle Dog	288.0	273.0	266.3	263.3	262.2	262.5	263.8	265.8	268.5	271.7
A-Double	363.0	344.6	335.9	331.3	328.9	327.9	327.8	328.4	329.5	331.2
B Triple	416.2	394.1	383.1	376.6	372.2	369.1	366.9	365.1	363.8	362.7
A B Combination	422.0	402.2	392.3	386.3	382.3	379.3	377.0	375.2	373.7	372.3
A-Triple	483.7	461.4	449.8	442.3	436.9	432.5	428.7	425.2	421.9	418.6
Double B-Double	490.2	468.2	456.9	450.0	445.1	441.3	438.3	435.6	433.3	431.0

Table 96 Vehicle operating costs for rural roads (cents/km) – D15

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 7, NRM = 184; Gradient = 6%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr) 20	30	40	50	60	70	80	90	100	110
Small Car	33.6	30.4	29.0	28.3	28.1	28.1	28.3	28.6	29.1	29.8
Medium Car	46.3	41.3	39.0	37.7	37.1	36.8	36.8	37.0	37.4	37.8
Large Car	61.0	54.1	50.9	49.1	48.1	47.6	47.3	47.4	47.6	47.9
Courier Van-Utility	55.9	51.8	49.8	48.6	47.9	47.5	47.2	47.0	47.0	47.0
4WD Mid-Size Petrol	57.7	53.3	51.3	50.3	49.8	49.6	49.7	49.9	50.3	50.8
Light Rigid	74.9	70.6	68.7	67.8	67.6	67.7	68.1	68.8	69.7	70.7
Medium Rigid	99.0	91.5	88.0	86.2	85.3	85.1	85.2	85.7	86.4	87.3
Heavy Rigid	163.0	151.6	146.0	142.8	140.8	139.5	138.7	138.2	138.0	137.9
Heavy Bus	212.0	198.0	190.4	185.1	180.8	176.9	173.2	169.5	165.8	161.9
Artic 4 Axle	226.8	211.8	204.5	200.4	197.9	196.4	195.5	195.0	194.9	195.1
Artic 5 Axle	252.9	237.5	230.2	226.3	224.0	222.8	222.4	222.4	222.9	223.8
Artic 6 Axle	273.9	258.0	250.4	246.2	243.8	242.4	241.8	241.7	242.0	242.7
Rigid + 5 Axle Dog	313.6	298.1	290.9	287.0	284.9	284.0	283.8	284.2	285.1	286.4
B-Double	349.8	332.0	323.3	318.3	315.3	313.4	312.2	311.6	311.3	311.4
Twin steer+5 Axle Dog	349.1	331.8	323.6	319.2	316.7	315.4	315.0	315.1	315.8	316.9
A-Double	438.4	416.6	405.6	398.9	394.3	390.9	388.2	386.0	384.1	382.4
B Triple	495.0	468.7	455.0	446.1	439.6	434.2	429.5	425.1	420.9	416.7
A B Combination	514.5	489.5	478.1	472.5	470.1	469.6	470.7	472.8	475.9	479.8
A-Triple	591.8	563.7	552.2	548.2	548.4	551.6	557.0	564.4	573.4	584.0
Double B-Double	602.3	574.9	564.4	561.5	563.0	567.8	575.1	584.5	595.9	609.0

IRI = 7, NRM = 184; Gradient = 6%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr) 20	30	40	50	60	70	80	90	100	110
Small Car	33.6	30.5	29.0	28.4	28.1	28.1	28.3	28.6	29.1	29.7
Medium Car	46.2	41.3	39.0	37.8	37.2	36.9	36.8	37.0	37.3	37.8
Large Car	60.9	54.2	50.9	49.2	48.2	47.6	47.4	47.4	47.5	47.9
Courier Van-Utility	55.8	51.8	49.8	48.7	48.0	47.5	47.2	47.0	46.9	46.9
4WD Mid-Size Petrol	57.7	53.3	51.3	50.3	49.8	49.7	49.7	50.0	50.4	50.9
Light Rigid	74.8	70.6	68.8	67.9	67.6	67.6	67.9	68.4	69.1	69.9
Medium Rigid	98.9	91.5	88.1	86.3	85.4	85.0	85.1	85.4	85.9	86.7
Heavy Rigid	162.9	151.6	146.1	143.0	141.0	139.9	139.2	138.8	138.8	138.9
Heavy Bus	212.0	198.0	190.3	185.0	180.7	176.8	173.1	169.4	165.6	161.7
Artic 4 Axle	226.2	211.8	205.0	201.2	198.9	197.7	197.1	197.0	197.2	197.8
Artic 5 Axle	252.4	237.4	230.5	226.9	225.2	224.5	224.7	225.4	226.7	228.3
Artic 6 Axle	273.4	257.9	250.6	246.9	245.0	244.3	244.3	245.0	246.3	247.9
Rigid + 5 Axle Dog	313.1	298.2	291.4	288.0	286.4	285.9	286.4	287.4	289.0	291.1
B-Double	349.1	332.0	323.8	319.3	316.6	315.2	314.6	314.5	314.9	315.7
Twin steer+5 Axle Dog	348.5	331.9	324.1	320.2	318.2	317.5	317.7	318.6	320.1	322.0
A-Double	437.8	417.0	406.5	400.2	396.0	393.0	390.8	389.0	387.6	386.4
B Triple	494.3	469.1	455.9	447.4	441.1	435.9	431.4	427.2	423.1	419.1
A B Combination	514.0	490.1	479.7	474.9	473.4	474.0	476.2	479.6	484.1	489.5
A-Triple	591.5	564.8	554.6	551.8	553.5	558.3	565.6	575.0	586.3	599.4
Double B-Double	602.1	576.1	566.9	565.5	568.8	575.5	584.9	596.8	610.9	627.0

IRI =7, NRM =184; Gradient = 6%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr) 20	30	40	50	60	70	80	90	100	110
Small Car	33.6	30.5	29.1	28.5	28.2	28.2	28.4	28.7	29.2	29.7
Medium Car	46.2	41.4	39.1	37.9	37.3	37.0	37.0	37.1	37.4	37.8
Large Car	60.8	54.3	51.1	49.4	48.4	47.8	47.5	47.5	47.6	47.9
Courier Van-Utility	55.8	51.8	49.9	48.8	48.1	47.7	47.4	47.2	47.1	47.1
4WD Mid-Size Petrol	57.6	53.4	51.5	50.5	50.1	50.0	50.2	50.6	51.2	51.8
Light Rigid	74.7	70.7	68.9	68.1	67.7	67.6	67.8	68.2	68.7	69.3
Medium Rigid	98.6	91.7	88.4	86.7	85.8	85.4	85.4	85.6	86.0	86.6
Heavy Rigid	162.8	151.6	146.4	143.6	142.1	141.4	141.3	141.6	142.3	143.2
Heavy Bus	211.9	198.1	190.5	185.4	181.3	177.8	174.4	171.1	167.8	164.3
Artic 4 Axle	225.7	212.2	205.8	202.5	200.8	200.1	200.1	200.6	201.6	202.9
Artic 5 Axle	251.9	237.6	231.2	228.2	227.1	227.2	228.2	229.9	232.2	235.0
Artic 6 Axle	273.0	258.0	251.3	248.2	247.1	247.2	248.2	250.0	252.4	255.4
Rigid + 5 Axle Dog	312.6	298.4	292.3	289.6	288.9	289.5	291.0	293.4	296.4	300.0
B-Double	348.7	332.3	324.8	321.0	319.2	318.7	319.1	320.2	321.8	324.0
Twin steer+5 Axle Dog	348.1	332.2	325.2	322.0	321.0	321.3	322.7	324.9	327.8	331.4
A-Double	437.3	417.5	407.8	402.1	398.4	395.9	394.2	393.0	392.2	391.7
B Triple	493.8	469.8	457.3	449.1	443.1	438.1	433.6	429.5	425.5	421.5
A B Combination	513.8	491.2	481.7	478.1	477.7	479.6	483.2	488.2	494.4	501.8
A-Triple	591.5	566.3	557.5	556.3	559.8	566.7	576.3	588.3	602.5	618.7
Double B-Double	602.0	577.7	570.1	570.5	576.0	585.1	597.3	612.4	629.9	649.9

Table 97 Vehicle operating costs for rural roads (cents/km) – D16

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 7, NRM = 184; Gradient = 8%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	34.7	31.5	30.0	29.2	28.9	28.8	28.9	29.1	29.4	29.9
Medium Car	47.6	42.6	40.3	39.0	38.2	37.8	37.6	37.6	37.7	38.0
Large Car	62.5	55.6	52.3	50.4	49.3	48.6	48.3	48.1	48.1	48.3
Courier Van-Utility	58.1	54.2	52.3	51.1	50.2	49.6	49.0	48.6	48.1	47.7
4WD Mid-Size Petrol	60.0	55.9	53.9	52.8	52.1	51.7	51.4	51.3	51.2	51.3
Light Rigid	79.8	75.4	73.4	72.4	71.8	71.6	71.6	71.7	72.0	72.5
Medium Rigid	107.3	99.9	96.4	94.4	93.4	92.8	92.6	92.6	92.9	93.3
Heavy Rigid	187.5	175.3	169.3	165.6	163.2	161.4	160.1	159.1	158.3	157.6
Heavy Bus	230.5	216.6	208.5	202.3	196.9	191.6	186.3	180.7	174.9	168.6
Artic 4 Axle	263.1	246.3	238.0	233.2	230.2	228.2	226.9	226.0	225.5	225.3
Artic 5 Axle	294.0	277.3	269.2	264.6	261.9	260.3	259.4	259.0	259.1	259.4
Artic 6 Axle	319.2	302.0	293.6	288.8	285.8	284.0	282.9	282.4	282.2	282.4
Rigid + 5 Axle Dog	375.3	357.6	349.6	345.7	344.0	343.7	344.5	346.0	348.2	351.1
B-Double	415.4	395.1	385.6	380.5	377.7	376.4	376.1	376.6	377.7	379.3
Twin steer+5 Axle Dog	417.5	397.9	388.9	384.3	382.1	381.4	381.8	383.0	384.9	387.3
A-Double	522.8	497.8	487.2	482.8	481.9	483.4	486.7	491.5	497.5	504.7
B Triple	582.5	552.7	539.7	534.0	532.3	533.2	536.1	540.7	546.6	553.7
A B Combination	617.6	591.9	584.9	586.8	594.5	606.6	622.4	641.5	663.8	689.0
A-Triple	714.0	687.7	684.6	693.4	710.4	734.0	763.3	798.0	837.7	882.3
Double B-Double	729.6	704.6	703.0	713.6	732.7	758.7	790.9	828.8	872.1	920.7

IRI = 7, NRM = 184; Gradient = 8%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	34.6	31.5	30.0	29.3	28.9	28.8	28.9	29.1	29.3	29.7
Medium Car	47.5	42.7	40.4	39.1	38.3	37.8	37.6	37.6	37.6	37.8
Large Car	62.5	55.7	52.4	50.5	49.4	48.7	48.3	48.1	48.0	48.1
Courier Van-Utility	58.0	54.3	52.3	51.1	50.2	49.6	49.0	48.6	48.1	47.7
4WD Mid-Size Petrol	60.0	56.0	54.0	52.8	52.1	51.7	51.4	51.3	51.2	51.2
Light Rigid	79.6	75.5	73.5	72.4	71.8	71.5	71.4	71.4	71.5	71.7
Medium Rigid	107.1	99.9	96.5	94.5	93.4	92.8	92.4	92.4	92.5	92.7
Heavy Rigid	187.4	175.3	169.4	165.8	163.5	161.9	160.7	159.9	159.2	158.8
Heavy Bus	230.4	216.6	208.4	202.3	196.8	191.6	186.2	180.6	174.7	168.4
Artic 4 Axle	262.4	246.7	239.0	234.4	231.5	229.5	228.2	227.2	226.6	226.2
Artic 5 Axle	293.3	277.4	269.9	265.7	263.4	262.1	261.6	261.6	262.1	262.9
Artic 6 Axle	318.5	302.0	294.2	289.9	287.4	286.1	285.5	285.5	285.9	286.7
Rigid + 5 Axle Dog	374.6	358.0	350.7	347.5	346.5	346.9	348.5	351.0	354.2	358.0
B-Double	414.7	395.5	386.7	382.3	380.2	379.5	380.0	381.2	383.2	385.7
Twin steer+5 Axle Dog	416.8	398.3	390.0	386.1	384.6	384.6	385.7	387.8	390.6	394.0
A-Double	522.2	498.7	489.2	486.0	486.3	489.2	494.1	500.5	508.5	517.7
B Triple	582.1	553.9	542.2	537.8	537.5	540.0	544.7	551.2	559.2	568.7
A B Combination	617.4	593.7	588.5	592.6	602.8	617.7	636.7	659.5	685.8	715.4
A-Triple	714.4	690.7	690.2	702.0	722.4	750.0	783.9	823.7	869.1	920.1
Double B-Double	729.9	707.6	708.7	722.4	745.2	775.5	812.5	855.9	905.3	960.6

IRI =7, NRM =184; Gradient = 8%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	34.6	31.5	30.1	29.4	29.0	28.9	28.9	29.0	29.2	29.5
Medium Car	47.4	42.8	40.5	39.2	38.4	37.9	37.6	37.5	37.4	37.5
Large Car	62.3	55.8	52.6	50.7	49.5	48.8	48.3	48.0	47.8	47.7
Courier Van-Utility	58.0	54.3	52.3	51.2	50.3	49.7	49.2	48.8	48.4	48.1
4WD Mid-Size Petrol	60.0	56.0	54.1	53.0	52.3	51.9	51.7	51.7	51.7	51.8
Light Rigid	79.5	75.6	73.7	72.6	71.9	71.5	71.2	71.1	71.0	71.0
Medium Rigid	106.9	100.0	96.7	94.8	93.6	92.9	92.5	92.3	92.2	92.3
Heavy Rigid	187.1	175.4	169.8	166.7	164.9	163.8	163.3	163.1	163.3	163.7
Heavy Bus	230.3	216.6	208.6	202.5	197.2	192.1	186.9	181.5	175.8	169.7
Artic 4 Axle	262.0	247.5	240.4	236.2	233.6	231.9	230.7	230.0	229.5	229.3
Artic 5 Axle	292.8	277.9	271.0	267.5	265.7	265.1	265.3	266.0	267.3	269.0
Artic 6 Axle	317.9	302.4	295.3	291.6	289.9	289.3	289.6	290.6	292.1	294.0
Rigid + 5 Axle Dog	374.3	358.8	352.4	350.0	349.9	351.4	354.2	357.9	362.6	368.0
B-Double	414.2	396.3	388.3	384.7	383.4	383.6	385.1	387.4	390.5	394.3
Twin steer+5 Axle Dog	416.4	399.1	391.8	388.7	388.1	389.2	391.5	394.8	399.0	404.0
A-Double	522.2	500.1	491.9	490.0	491.8	496.3	503.0	511.4	521.6	533.3
B Triple	581.9	555.5	545.2	542.2	543.5	547.8	554.5	563.1	573.6	585.8
A B Combination	617.7	596.2	593.3	600.1	613.4	632.0	655.2	682.7	714.2	749.6
A-Triple	715.1	694.2	697.0	712.6	737.6	770.6	810.6	857.3	910.4	969.8
Double B-Double	730.8	711.5	716.0	733.8	761.5	797.4	841.0	891.7	949.3	1013.6

Table 98 Fuel consumption for rural roads (L/100km)

Use this page to look up VOC values for the following highlighted road conditions				
Gradient (Rise and fall)	0% to 2%	2% to 4%	4% to 6%	6% to 8%
Curvature (Terrain type)	Straight (0-99'/km)	Curvy (100-299'/km)	Very curvy (300'+/km)	
Roughness (IRI)	1 - 2 (Very good)	3 – 4 (Good)	5 – 6 (Fair)	7 – 8 (Poor)
Roughness (NRM)	0 - 49	50 - 99	100 - 149	150 - 199

IRI = 3, NRM = 78; Gradient = 4%; Curvature = Straight (20 degrees / km)

Vehicle class	Speed (km/hr)									
	20	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**
Small Car	8.9	7.7	7.3	7.3	7.5	7.9	8.4	9.0	9.8	10.7
Medium Car	11.4	9.7	9.0	8.8	8.9	9.3	9.7	10.4	11.1	12.0
Large Car	14.8	12.4	11.4	11.1	11.1	11.3	11.8	12.4	13.1	14.0
Courier Van-Utility	13.7	11.2	10.1	9.7	9.7	9.9	10.3	10.9	11.6	12.4
4WD Mid-Size Petrol	15.3	13.0	12.1	11.8	11.8	12.2	12.7	13.3	14.1	15.1
Light Rigid	13.9	11.9	11.3	11.4	11.9	12.7	13.8	15.2	16.7	18.5
Medium Rigid	25.0	23.0	22.5	22.7	23.2	24.1	25.3	26.8	28.5	30.4
Heavy Rigid	55.4	50.4	48.4	47.6	47.6	48.2	49.2	50.5	52.0	53.9
Heavy Bus	51.9	47.7	45.7	44.6	44.0	43.7	43.6	43.7	43.9	44.2
Artic 4 Axle	70.5	64.6	62.6	62.5	63.5	65.4	67.9	71.1	74.9	79.1
Artic 5 Axle	80.5	74.9	73.0	72.8	73.8	75.5	77.9	80.8	84.2	88.2
Artic 6 Axle	86.7	81.4	79.6	79.5	80.3	81.9	84.1	86.9	90.1	93.7
Rigid + 5 Axle Dog	111.6	106.3	104.5	104.3	105.0	106.4	108.5	111.0	114.0	117.4
B-Double	118.0	113.2	111.5	111.1	111.7	112.8	114.5	116.6	119.0	121.9
Twin steer+5 Axle Dog	119.5	114.5	112.8	112.5	113.3	114.7	116.6	119.0	121.9	125.2
A-Double	145.4	140.3	138.4	138.0	138.5	139.6	141.2	143.3	145.8	148.6
B Triple	152.0	146.9	145.0	144.6	145.1	146.3	148.0	150.1	152.6	155.6
A B Combination	178.3	172.2	170.4	170.5	171.9	174.2	177.2	181.0	185.4	190.4
A-Triple	204.8	198.2	196.6	197.5	200.0	203.7	208.5	214.3	221.0	228.6
Double B-Double	211.4	204.7	203.2	204.3	207.1	211.1	216.3	222.6	229.7	237.9

IRI = 3, NRM = 78; Gradient = 4%; Curvature = Curvy/Hilly/Winding (120 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	8.9	7.7	7.3	7.3	7.5	7.9	8.4	9.1	9.8	10.7
Medium Car	11.4	9.7	9.0	8.8	9.0	9.3	9.8	10.4	11.2	12.1
Large Car	14.8	12.4	11.5	11.1	11.1	11.4	11.8	12.4	13.2	14.1
Courier Van-Utility	13.6	11.2	10.2	9.8	9.7	10.0	10.4	11.0	11.7	12.5
4WD Mid-Size Petrol	15.4	13.0	12.1	11.8	11.9	12.3	12.8	13.5	14.4	15.4
Light Rigid	13.8	11.9	11.3	11.4	11.9	12.6	13.6	14.9	16.4	18.0
Medium Rigid	24.9	23.1	22.7	22.8	23.4	24.3	25.5	26.9	28.5	30.4
Heavy Rigid	55.4	50.5	48.4	47.7	47.8	48.3	49.3	50.5	52.1	54.0
Heavy Bus	51.9	47.6	45.7	44.6	44.1	43.9	44.0	44.2	44.6	45.1
Artic 4 Axle	70.2	64.9	63.0	62.7	63.3	64.5	66.4	68.7	71.4	74.6
Artic 5 Axle	80.1	75.2	73.5	73.2	73.8	75.1	77.0	79.3	82.0	85.1
Artic 6 Axle	86.4	81.8	80.1	79.9	80.5	81.7	83.5	85.6	88.2	91.1
Rigid + 5 Axle Dog	111.5	106.4	104.7	104.6	105.3	106.8	108.9	111.4	114.4	117.8
B-Double	118.1	113.3	111.6	111.5	112.3	113.7	115.7	118.1	121.0	124.4
Twin steer+5 Axle Dog	119.5	114.6	113.0	112.9	113.8	115.3	117.4	120.0	123.1	126.6
A-Double	145.5	140.2	138.5	138.5	139.5	141.2	143.6	146.6	150.0	153.9
B Triple	152.1	146.9	145.2	145.2	146.2	148.0	150.5	153.5	157.0	161.1
A B Combination	178.4	172.3	170.7	171.3	173.4	176.5	180.6	185.6	191.3	197.7
A-Triple	204.9	198.2	197.0	198.5	201.9	206.7	212.8	220.0	228.4	237.7
Double B-Double	211.5	204.8	203.7	205.4	209.1	214.2	220.7	228.4	237.3	247.3

IRI = 3, NRM = 78; Gradient = 4%; Curvature = Very Curvy/Very Winding(300 - 320 degrees / km)

Vehicle class	Speed (km/hr)									
	20	30	40	50	60	70	80	90	100	110
Small Car	8.9	7.7	7.4	7.4	7.6	8.1	8.6	9.3	10.2	11.1
Medium Car	11.4	9.7	9.1	9.0	9.1	9.5	10.1	10.8	11.6	12.6
Large Car	14.8	12.5	11.6	11.3	11.4	11.7	12.2	12.9	13.7	14.7
Courier Van-Utility	13.6	11.2	10.3	9.9	10.0	10.4	10.9	11.6	12.5	13.5
4WD Mid-Size Petrol	15.4	13.1	12.2	12.0	12.3	12.8	13.6	14.6	15.7	17.1
Light Rigid	13.8	12.0	11.5	11.6	12.1	12.9	13.9	15.2	16.6	18.3
Medium Rigid	24.8	23.3	23.1	23.4	24.3	25.4	26.9	28.6	30.6	32.8
Heavy Rigid	55.2	50.7	48.9	48.4	48.6	49.4	50.5	52.0	53.8	55.9
Heavy Bus	52.0	47.7	45.9	45.3	45.3	45.7	46.5	47.6	49.0	50.5
Artic 4 Axle	70.0	65.2	63.5	63.3	64.1	65.5	67.4	69.8	72.6	75.9
Artic 5 Axle	79.9	75.6	74.2	74.1	74.8	76.2	78.1	80.4	83.2	86.3
Artic 6 Axle	86.2	82.1	80.9	80.9	81.8	83.2	85.2	87.7	90.6	93.8
Rigid + 5 Axle Dog	111.5	106.6	105.3	105.7	107.2	109.6	112.7	116.4	120.8	125.7
B-Double	118.1	113.4	112.2	112.7	114.3	116.8	120.0	123.8	128.3	133.3
Twin steer+5 Axle Dog	119.5	114.8	113.6	114.1	115.7	118.1	121.3	125.1	129.5	134.5
A-Double	145.6	140.3	139.1	140.1	142.5	145.9	150.4	155.6	161.7	168.6
B Triple	152.3	146.9	145.8	146.8	149.3	152.9	157.5	162.9	169.2	176.3
A B Combination	178.5	172.4	171.5	173.4	177.1	182.3	188.8	196.6	205.4	215.4
A-Triple	205.0	198.4	198.0	201.0	206.2	213.3	222.1	232.5	244.3	257.5
Double B-Double	211.5	204.9	204.7	207.9	213.5	221.1	230.4	241.3	253.8	267.7

Appendix E Key indices

Table 99 Key indices for back-casting and forecasting

Indices	Actuals						Forecast			
	2013-14	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**
CPI Sydney	105.23	107.25	108.88	111.08	113.35	114.75	117.05	119.68	122.37	125.43
CPI Private Motoring	102.33	98.65	97.23	97.23	100.00	101.83	103.86	106.20	108.59	111.30
CPI Maintenance & Repair	103.00	101.43	104.55	105.43	106.55	108.00	110.16	112.64	115.17	118.05
CPI Motor vehicles	95.55	95.68	97.20	95.15	93.48	92.73	94.58	96.71	98.88	101.36
AWE NSW ($)	1440.05	1502.20	1534.15	1540.80	1585.90	1614.10	1654.45	1699.95	1750.95	1803.48
PPI road freight	106.28	107.20	105.45	106.53	108.60	111.00	113.22	115.77	118.37	121.33
Fuel cost exc GST (cent/L) - petrol	90.56	75.71	61.76	60.25	68.74	69.94	71.34	72.95	74.59	76.45
Fuel cost exc GST (cent/L) - diesel	93.99	76.23	57.26	58.68	69.02	70.23	71.64	73.25	74.90	76.77

Sources: Estimated by Evaluation and Assurance, TfNSW. (1) ABS Series ID A2325806K. CPI forecast from 2019/20 NSW Treasury Budget Paper 1. (2) ABS Series ID A2326616R. Assume growth by Sydney CPI 2019/20 NSW Treasury Budget Paper 1. (3) ABS Series ID A2328771A. Assume growth by Sydney CPI 2019/20 NSW Treasury Budget Paper 1. (4) ABS Series ID A2328591T. Assume growth by Sydney CPI 2017/18 NSW Treasury Budget Paper 1. (5) ABS Series ID A84994877K. Assume growth by NSW wage price index from NSW Treasury Budget Paper 1. (6) ABS Series ID A2314058K. Assume growth by Sydney CPI 2017/18 NSW Treasury Budget Paper 1. (7) Average of actual Sydney monthly fuel prices from Exxon Mobil TGP. Assume growth by Sydney CPI 2019/20 NSW Treasury Budget Paper 1.
Note: * 2018-19 data escalated to June 2019.