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User Guide

Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

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Acknowledgements

Acknowledgement of Traditional Owners

WALGA acknowledges the continuing connection of Aboriginal people to Country, culture and community. We embrace the vast Aboriginal cultural diversity throughout Western Australia, including Boorloo (Perth), on the land of the Whadjuk Nyoongar People, where WALGA is located and we acknowledge and pay respect to Elders past and present.

WALGA is committed to supporting the efforts of WA Local Governments to foster respectful partnerships and strengthen relationships with local Aboriginal communities.

This guideline has been prepared by the Western Australian Local Government Association (WALGA) with the assistance of the National Transport Research Organisation (NTRO).

Disclaimer

Contents

Version	Revision Date	Author	Summary of changes
1	2015	WALGA/ARRB Group	This version represents the initial Guide
2	2025	WALGA/NTRO	Revised content and Unit rates

Front Cover: Bushby Road, Karridale

Introduction

Western Australian local governments face significant costs from road wear as a consequence of unforeseen heavy vehicle traffic triggered by projects, typically in the resources industry. The impacts of additional heavy vehicle traffic on shortening road life and increasing maintenance requirements are greater for roads that were not designed and constructed for this purpose, which is the case for most local government roads.

This guide provides local governments with a tool to quantify the cost of additional wear and damage to affected roads for a defined freight task. It can be used as the basis for negotiation of cost recovery from industry, to ensure that the local community does not bear the costs imposed by private businesses, and to adjust long term financial plans. Substantial cost escalation has occurred since 2015, necessitating a review of the unit rates and calculated marginal costs resulting in the publication of this revised Version 2 (2025).

Methods previously used to estimate the cost impact often required detailed input data, specialised engineering evaluation and modelling skills which are not readily available to local governments. This user guide presents a method for estimating the cost of road wear using simple input parameters. The technical basis is provided in a separate report, '*Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks' (ARRB 2015) and addendum 'Updates to the Incremental Cost Guides on Sealed and Unsealed Local Roads*' (NTRO 2025).

Users of this guide will require a basic understanding of the Western Australian road classification system and will be assisted to select appropriate parameters based on the situation and freight task. The guide is designed to be applied to sealed roads only. Estimating the cost of additional heavy vehicle traffic on unsealed roads is covered by the separate guideline '*Estimating the Incremental Cost Impact on Unsealed Local Roads from Additional Freight Tasks*' (WALGA 2025)'.

Development background

The guide has been developed around the concept of a marginal cost of road wear. The marginal cost of road wear is the difference in cost of maintaining a road in a serviceable condition, between a base traffic loading and an increased traffic loading, comprising the base and additional loading. Analysis has shown that the marginal cost is mostly dependent on:

- the magnitude and duration of the additional loading
- the structural strength of the road
- the cost of road maintenance activities.

Using these variables, a catalogue of charts has been developed to represent the spectrum of scenarios that are likely to be encountered on local government roads across the State.

The marginal cost for each scenario was modelled by using a custom software tool developed by Austroads in 2015 called the 'Freight Axle Mass Limits Investigation Tool' (FAMLIT) and adapted for Western Australian Local Government conditions. FAMLIT models the life of the road based on deterioration curves that were developed by monitoring numerous different types of roads over many years. As the defined road condition and structure deteriorates under specific loading conditions, the model triggers maintenance interventions that are required to keep the road serviceable. FAMLIT then calculates the difference in costs incurred between the base, or normal loading and the base plus the additional loading.

The scenarios are presented by graphs showing marginal cost (in cents per equivalent standard axle repetition) versus load duration. The user needs to define their scenario in terms of the vehicle type undertaking the task, annual tonnage and road category and the guide will then lead the user to the applicable graph. Detailed information on how to use the guide is provided in the following section.

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What are the limitations of the guide?

The marginal costs presented in the guide have been developed by modelling a road network intended to represent the majority of scenarios likely to be encountered in WA. **There are many factors that can influence the cost of road wear and the calculated values are only an estimate.** The local situation and scenario may include factors that render the estimate inaccurate. In such cases a first principles approach may be necessary involving specialist assistance.

The guide may be unsuitable when:

- The road has been constructed to a level that is markedly different to the road class design assumptions employed (see Table C.1).
- The road is in a very poor or failed condition and requires an initial capital upgrade to support the proposed traffic volumes.
- Sections of the road are subject to unusual conditions, e.g. flooding or very weak subgrades.
- The scenario factors are well beyond those presented in this guide, e.g. loading durations which exceed 10 years, and more than 200,000 standard axle repetitions per year.

The limitations of the guide are:

- Associated infrastructure such as bridges, culverts and guardrails are not included.
- The calculations assume that the initial condition is suitable to carry the proposed traffic. Initial capital upgrades would be subject of a separate calculation.
- Where the scenario factors lie between or near the given values the user should use the nearest loading scenario and duration.
- The guide is only applicable to sealed local roads comprising sprayed seal unbound granular pavements. .
- The unit rates are current for 2024. Practitioners will need to apply escalation factors in future years and accounting for any variation to these to ensure consistency with costs in local government.
- The guide has been developed for the WA local government road network and the catalogue of solutions (and underlying assumptions) may not be valid in other jurisdictions.
- Due to the large range of heavy vehicle configurations, users may need to refer to the Main Roads WA Vehicle Estimated Equivalent Standard Axles (ESA) Tool at https://ravrat.au/esa to determine the correct vehicle parameters.

WALGA Road Wear Cost Calculator as an alternative

A calculator has been developed in an Excel spreadsheet that follows the process, described in *How to use this guide* which can be used as an alternative to the manual chart based method also provided in this guide. Practitioners are able to download the calculator here, and input the variables associated with their loading scenario.

Instructions for accessing and using the calculator are provided in Appendix D.

How to use this guide

The guide is structured around a simple stepped process. Figure 1 presents the eight step procedure to be followed.

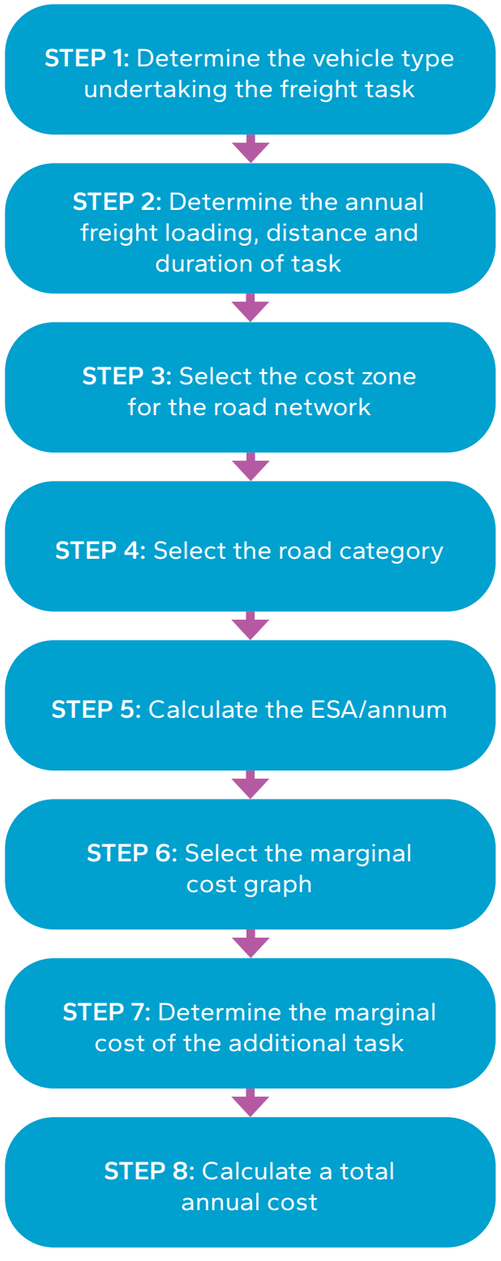

Figure 1: Process for calculating the marginal cost estimate and total annual cost

Details for completing each step are given below. This is followed by a series of typical worked examples.

What information is required?

The user will need the following information:

1. The type of vehicles to be used for the task
2. The annual freight tonnage for the task
3. The duration of the task
4. The task routing and distance.

The following sections outline the sequential steps to determine a marginal cost for a particular additional loading task. Users are able to manually calculate from the guide or use the WALGA Road Wear Cost Calculator tool.

Setup as a downloadable spreadsheet, the WALGA Road Wear Cost Calculator tool follows the steps in the guide and is self-explanatory. The tool is available for download here.

STEP 1: Determine the Vehicle Type Undertaking the Task

The first step is to determine the type of vehicle or vehicles that will be used to undertake the task. The vehicle type will typically be supplied by the freight generator. The vehicle type must then be matched to a Main Roads WA heavy vehicle RAV category and configuration. The RAV types are provided from Main Roads WA in Appendix A.

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STEP 2: Determine the Annual Freight Loading, Distance and Duration

To determine the annual freight loading, a good appreciation of the total freight task needs to be gained. This will usually involve discussions with the freight generator to determine the duration of the additional loading and the total loading to be applied. Typically, such requests are well structured, with the proponent possibly having a lease on a mine or similar to extract a certain amount of product over a defined period of time.

An example of a typical total load and duration is shown below:

Iron ore extraction – 600,000 tonnes over 3 years.

In this case, the annual tonnage is determined by dividing the total freight tonnage by the duration:

600,000/3 = 200,000 tonnes per year.

The distance is defined as the road distance to be traversed by the loaded vehicles.

STEP 3: Select the Cost Zone

The appropriate cost zone must be selected from one of the four cost zones shown in Figure 2.

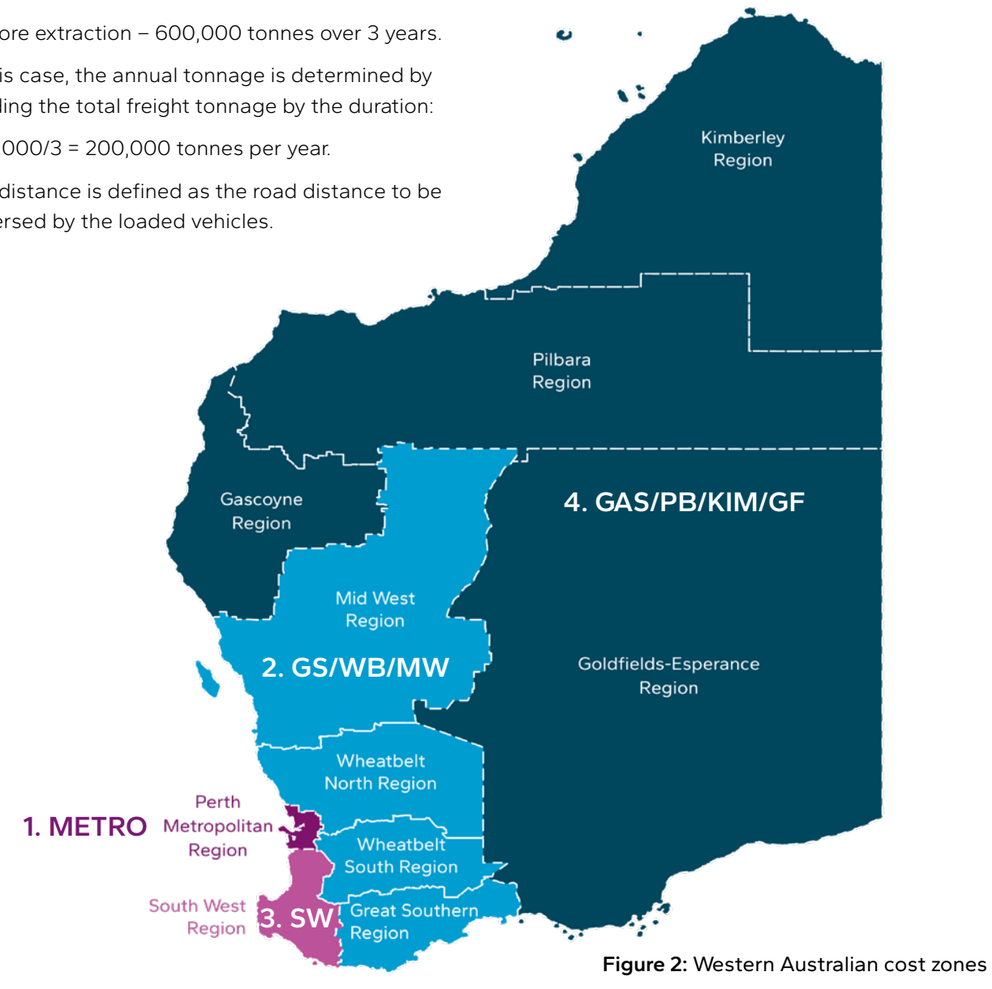

Figure 2: Western Australian cost zones

The cost zones were determined with reference to unit rates collected from a survey conducted by the Department of Local Government in 2011 and 2024.

STEP 4: Select the Road Category

The user must select the road category from the list below:

- access road
- local distributor
- regional distributor
- district distributor.

The road categories are based on the Main Roads WA classification system.

Because of the variability in performance of these four road categories, due in part to design factors and location, users need to determine the exact route associated with the additional freight task. Where the route is well-defined and constrained to only one road category, the analysis produces one cost estimate as demonstrated in *Example Calculations, Worked Example #1*. If the task traverses more than one road category then each section of road must be assessed separately as demonstrated in *Example Calculations, Worked Example #2*.

Appendix C.3 provides details of the design traffic that was assigned to each of these categories for model development. Some roads may be constructed to levels that are markedly different to the road category design assumptions and users must adjust their choice accordingly.

In this step the user must determine the ESA per payload tonne from Figure 4 and then multiply by the annual tonnage to determine the ESA per year. Alternatively the user can determine the ESA and payload per vehicle from Table 1 or Figure 3. Calculate the number of vehicle movements required to move the annual tonnage and multiply by the ESA per vehicle.

STEP 5: Calculate Equivalent Standard Axles

In this step the user must determine the Equivalent Standard Axles (ESA) per vehicle and multiply this by the annual number of vehicle movements to obtain the ESA per year in the loaded direction.

The road wear caused by the movement of a quantity of freight will differ depending on the types of heavy vehicles that are used for the task. That is why the load equivalencies of all heavy vehicles need to be expressed in a common measure that is related to the amount of road wear.

The road wear caused by the passage of a heavy vehicle is proportional to the number and type of axle groupings (e.g. single, double or tri-axle) and the load carried by each of the axle groups. The allowable load on an axle group is strictly controlled in Western Australia and is termed the Regulation Mass Limit (RML). Some vehicles may operate under the Accredited Mass Management Scheme (AMMS) which allows for up to an additional 3.5 tonnes per tri-axle combination and 1.0 tonne per tandem axle combination. The damage caused to the pavement per payload tonne will therefore differ depending on the type of vehicle that is used and the loading scheme that is applied. For design and evaluation purposes, all heavy vehicle loadings are converted to ESA.

Table 1 gives the ESA per vehicle for different vehicle configurations and loads. The values have been extracted from the Main Roads WA Vehicle Estimated Equivalent Standard Axles (ESA) Tool (https://ravrat.au/esa). Actual tare weights and loads vary across vehicle configurations and loading schemes and users may choose to use the closest vehicle and load in Table 1 for their calculations, or derive the ESA for their vehicle by referencing the Main Roads WA tool. The ESA per vehicle is shown graphically in Figure 3 and ESA per payload tonne for a range of vehicles is given in Figure 4.

For instance, a fully loaded RAV category 7A operating at RML, has an ESA per vehicle of 10.44. A full list of RAV descriptions is given in Appendix A.

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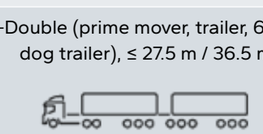
Table 1: Examples of ESA for common RAV configurations

Cat.	Configuration	Max. payload RML (t)	Max payload AMMS 3 (t)	ESA empty	ESA at half load	ESA for RML at max. load	ESA for AMMS 3
1A	Rigid truck, ≤ 12.5 m 	11.6	12.1[1]	0.51	1.27	5.04	5.30[1]
2A	Prime mover and trailer, ≤ 20.0 m 	25.6	30.1	1.14	2.19	6.39	8.14
2C	B-Double ≤ 27.5 m 	39.6	47.6	1.17	2.49	7.74	10.73
3A	A-Double (prime mover, trailer, dog trailer), ≤ 27.5 m 	50.1	59.1	1.4	2.89	9.80	13.35
4A/6A	A-Double (prime mover, trailer, 6-axle dog trailer), ≤ 27.5 m / 36.5 m 	53.6	65.1	1.39	2.79	9.09	13.30
7A	AB-Triple (prime mover, trailer, B-Double), ≤ 36.5 m 108.5 t 	67.6	82.6	1.4	2.98	10.44	15.88
10A	A-Triple (prime mover, trailer, 2 dog trailers), ≤ 53.5 m 	83.6	102.1	1.44	3.27	11.79	18.45

Source: Values extracted from Main Roads WA 'Vehicle Estimated Equivalent Standard Axles (ESA) Tool' at https://ravrat.au/esa
Note: All values are estimates based on options chosen for each configuration. To identify the specific ESA for a vehicle configuration, refer to the Vehicle Estimated Equivalent Standard Axles (ESA) Tool.
[1] Showing AMMS level 2 values for category 1A vehicles.

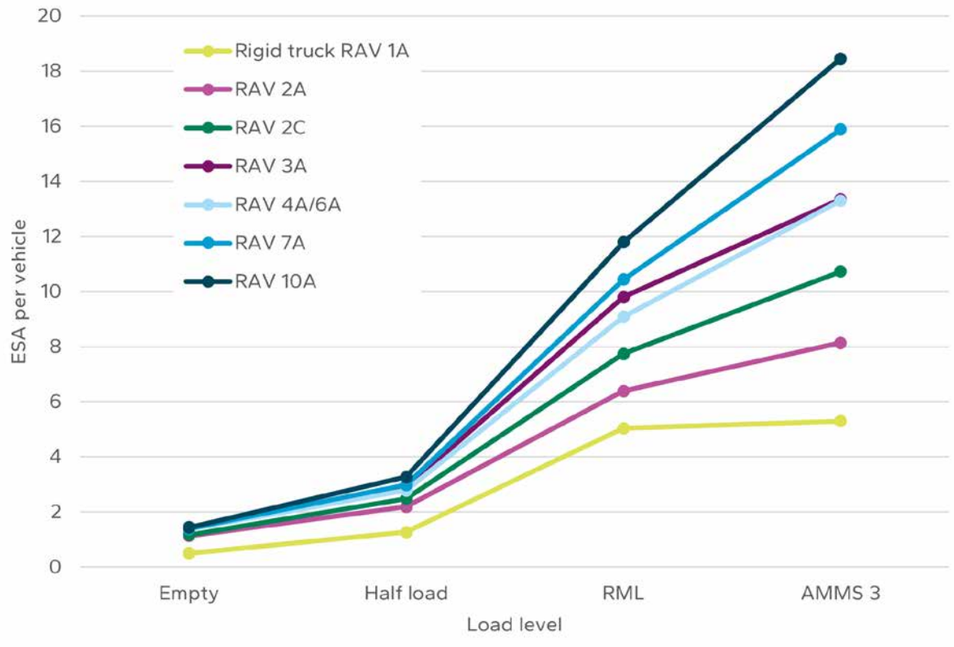


Figure 3: ESA per vehicle for common RAV configurations

Note: The AMMS has three levels. The displayed values are for Level 3. If the vehicle is operating at a lower level then select a proportionate value between the RML value and the AMMS L3 value.

The ESA per payload tonne is provided in Figure 4 for some common vehicle combinations.

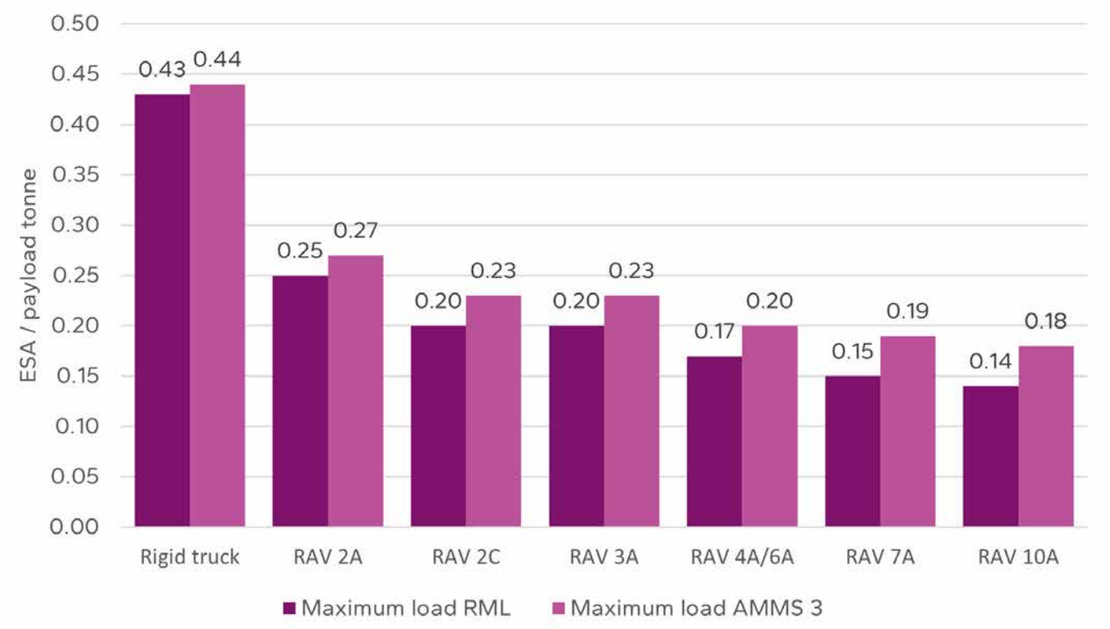


Figure 4: ESA per payload tonne for common RAV configurations

Note: The AMMS has three levels. The displayed values are for Level 3. If the vehicle is operating at a lower level then select a proportionate value between the RML value and the AMMS L3 value.

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STEP 6: Select the Marginal Cost Graph

There are 64 output charts representing four cost zones, four road categories and four loading scenarios. Users must select the chart or charts that are relevant to the scenario that is being assessed.

The charts are structured in order of cost zone, then by road category and finally by the modelled loading scenarios. Table 2 facilitates easy access to the generated charts with a series of links to each of the relevant figures. The user must select the loading scenario that is closest to their actual scenario.

Table 2: Table of marginal cost graphs

From STEP 3 Cost Zone	From STEP 4 Road Class	From STEP 5 Loading Scenario (ESA/year)	Refer to Chart
1	Access road	20,000	Figure B 1.1
		60,000	Figure B 1.2
		100,000	Figure B 1.3
		200,000	Figure B 1.4
	Local distributor	20,000	Figure B 2.1
		60,000	Figure B 2.2
		100,000	Figure B 2.3
		200,000	Figure B 2.4
	Regional distributor	20,000	Figure B 3.1
		60,000	Figure B 3.2
		100,000	Figure B 3.3
		200,000	Figure B 3.4
	District distributor	20,000	Figure B 4.1
		60,000	Figure B 4.2
		100,000	Figure B 4.3
		200,000	Figure B 4.4
2	Access road	20,000	Figure B 5.1
		60,000	Figure B 5.2
		100,000	Figure B 5.3
		200,000	Figure B 5.4
	Local distributor	20,000	Figure B 6.1
		60,000	Figure B 6.2
		100,000	Figure B 6.3
		200,000	Figure B 6.4
	Regional distributor	20,000	Figure B 7.1
		60,000	Figure B 7.2
		100,000	Figure B 7.3
		200,000	Figure B 7.4
	District distributor	20,000	Figure B 8.1
		60,000	Figure B 8.2
		100,000	Figure B 8.3
		200,000	Figure B 8.4

From STEP 3 Cost Zone	From STEP 4 Road Class	From STEP 5 Loading Scenario (ESA/year)	Refer to Chart
3	Access road	20,000	Figure B 9.1
		60,000	Figure B 9.2
		100,000	Figure B 9.3
		200,000	Figure B 9.4
	Local distributor	20,000	Figure B 10.1
		60,000	Figure B 10.2
		100,000	Figure B 10.3
		200,000	Figure B 10.4
	Regional distributor	20,000	Figure B 11.1
		60,000	Figure B 11.2
		100,000	Figure B 11.3
		200,000	Figure B 11.4
	District distributor	20,000	Figure B 12.1
		60,000	Figure B 12.2
		100,000	Figure B 12.3
		200,000	Figure B 12.4
4	Access road	20,000	Figure B 13.1
		60,000	Figure B 13.2
		100,000	Figure B 133
		200,000	Figure B 13.4
	Local distributor	20,000	Figure B 14.1
		60,000	Figure B 14.2
		100,000	Figure B 14.3
		200,000	Figure B 14.4
	Regional distributor	20,000	Figure B 15.1
		60,000	Figure B 15.2
		100,000	Figure B 15.3
		200,000	Figure B 15.4
	District distributor	20,000	Figure B 16.1
		60,000	Figure B 16.2
		100,000	Figure B 16.3
		200,000	Figure B 16.4

Figure B 1.1 to Figure B 16.4 are located in Appendix B. An example is presented in Figure 5.

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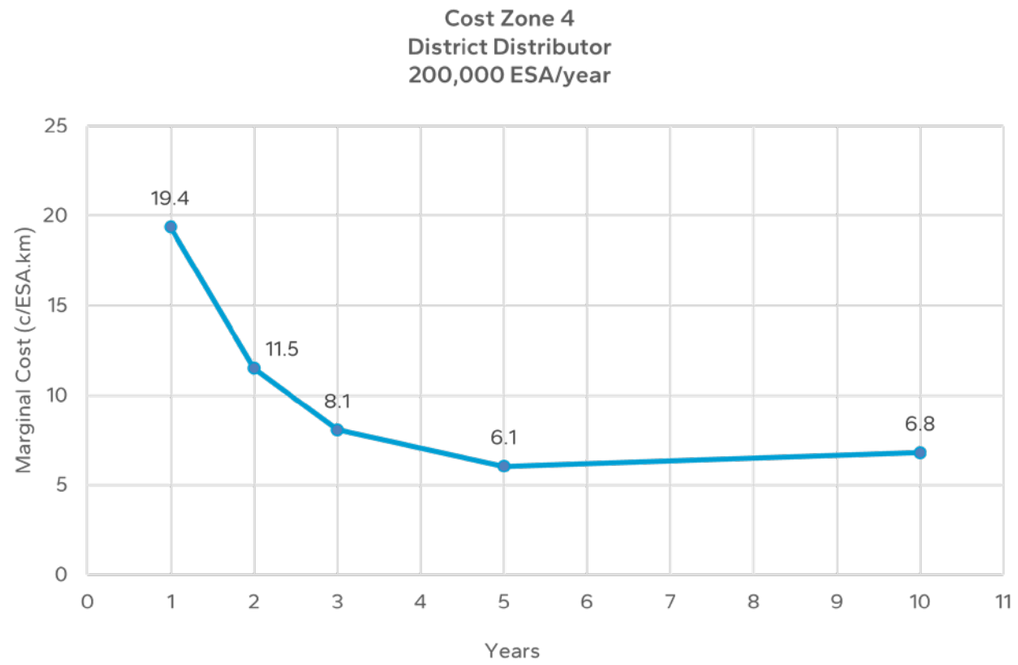

Figure 5: Example chart of estimated marginal costs

It is likely that the requested additional loading calculated in Step 5 will not match one of the four loading scenarios presented in this guide. The user must select the loading scenario that is closest to their calculated value.

For instance, a calculated value of 185,000 ESA/year would result in the selection of a loading scenario of 200,000 ESA/year from Table 1 as this is the closest matching available scenario.

STEP 7: Determine the Annual Marginal Cost of the Additional Task

Using the chart selected in STEP 6, the marginal cost of the additional loading can be determined. An example of how the chart is to be used is presented in Figure 6, which has been selected for a district distributor in cost zone 4 with an additional loading of 200,000 ESA/year.

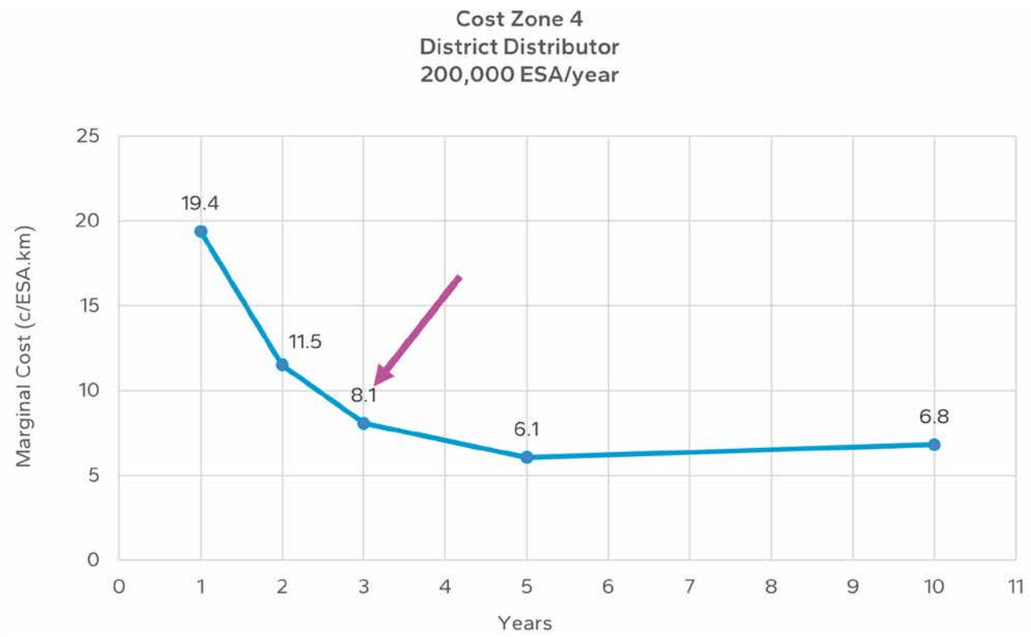

Figure 6: Marginal cost chart of a district distributor in cost zone 4 with an additional 200,000 ESA/year

To evaluate the marginal cost of a particular task, the duration of the task is required. For example in Figure 6, a loading duration of 3 years has been selected, and therefore the annual marginal cost is 8.1 cents per ESA.km/ year or represented in dollars as $0.081 per ESA.km/year.

STEP 8: Calculate the Annual Cost

The annual total cost is calculated using the annual marginal cost. The relevant equations are as follows:

Annual Cost = Annual Marginal Cost x ESA per year x Distance

Annual Marginal Cost in cents/ ESA.km is determined from Step 7

ESA per year is the actual ESA per year from Step 5.

Distance is the road distance in kilometres

This can converted back to a cost per tonne as follows:

Cost per tonne = Annual Cost / (Annual Tonnage x Distance)

Due to the inherent assumptions and margins of error in the sources of data, the total annual cost should be rounded to the nearest $1,000.

The calculated costs are based on 2024 rates with forecasting for future years' costs. If the evaluation is undertaken from 2025 onwards, the user will need to consider applying indexation to update the base rates.

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Example Calculations

Worked Example #1

A mining company is developing a mine site in the Mid West and proposes to transport 2 million tonnes of iron ore over a five year period along a local government road to access the state road network. They will be using a prime mover and semi-trailer towing two six axle dog trailers with a concessional loading permit at AMMS 3. The road is a local distributor and is 64 km long.

Calculate the annual cost of road wear resulting from this additional freight task.

Solution:

1. **Determine the vehicle type:**

   Go to Appendix A and select the applicable RAV Configuration.

   A prime mover and semi-trailer towing two six axle dog trailers under AMMS 3 is a RAV 10A, with maximum payload of 102.1 t (Table 1).

2. **Determine the annual tonnage, distance and duration:**

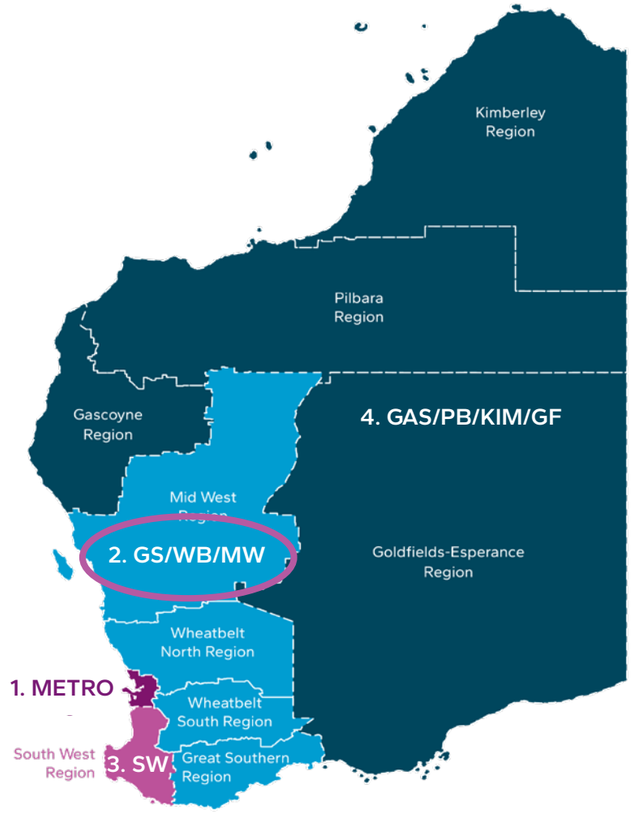
   The annual tonnage is 2 000,000 / 5 = 400,000 tonnes per year.

   The distance is 64 km.

   The duration is 5 years.

3. **Select the cost zone:**

   Go to Figure 2 and select cost zone 2.



4. Select the road class:

As stated , the task is to be undertaken on a local distributor.

5. Calculate the ESA per year:

With reference to Table 1, a RAV category 10A at AMMS 3 has a payload of 102.1 t and ESA of 18.45 per vehicle.

Carrying 400,000 tonnes per year will require 400,000 / 102.1 = 3,918 trips.

The total ESA is 3,918 * 18.45 = 72,287 per year.

6. Select the marginal cost graph:

Based on the calculated task of 72,287 ESA/year, the 60,000 ESA/year loading scenario is the closest available value to be applied in this calculation. Therefore all of the required parameters to select a marginal cost graph are available, including:

Cost zone = 2, road class = local distributor, applicable load = 60,000 ESA/year and specified period of additional loading = 5 years

Using these values, Table 1 will lead you to the applicable marginal cost graph.

2	Access road	20,000	Figure B 5.1
		60,000	Figure B 5.2
		100,000	Figure B 5.3
		200,000	Figure B 5.4
	Local distributor	20,000	Figure B 6.1
		60,000	Figure B 6.2
		100,000	Figure B 6.3
		200,000	Figure B 6.4
	Regional distributor	20,000	Figure B 7.1
		60,000	Figure B 7.2
		100,000	Figure B 7.3
		200,000	Figure B 7.4
	District distributor	20,000	Figure B 8.1
		60,000	Figure B 8.2
		100,000	Figure B 8.3

With all of the required criteria determined, select the required marginal cost chart from Appendix B. For this example, this is Figure B 6.2 and is shown in Step 7 below.

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7. Determine the marginal cost:

With the appropriate marginal cost graph selected in Step 6, read off the marginal cost for the task duration.

Therefore, from the graph, the marginal cost is 17.9 cents per ESA.km/year or $0.179 per ESA.km/year.

8. Calculate annual cost:

The annual cost can now be calculated from all of the above information.

The total loading task is 72,287 ESA/ year being applied over 64 km, so the total annual cost can be determined by multiplying these together:

Total Annual Cost = 0.179 x 72,287 x 64 = $828,120 per year, say $828,000.

Due to the inherent assumptions and margins of error in the sources of data, the total annual cost should be rounded to the nearest $1,000 as shown.

The cost can be converted into cents per tonne.km:

Cost = $828,000 x 100 / (400,000 x 64) = 3.23 cents per tonne.km.

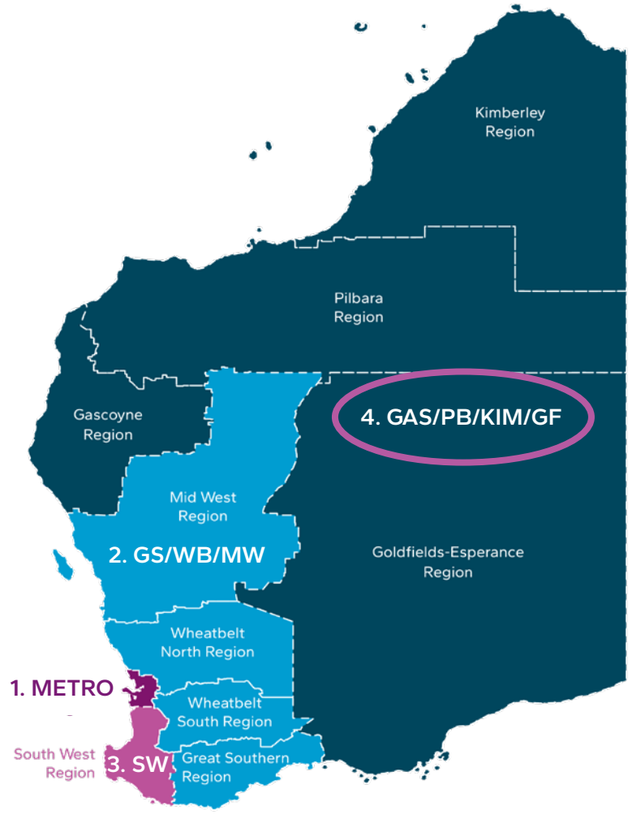
Note 1: This is the estimated cost for the first year of the operation. Increases in the annual charge should be considered during discussions with the freight generator.

Note 2: The Road Wear Cost Calculator uses the ESA/tonne.km rates, which may lead to a small difference in output values when compared with a manual calculation using the ESA per vehicle.

Worked Example #2

A mining company has decided to open up a mine site in the Kimberley region and wishes to transport 3.5 million tonnes of ore over a 5 year period along a Local Government road to access the state road network. Accessing the state road network consists of travelling along a district distributor for 40 km and a regional distributor for another 15 km. They are to use a prime mover and semi-trailer towing a B-double combination operating under the Accredited Mass Management Scheme Level 3.

Calculate the annual cost of road wear resulting from this additional freight task.



Solution:

1. **Determine the vehicle type:**

   Refer to Appendix A for an outline of all defined vehicles in WA.

   A prime mover and semi-trailer towing a B-double under AMMS 3 is a RAV 7A with a maximum payload of 82.6 t (Table 1).

2. **Determine the annual tonnage, distance and duration:**

   The annual tonnage is 3,500,000 / 5 = 700,000 tonnes per year.

   The distances are 40 km and 15 km.

   The duration is 5 years.

3. **Select the cost zone:**

   Go to Figure 2 and select cost zone 4.

4. **Select the road class:**

   As outlined previously, both district distributor and regional distributor roads are selected.

5. **Calculate the ESA per year:**

   With reference to Table 1, a RAV category 7A at AMMS 3 has a maximum payload of 82.6 t and ESA of 15.88 per vehicle.

   Carrying 700,000 tonnes per year will require 700,000 / 82.6 = 8,475 trips.

   The total ESA is 8,475 * 15.88 =134,583 per year.

6. **Select the marginal cost graph:**

   Using the calculated task of 134,583 ESA/year, the 100,000 ESA/year loading scenario is the closest value to be applied in this calculation. Therefore all of the required parameters to select a marginal cost graph are available, including:

   Cost zone = 4, road classes = district distributor and regional distributor, applicable load = 100,000 ESA/year and specified period of additional loading = 5 years

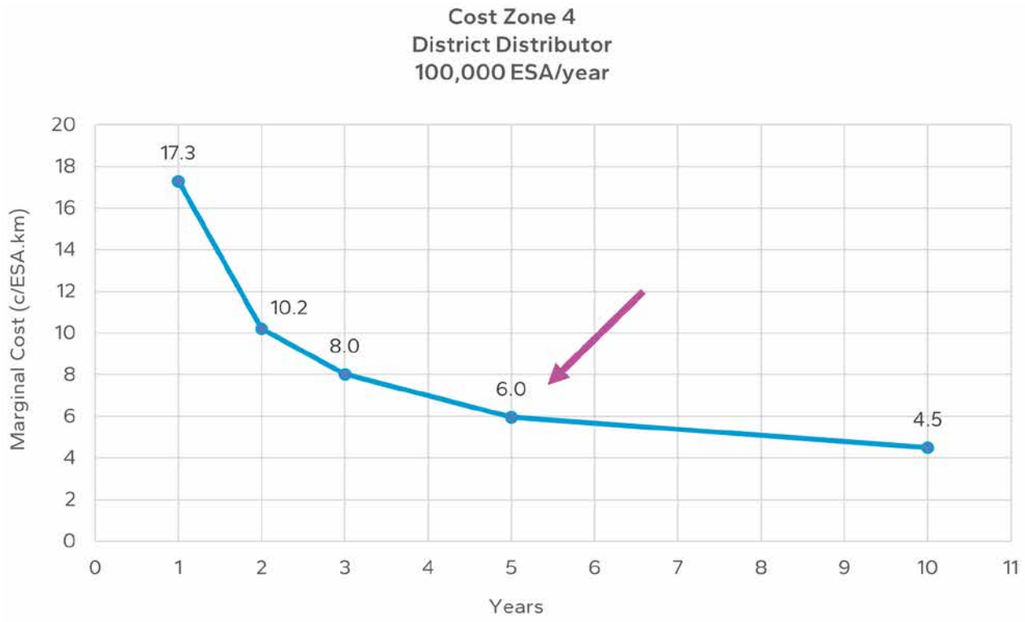
   Using these values, Table 1 will lead you to the applicable marginal cost graphs.

4	Access road	20,000	Figure B 13.1
		60,000	Figure B 13.2
		100,000	Figure B 133
		200,000	Figure B 13.4
	Local distributor	20,000	Figure B 14.1
		60,000	Figure B 14.2
		100,000	Figure B 14.3
		200,000	Figure B 14.4
	Regional distributor	20,000	Figure B 15.1
		60,000	Figure B 15.2
		100,000	Figure B 15.3
		200,000	Figure B 15.4
	District distributor	20,000	Figure B 16.1
		60,000	Figure B 16.2
		100,000	Figure B 16.3
		200,000	Figure B 16.4

With all of the required criteria determined, select the required marginal cost chart from Appendix B. For this example, this is Figure B 16.3 for the district distributor and Figure B 15.3 for the regional distributor, as shown in Step 7 below respectively.

7. Determine the marginal cost:

With the appropriate marginal cost graphs selected in Step 6, read off the marginal cost for the task duration.



From the graphs, the marginal cost is 6.0 cents per ESA.km/year for the district distributor and 5.8 cents per ESA.km/year for the regional distributor.

User Guide: Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

8. Calculate annual cost:

The annual cost can now be calculated from all of the above information.

The total loading task of 134,583 ESA/year will be applied to the district distributor for 40 km and then to the regional distributor for another 15 km, therefore the total annual cost can be determined as follows:

0.060 x 134,583 x 40 = $322,999 per year (for the district distributor)

0.058 x 134,583 x 15 = $117,087 per year (for the regional distributor)

The total annual cost is therefore $440,086 per year, say $440,000.

Due to the inherent assumptions and margins of error in the sources of data, the total annual cost should be rounded to the nearest $1,000 as shown.

The cost can be converted into cents per tonne.km:

Cost = $322,999 x 100 / (700,000 x 40) = 1.15 cents per tonne.km (for the district distributor)

$117,087 x100 / (700,000 x 15) = 1.12 cents per tonne.km (for the regional distributor)

Note 1: These are the estimated costs for the first year of the operation. Increases in the annual charge should be considered during discussions with the generator.

Note 2: The Road Wear Cost Calculator uses the ESA/tonne.km rates, which may lead to a small difference in output values when compared with a manual calculation using the ESA per vehicle.

Worked Example #3

A sand quarry in the Metropolitan area is applying to transport an estimated 75,000 tonnes per year using a prime mover and triple axle trailer operating under the regulation mass limit (RML). The task route will follow an access road for 1.3 km and then a regional distributor for 2.5 km to access the state road network. The quarry will operate for five years.

Calculate the annual cost of road wear resulting from this additional freight task.

Solution:

1. **Determine the vehicle type:**

   A prime mover and semi-trailer within the RML is a category 2A vehicle with a maximum payload of 25.6 t (Table 1). If not provided by the generator, the loading values need to be identified by using the Main Roads WA *Vehicle Estimated Equivalent Standard Axles (ESA) Tool*.

2. **Determine the annual tonnage, distance and duration:**

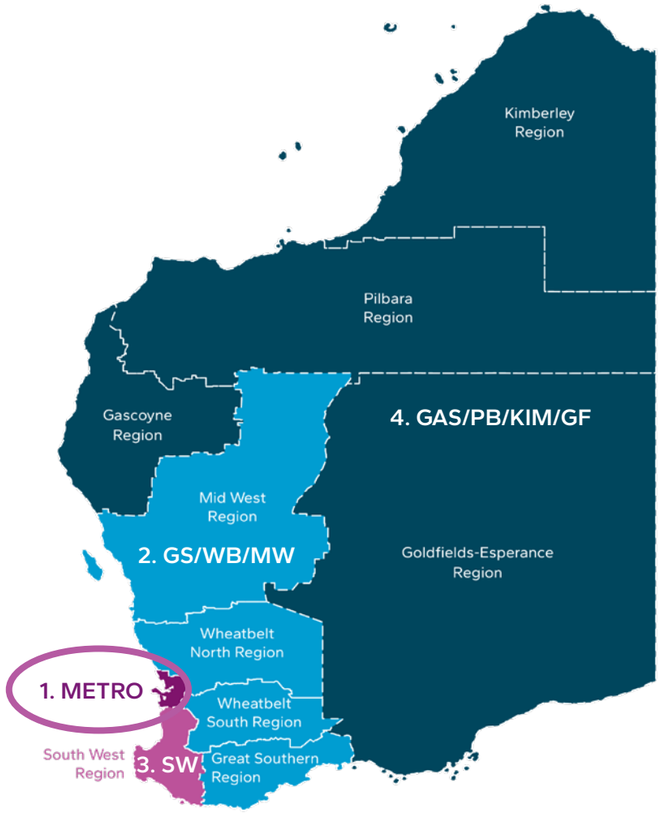
   The annual tonnage is 75,000 tonnes per year.

   The distances are 1.3 km and 2.5 km.

   The duration is 5 years.

3. **Select the cost zone:**

   Go to Figure 2 and select cost zone 1.



User Guide: Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

4. **Select the road class:**

   As given, both an access road and a regional distributor are to be used in the calculation.

5. **Calculate the ESA per year:**

   From Figure 4, the ESA per payload tonne for a RAV 2A at RML is 0.25.

   The ESA is therefore 0.25 x 75,000 = 18,750 per year

   Alternatively using Table 1, the prime mover and trailer has a maximum payload of 25.6 t and ESA of 6.39 per vehicle.

   Carrying 75,000 tonnes per year will require 75,000 / 25.6 = 2,930 trips.

   The total ESA is 2,930 x 6.39 =18,723 per year.

6. **Select the marginal cost graph:**

   Based on the calculated task of 18,723 ESA/year, the 20,000 ESA/year loading scenario is the closest value to be applied in this calculation. Therefore all of the required parameters to select a marginal cost graph are available, including:

   Cost zone = 1, road classes = access road and regional distributor, applicable load = 20,000 ESA/year and specified period of additional loading = 5 years

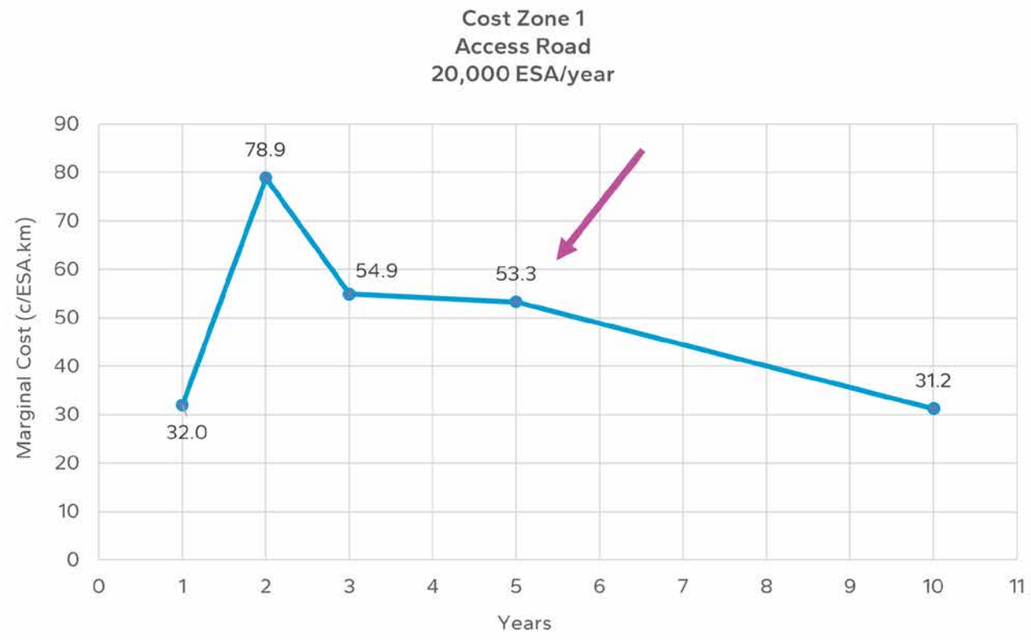
   Using these values, Table 1 will lead you to the applicable marginal cost graphs.

1	Access road	20,000	Figure B 1.1
		60,000	Figure B 1.2
		100,000	Figure B 1.3
		200,000	Figure B 1.4
	Local distributor	20,000	Figure B 2.1
		60,000	Figure B 2.2
		100,000	Figure B 2.3
		200,000	Figure B 2.4
	Regional distributor	20,000	Figure B 3.1
		60,000	Figure B 3.2
		100,000	Figure B 3.3
		200,000	Figure B 3.4
	District distributor	20,000	Figure B 4.1
		60,000	Figure B 4.2
		100,000	Figure B 4.3

With all of the required criteria determined, select the required graphs from Appendix B. For this example, this is Figure B 1.1 for the access road and Figure B 3.1 for the regional distributor, as shown in Step 7 below respectively.

7. Determine the marginal cost:

With the appropriate marginal cost graphs selected in Step 6, read off the marginal cost for the task duration.



From the graphs, the marginal cost is 53.3 cents per ESA.km/year for the access road and 5.4 cents per ESA. km/year for the regional distributor.

8. Calculate annual cost:

The annual cost can now be calculated from all of the above information.

The total loading task is 18,723 ESA/year being applied to the access road for 1.3 km and then to the regional distributor for 2.5 km, so the annual cost can be determined as follows:

0.533 x 18,723 x 1.3 = $12,973 per year (for the access road)

0.054 x 18,723 x 2.5 = $2,528 per year (for the regional distributor)

The total annual cost is therefore $15,501 per year, say $16,000.

Due to the inherent assumptions and margins of error in the sources of data, the total annual cost should be rounded to the nearest $1,000 as shown.

The cost can be converted into cents per tonne.km:

Cost per tonne = $12,973 x 100/ (75,000 x 1.3)
= 13.3 cents per tonne.km (for the access road)

$2,528 x 100 / (75,000 x 2.5) = 1.3 cents per tonne.km (for the regional distributor)

Note: These are the estimated costs for the first year of the operation. Increases in the annual charge should be considered during discussions with the generator.

Worked Example #4

A new mining company has decided to open up a mine site in the Gascoyne region. In this case however they are constrained by the number of vehicles they have at their disposal and have calculated that within a year they can deliver 10,000 trips to the site while using only prime movers with a semi-trailer towing two six axle dog trailers. The company is operating their vehicles under the Accredited Mass Management Scheme Level 3. The life of the mine is forecast as 6 years. The company would like access to a 30 km long regional distributor that is managed by the Local Government.

Calculate the annual cost of road wear resulting from this additional freight task.

Solution:

1. **Determine the vehicle type:**

   Refer to Appendix A for an outline of all defined vehicles in WA.

   A prime mover and semi-trailer towing two six axle dog trailers under AMMS 3 is a RAV category 10A with maximum payload of 102.1 t (Table 1).

2. **Determine the annual tonnage, distance and duration:**

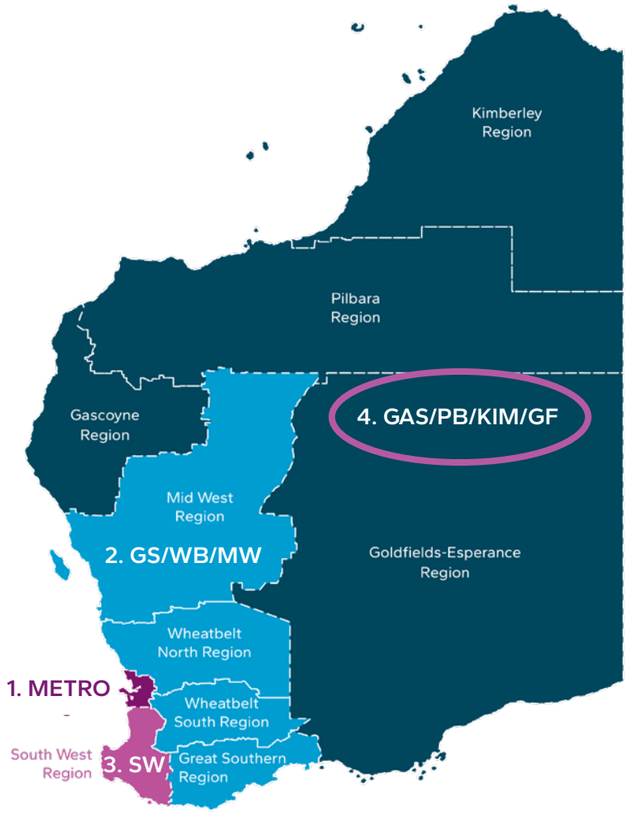
   As outlined above, the annual freight loading is unknown but the number of trips with a RAV 10A is estimated to be 10,000 per year.

   The distance is 30km.

   The duration is 6 years.

3. **Select the cost zone:**

   Go to Figure 2 and select cost zone 4.



User Guide: Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

4. **Select the road class:**

   As outlined previously, the task is to operate on a regional distributor.

5. **Calculate the ESA per year:**

   Referring to Table 1, an A-Triple (prime mover, semi trailer and 2 dog trailers) under AMMS level 3 has an ESA per vehicle of 18.45.

   The total ESA per year is therefore 18.45 x 10,000 trips = 184,500 ESA/year

6. **Select the marginal cost graph:**

   Based on the calculated task of 184,500 ESA/year as outlined Step 5, the 200,000 ESA/year loading scenario is the closest value to be applied in this calculation. Therefore all of the required parameters to select a marginal cost graph are available, including:

   Cost zone = 4, road class = regional distributor, applicable load = 200,000 ESA/year and specified period of additional loading = 6 years.

   Using these values, Table 1 will lead you to the applicable marginal cost graph as follows:

4	Access road	20,000	Figure B 13.1
		60,000	Figure B 13.2
		100,000	Figure B 133
		200,000	Figure B 13.4
	Local distributor	20,000	Figure B 14.1
		60,000	Figure B 14.2
		100,000	Figure B 14.3
		200,000	Figure B 14.4
	Regional distributor	20,000	Figure B 15.1
		60,000	Figure B 15.2
		100,000	Figure B 15.3
		200,000	Figure B 15.4
		20,000	Figure B 16.1
		60,000	Figure B 16.2

With all of the required criteria determined, select Figure B 15.4 from Appendix B.

7. Determine the marginal cost:

With the appropriate marginal cost graph selected in Step 6, read off the marginal cost for the task duration.

Interpolating from the graph, the annual marginal cost is 10.0 cents per ESA.km (10.8-(10.8-6.7)/5).

8. Calculate annual cost:

The annual cost can now be calculated from all of the above information.

The total loading task was 184,500 ESA/year being applied over 30 km, so the total marginal cost can be determined by multiplying these together:

0.1 x 184,500 x 30 = $553,500 per year, say $554,000.

Due to the inherent assumptions and margins of error in the sources of data, the total annual cost should be rounded to the nearest $1,000 as shown.

With the total marginal cost determined, the cost per trip can be calculated:

Cost per trip = $554,000 / 10,000 = $55.40 per trip

Note: These are the estimated costs for one year of operation. Increases in the cost per trip charge should be considered during discussions with the generator for each year of operation.

User Guide: Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

References

ARRB Group 2015, 'Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks', ARRB Group Contract Report 009335 for Western Australia Local Government Association, Perth, Western Australia.

Bartlett, D, Michell, N, Toole, T 2025, 'Updates to the Incremental Cost Guides for Additional Freight Tasks on Sealed and Unsealed Roads – Technical Basis', National Transport Research Organisation, Melbourne, VIC.

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Appendices

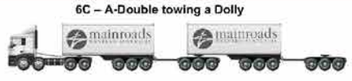
User Guide: Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

Appendix A

Restricted Access Vehicle Classes and Configurations in WA

Heavy Vehicle Services
May 2022

Accredited Mass Management Scheme (AMMS)
Tandem Drive Prime Mover, Trailer Combinations
Restricted Access Vehicle (RAV) Categories

RAV Category	RAV Description		Max. Length	Max. Mass & Approved Network		
				Level 1	Level 2	Level 3
Category 1	1A – Prime Mover & Semi Trailer 		19 m	50 t	-	-
				N1.1	-	-
Category 2	2A – Prime Mover & Semi Trailer  2B - Prime Mover, Semi Trailer & Pig Trailer or Dolly  2C – B-double 	2A	20 m	50.5 t	51.5 t	53 t
		2B	27.5 m	68.5 t	69.5 t	71 t
		2C	27.5 m	72 t	74 t	76.5 t
		All	-	N2.1	N2.2	N2.3
Category 3	3A – A-double 		27.5 m	89 t	91 t	94 t
				N3.1	N3.2	N3.3
Category 4	4A – A-double 		27.5 m	93.5 t	96.5 t	100 t
				N4.1	N4.2	N4.3
Category 5	5A – B-Double towing a Dolly  5B – A-Double  5C – A-Double towing a Dolly  5D – B-Triple 	5A	27.5 m + Dolly	72 t + Dolly	74 t + Dolly	76.5 t + Dolly
		5B / 5D	36.5 m	89 t	91 t	94 t
		5C	27.5 m + Dolly	89 t + Dolly	91 t + Dolly	94 t + Dolly
		All	-	N5.1	N5.2	N5.3
Category 6	6A – A-double  6B – B-Triple  6C – A-Double towing a Dolly 	6A / 6B	36.5 m	93.5 t	96.5 t	100 t
		6C	27.5 m + Dolly	93.5 t + Dolly	96.5 t + Dolly	100 t + Dolly
		All	-	N6.1	N6.2	N6.3
Category 7	7A – AB-Triple  7B – BA-Triple 		36.5 m	115 t	119 t	123.5 t
				N7.1	N7.2	N7.3
Category 8	There are no Category 8 RAVs for AMMS					
Category 9	9A – A-Triple  9B – A-Double towing a Dolly  9C – AB-Triple  9D – BA-Triple 	9A	53.5 m	127.5 t	130.5 t	135 t
		9B	36.5 m + Dolly	89 t + Dolly	91 t + Dolly	94 t + Dolly
		9C / 9D	45 m	115 t	119 t	123.5 t
		All	-	N9.1	N9.2	N9.3
Category 10	10A – A-Triple  10B – A-Double towing a Dolly  10C – Double B-Double  10D – ABB-Quad  10E – AAB-Quad 	10A / 10C / 10D	53.5 m	136.5 t	141.5 t	147 t
		10B	36.5 m + Dolly	93.5 t + Dolly	96.5 t + Dolly	100 t + Dolly
		10E	53.5 m	158 t	164 t	170.5 t
		All	-	N10.1	N10.2	N10.3

Source: Reprinted with permission from Main Roads WA *Accredited Mass Management Scheme Tandem Drive Prime Mover, Trailer Combinations* (2022).

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Appendix A

Restricted Access Vehicle Classes and Configurations in WA

Heavy Vehicle Services
May 2022

Accredited Mass Management Scheme (AMMS)

Tandem Drive Truck, Trailer Combinations

Restricted Access Vehicle (RAV) Categories

RAV Category	RAV Description		Max. Length	Max. Mass & Approved Network		
				Level 1	Level 2	Level 3
Category 1	1A – Rigid Truck  1B – Rigid Truck towing a Pig Trailer or Dolly 	1A	12.5 m	29 t	29 t	-
		1B	20 m	47 t	47 t	-
		All	-	N1.1	N1.1	-
Category 2	2A – Rigid Truck  2B – Rigid Truck towing a 4 or 5 Axle Dog Trailer  2C – Rigid Truck towing a 6 Axle Dog Trailer 	2A	12.5 m	-	-	29.5 t
		2B	25 m	67.5 t	68.5 t	70.5 t
		2C	25 m	72 t	74 t	76.5 t
		All	-	N2.1	N2.2	N2.3
Category 3	Refer to AMMS Tandem Drive Prime Mover, Trailer Combinations					
Category 4	Refer to AMMS Tandem Drive Prime Mover, Trailer Combinations					
Category 5	Refer to AMMS Tandem Drive Prime Mover, Trailer Combinations					
Category 6	Refer to AMMS Tandem Drive Prime Mover, Trailer Combinations					
Category 7	7A – Rigid Truck Towing two Dog Trailers 		36.5 m	115 t N7.1	119 t N7.2	123.5 t N7.3
Category 8	There are no Category 8 RAVs for AMMS					
Category 9	Refer to AMMS Tandem Drive Prime Mover, Trailer Combinations					
Category 10	Refer to AMMS Tandem Drive Prime Mover, Trailer Combinations					

Source: Reprinted with permission from Main Roads WA *Accredited Mass Management Scheme Tandem Drive Prime Mover, Trailer Combinations* (2022).

Appendix B
Marginal Cost Charts

B.1 Cost Zone 1

B.1.1 Cost Zone 1 – Access roads

Figure B 1.1: Marginal cost chart for cost zone 1 access roads with 20,000 ESA/year loading

Figure B 1.2: Marginal cost chart for cost zone 1 access roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

Figure B 1.3: Marginal cost chart for cost zone 1 access roads with 100,000 ESA/year loading

Figure B 1.4: Marginal cost chart for cost zone 1 access roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.1.2 Cost Zone 1 – Local distributor

Figure B 2.1: Marginal cost chart for cost zone 1 local distributor roads with 20,000 ESA/year loading

Figure B 2.2: Marginal cost chart for cost zone 1 local distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

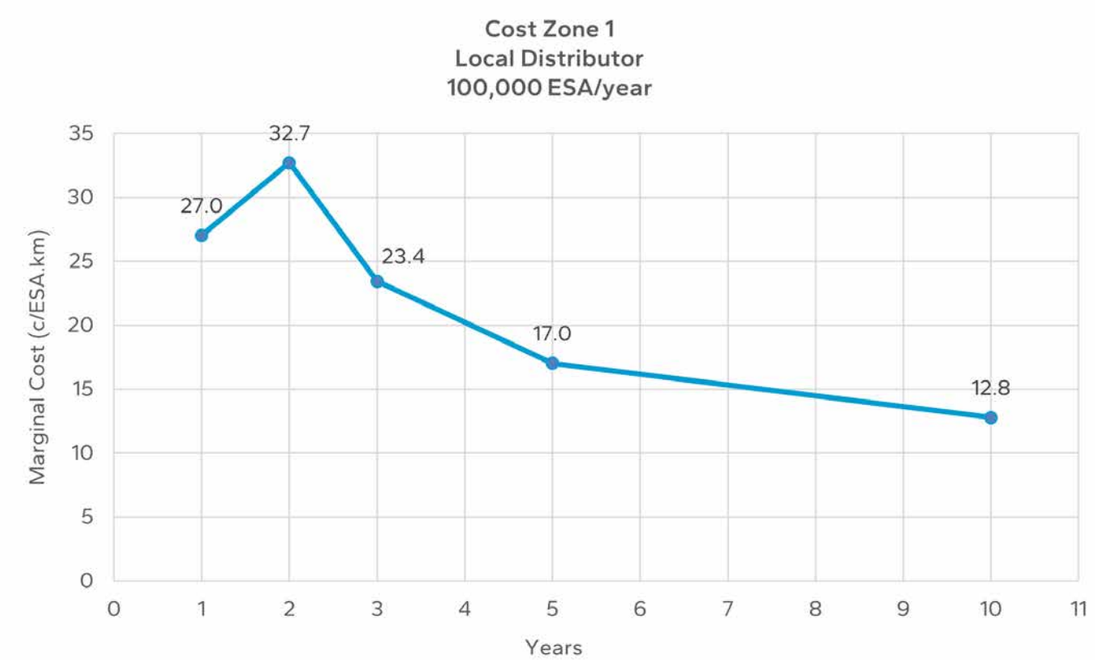

Figure B 2.3: Marginal cost chart for cost zone 1 local distributor roads with 100,000 ESA/year loading

Figure B 2.4: Marginal cost chart for cost zone 1 local distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.1.3 Cost Zone 1 – Regional distributor

Figure B 3.1: Marginal cost chart for cost zone 1 regional distributor roads with 20,000 ESA/year loading

Figure B 3.2: Marginal cost chart for cost zone 1 regional distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

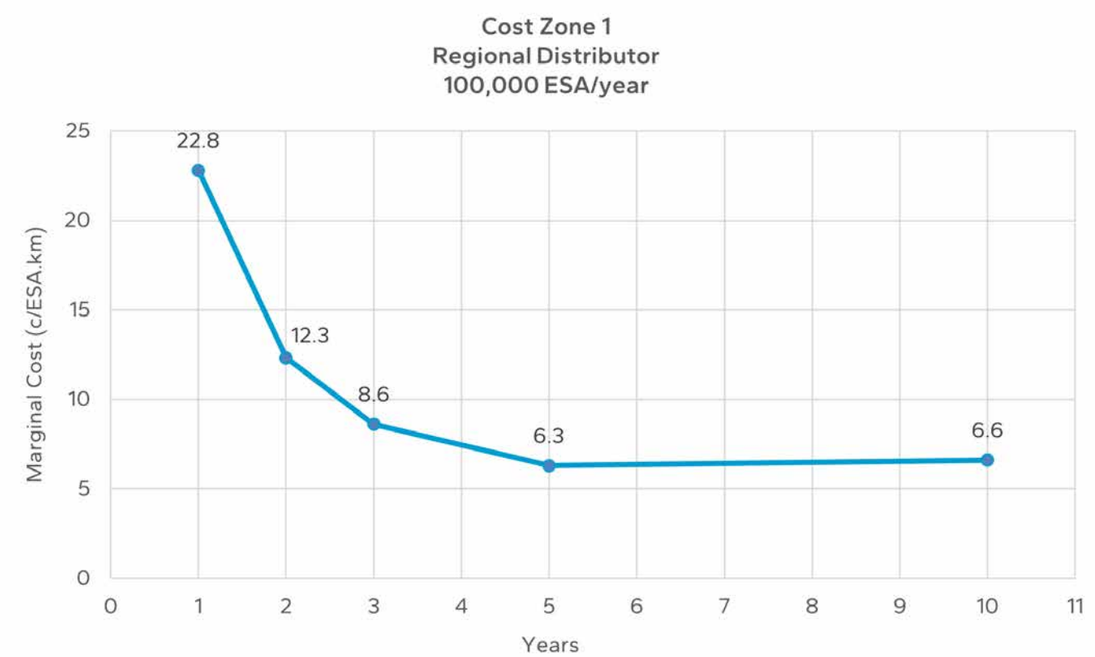

Figure B 3.3: Marginal cost chart for cost zone 1 regional distributor roads with 100,000 ESA/year loading

Figure B 3.4: Marginal cost chart for cost zone 1 regional distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.1.4 Cost Zone 1 – District distributor

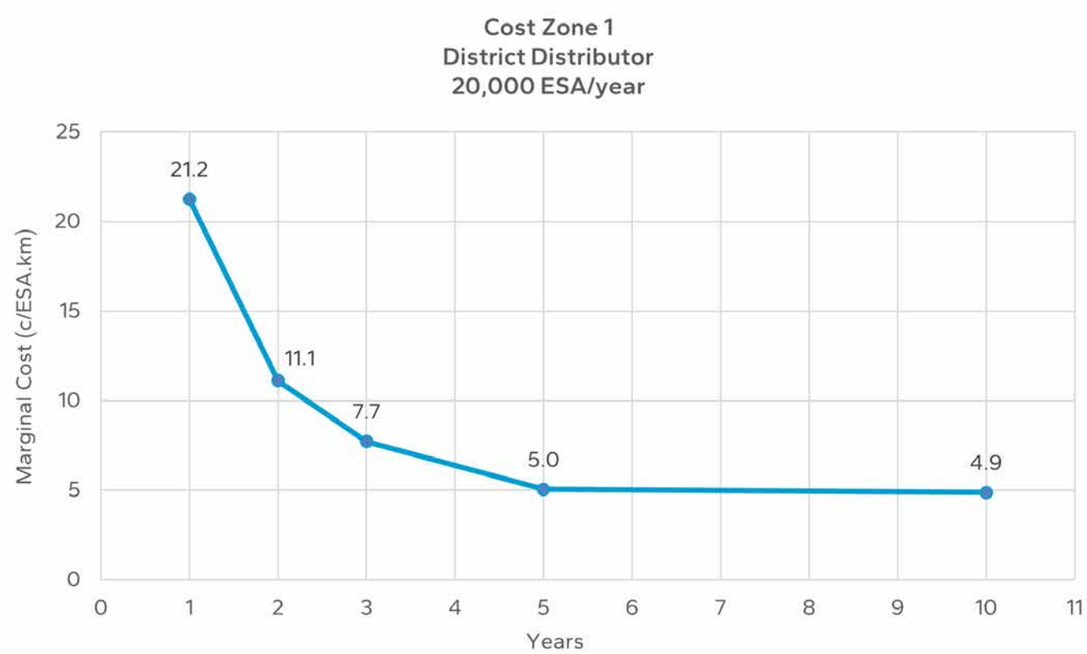

Figure B 4.1: Marginal cost chart for cost zone 1 district distributor roads with 20,000 ESA/year loading

Figure B 4.2: Marginal cost chart for cost zone 1 district distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

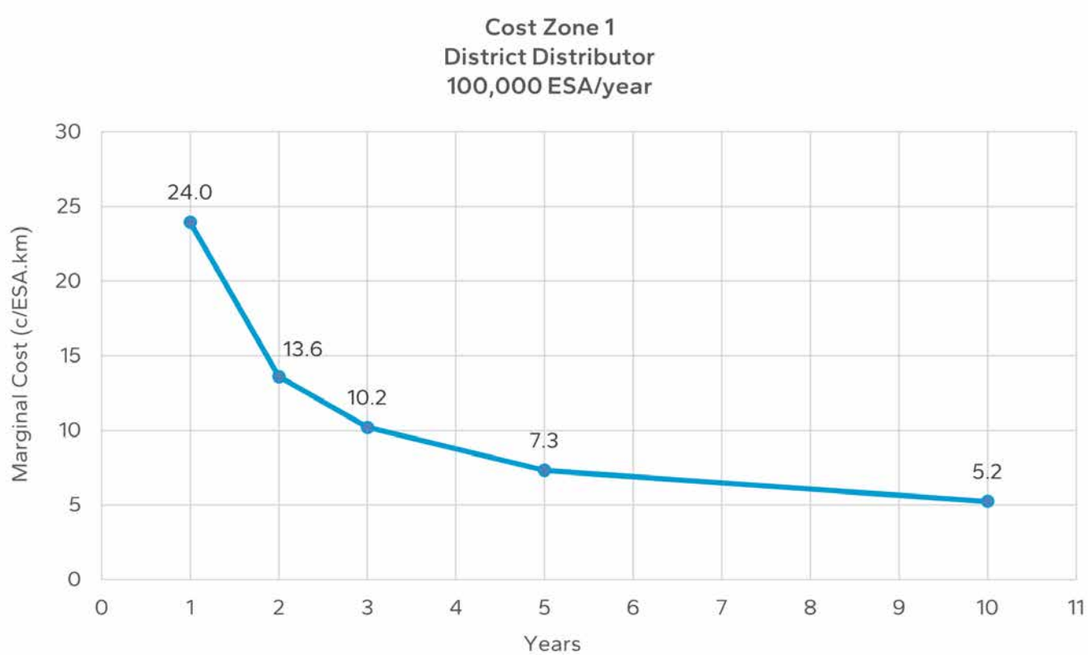

Figure B 4.3: Marginal cost chart for cost zone 1 district distributor roads with 100,000 ESA/year loading

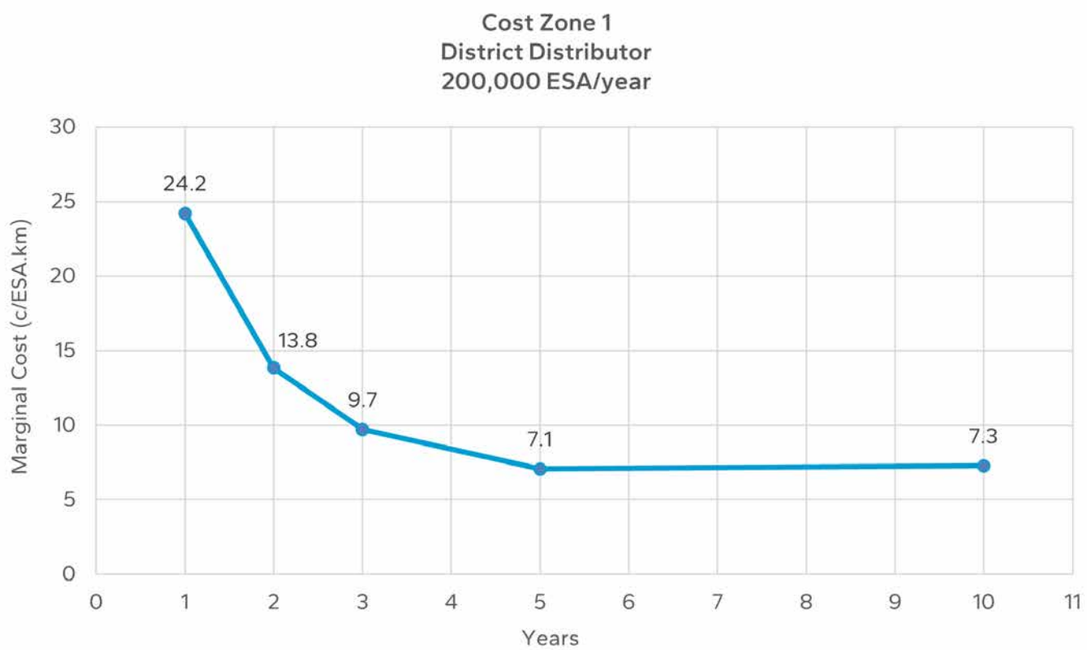

Figure B 4.4: Marginal cost chart for cost zone 1 district distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.2 Cost Zone 2

B.2.1 Cost Zone 2 – Access roads

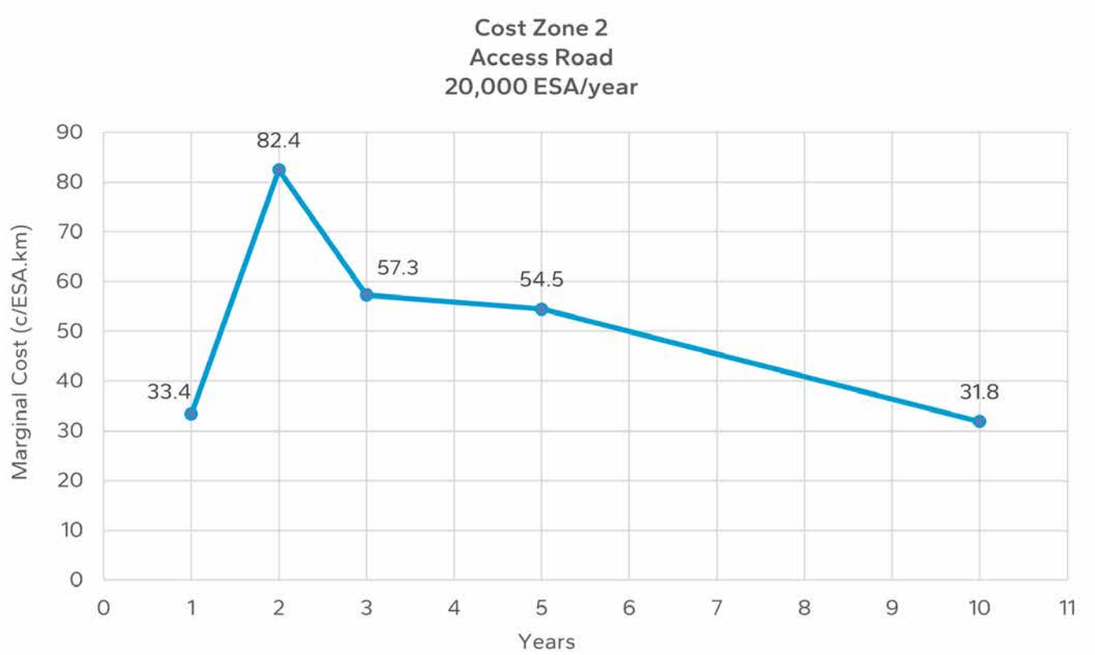

Figure B 5.1: Marginal cost chart for cost zone 2 access roads with 20,000 ESA/year loading

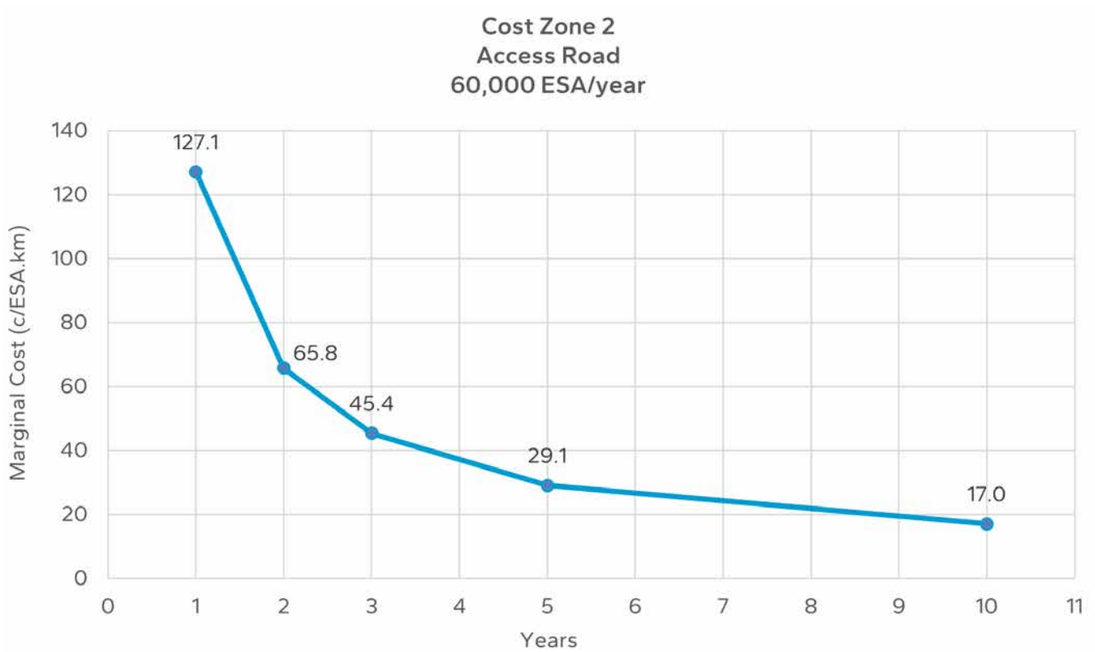

Figure B 5.2: Marginal cost chart for cost zone 2 access roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

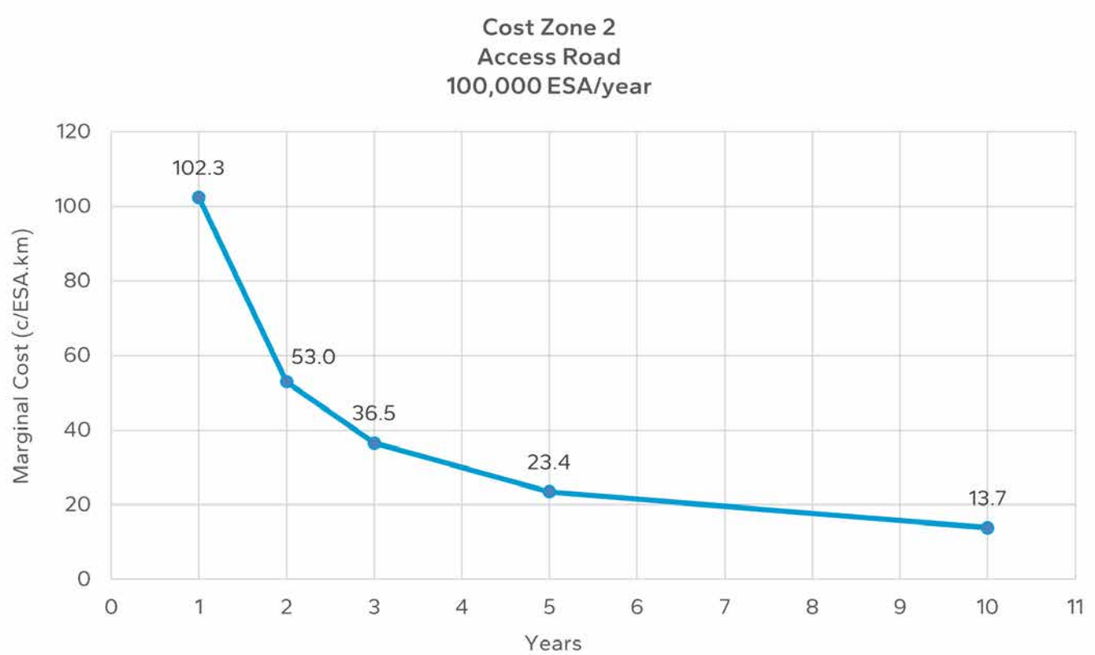

Figure B 5.3: Marginal cost chart for cost zone 2 access roads with 100,000 ESA/year loading

Figure B 5.4: Marginal cost chart for cost zone 2 access roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.2.2 Cost Zone 2 – Local distributor

Figure B 6.1: Marginal cost chart for cost zone 2 local distributor roads with 20,000 ESA/year loading

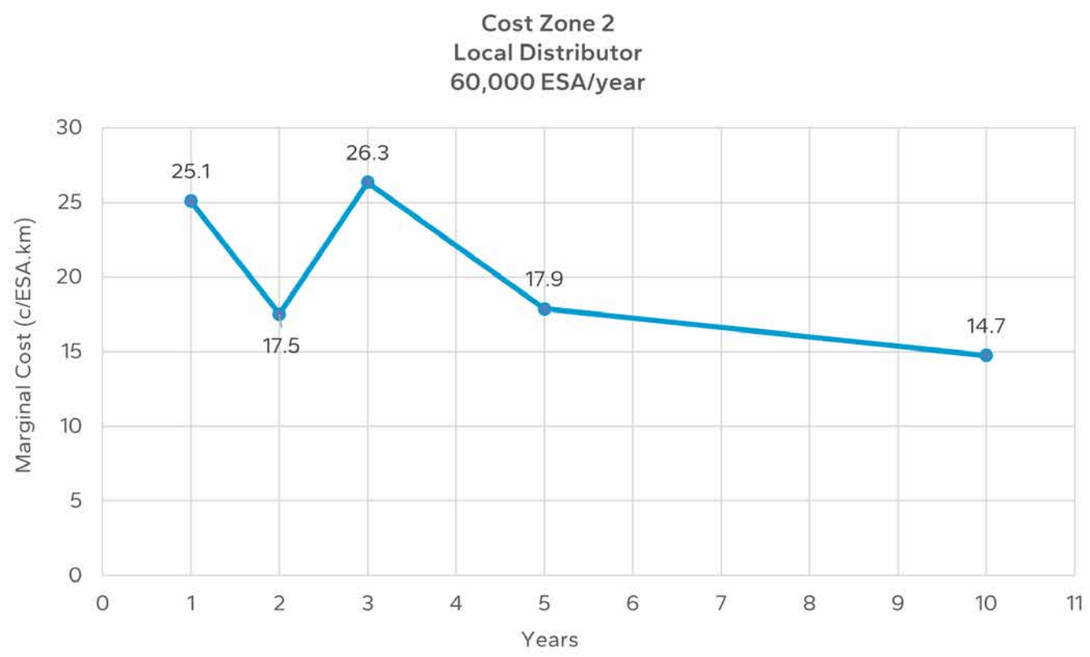

Figure B 6.2: Marginal cost chart for cost zone 2 local distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

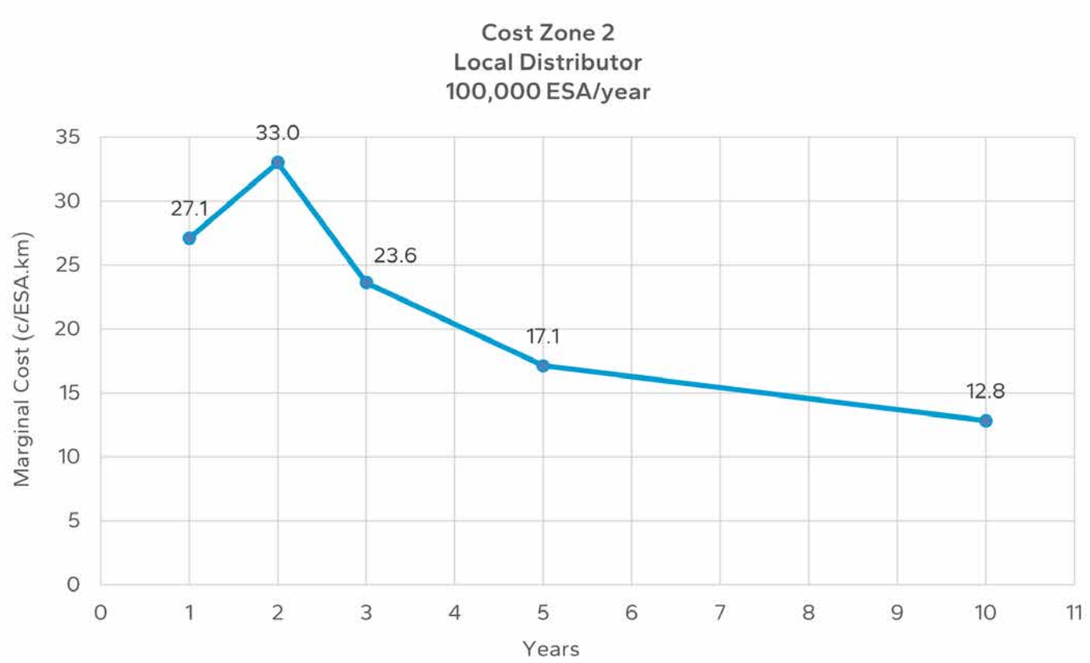

Figure B 6.3: Marginal cost chart for cost zone 2 local distributor roads with 100,000 ESA/year loading

Figure B 6.4: Marginal cost chart for cost zone 2 local distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.2.3 Cost Zone 2 – Regional distributor

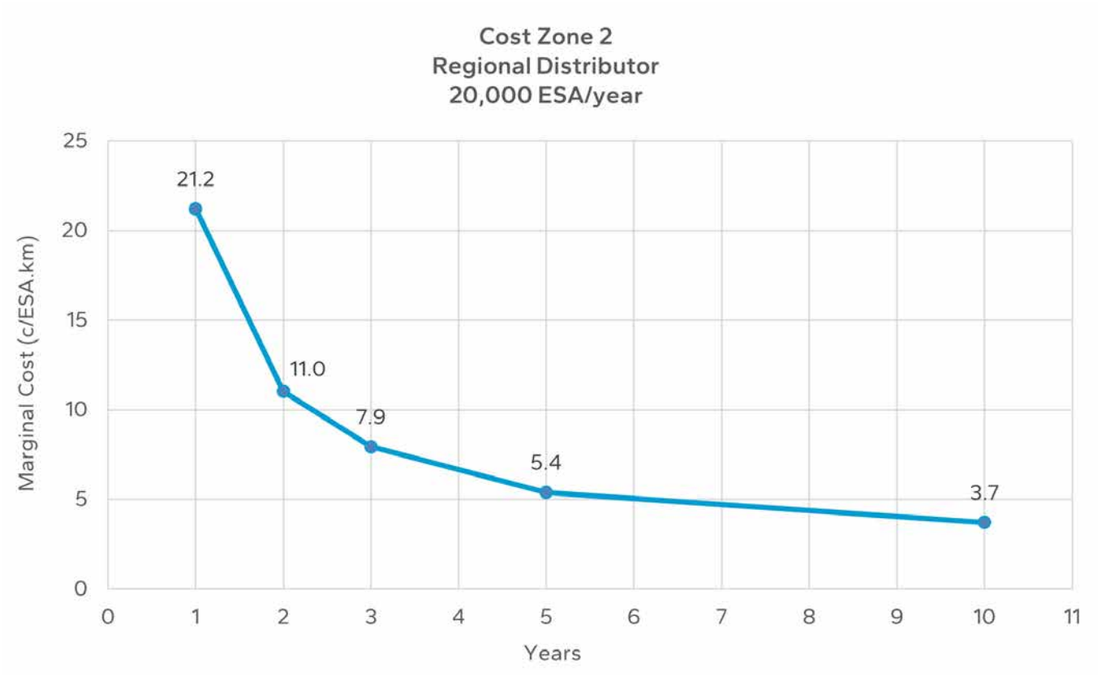

Figure B 7.1: Marginal cost chart for cost zone 2 regional distributor roads with 20,000 ESA/year loading

Figure B 7.2: Marginal cost chart for cost zone 2 regional distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

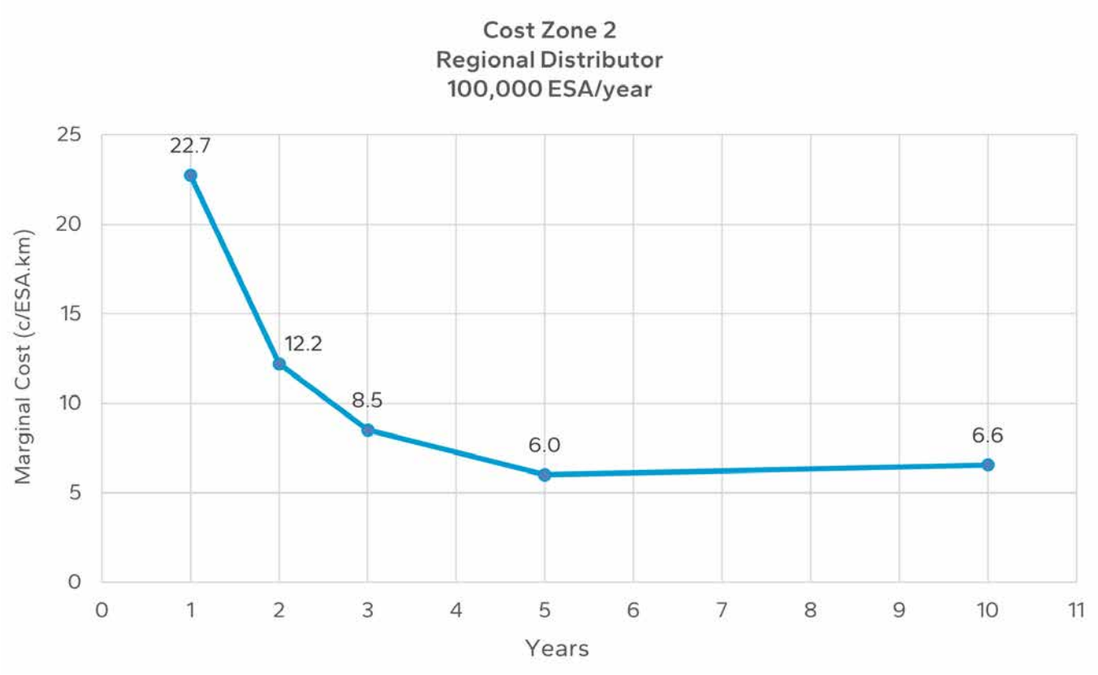

Figure B 7.3: Marginal cost chart for cost zone 2 regional distributor roads with 100,000 ESA/year loading

Figure B 7.4: Marginal cost chart for cost zone 2 regional distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.2.4 Cost Zone 2 – District distributor

Figure B 8.1: Marginal cost chart for cost zone 2 district distributor roads with 20,000 ESA/year loading

Figure B 8.2: Marginal cost chart for cost zone 2 district distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

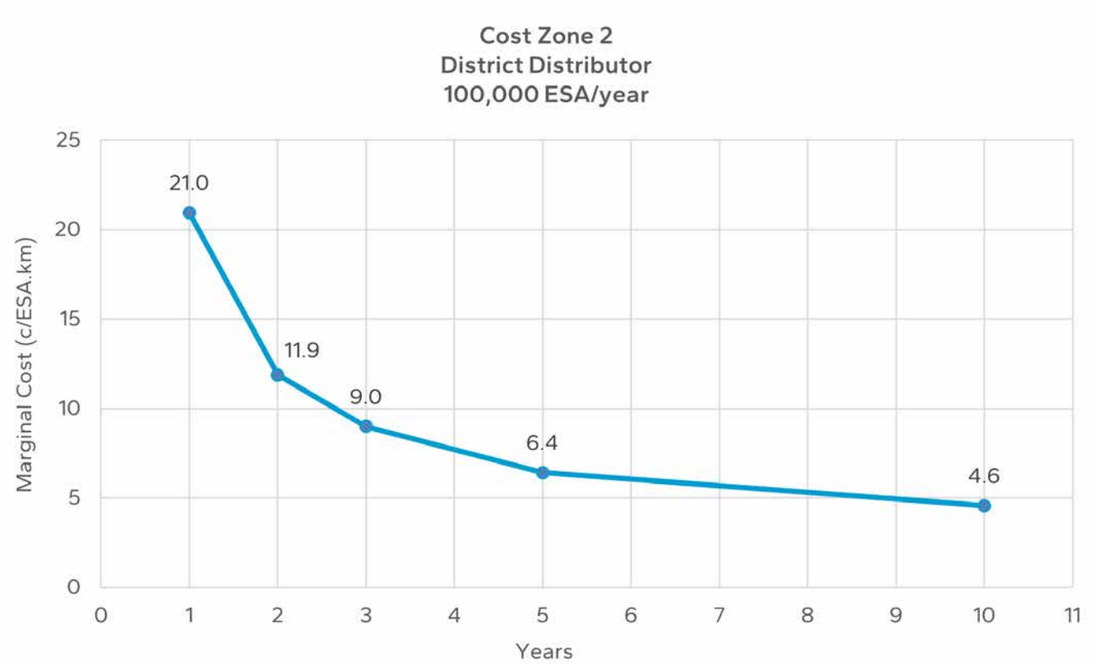

Figure B 8.3: Marginal cost chart for cost zone 2 district distributor roads with 100,000 ESA/year loading

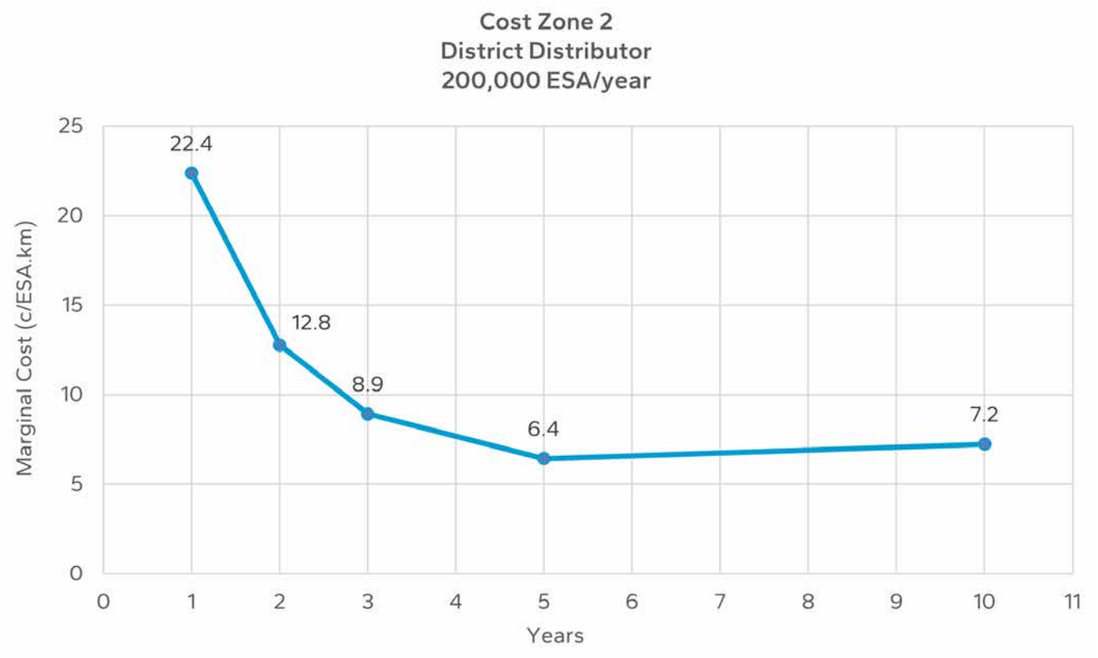

Figure B 8.4: Marginal cost chart for cost zone 2 district distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.3 Cost Zone 3

B.3.1 Cost Zone 3 – Access roads

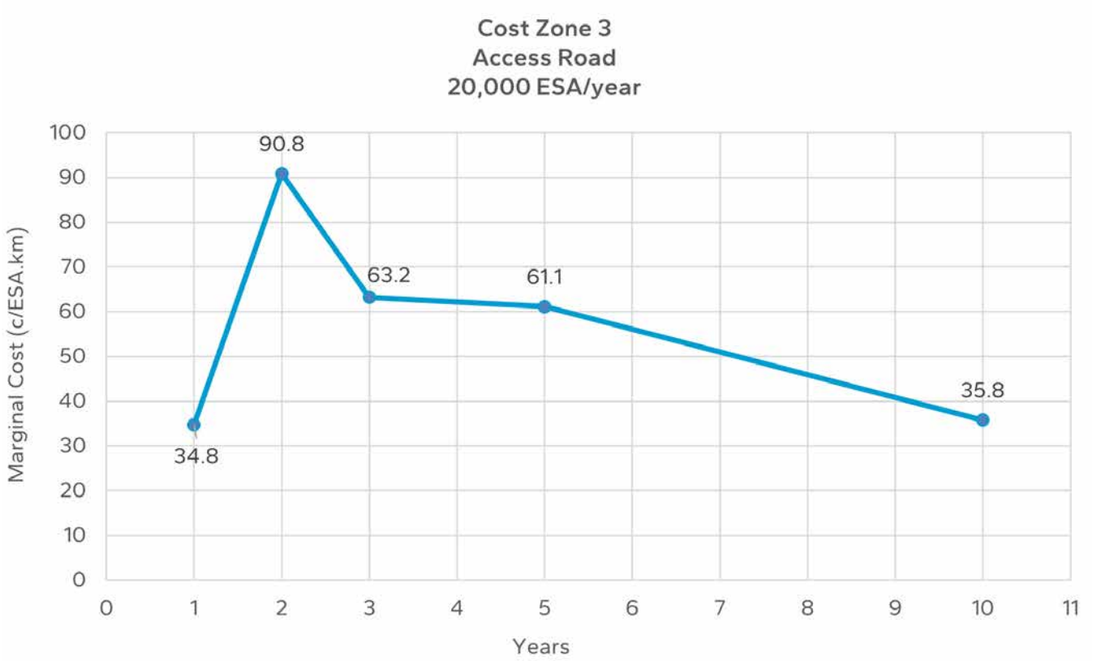

Figure B 9.1: Marginal cost chart for cost zone 3 access roads with 20,000 ESA/year loading

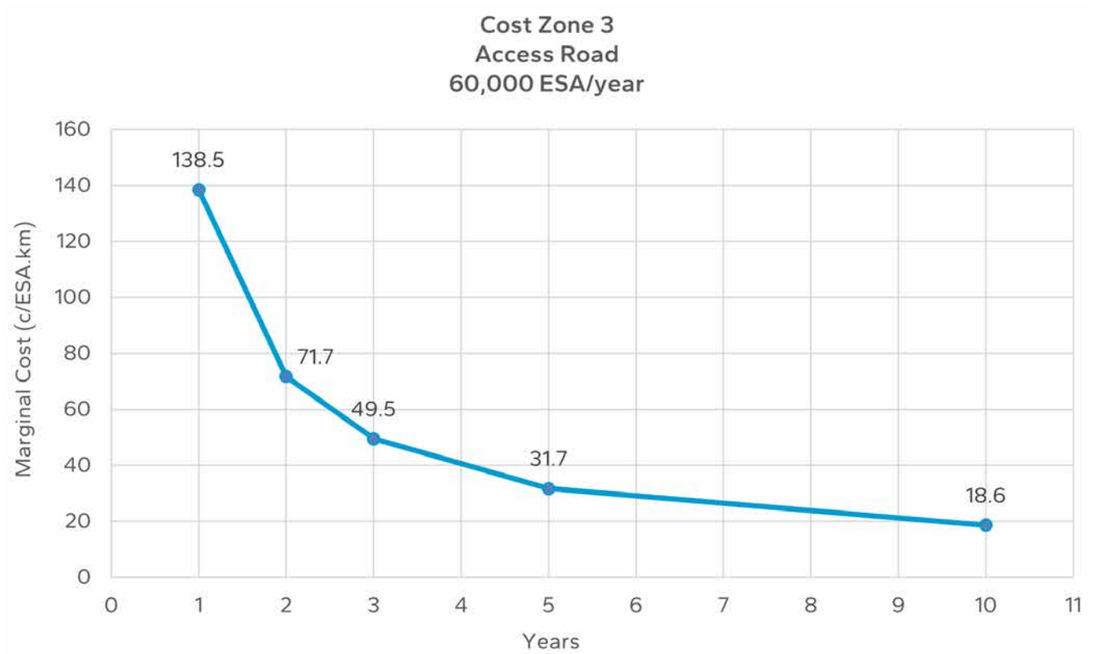

Figure B 9.2: Marginal cost chart for cost zone 3 access roads with 60,000 ESA/year loading

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Figure B 9.3: Marginal cost chart for cost zone 3 access roads with 100,000 ESA/year loading

Figure B 9.4: Marginal cost chart for cost zone 3 access roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.3.2 Cost Zone 3 – Local distributor

Figure B 10.1: Marginal cost chart for cost zone 3 local distributor roads with 20,000 ESA/year loading

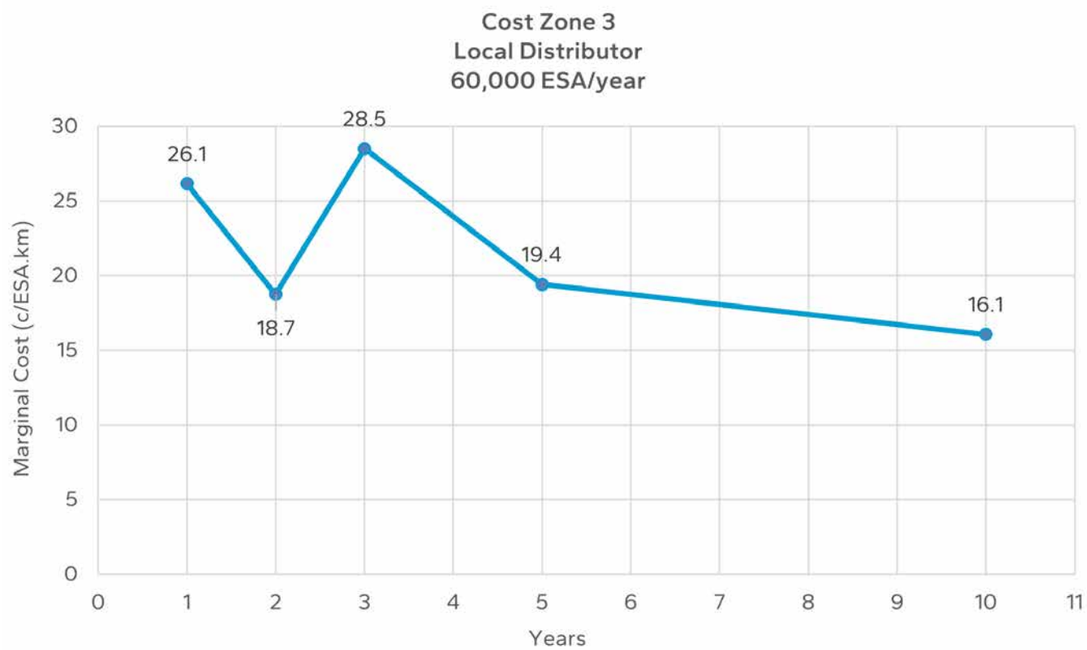

Figure B 10.2: Marginal cost chart for cost zone 3 local distributor roads with 60,000 ESA/year loading

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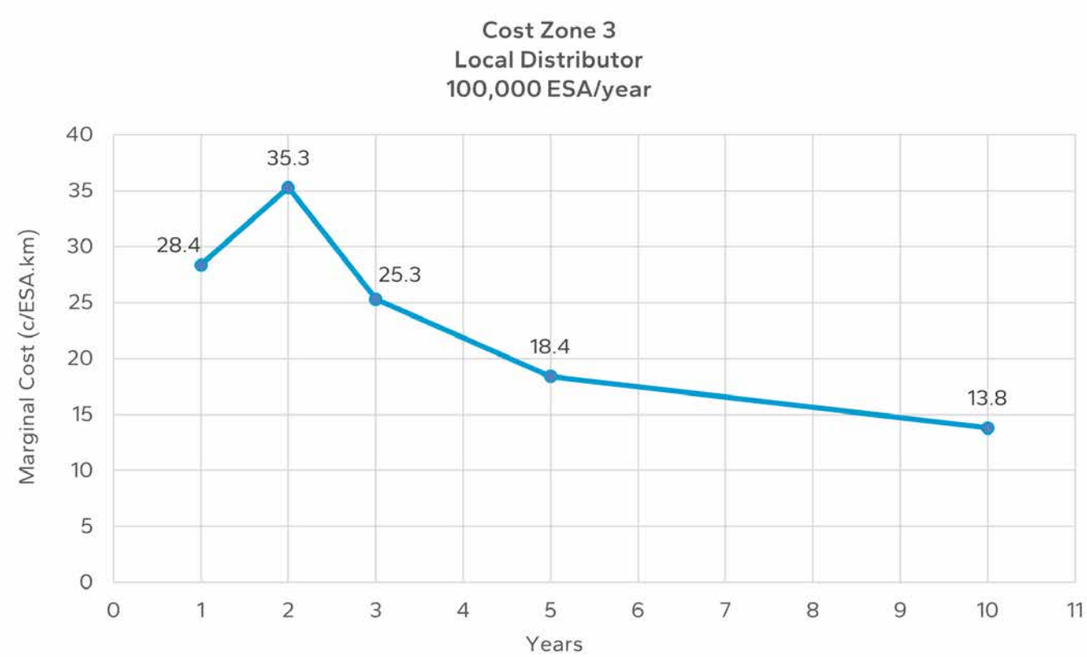

Figure B 10.3: Marginal cost chart for cost zone 3 local distributor roads with 100,000 ESA/year loading

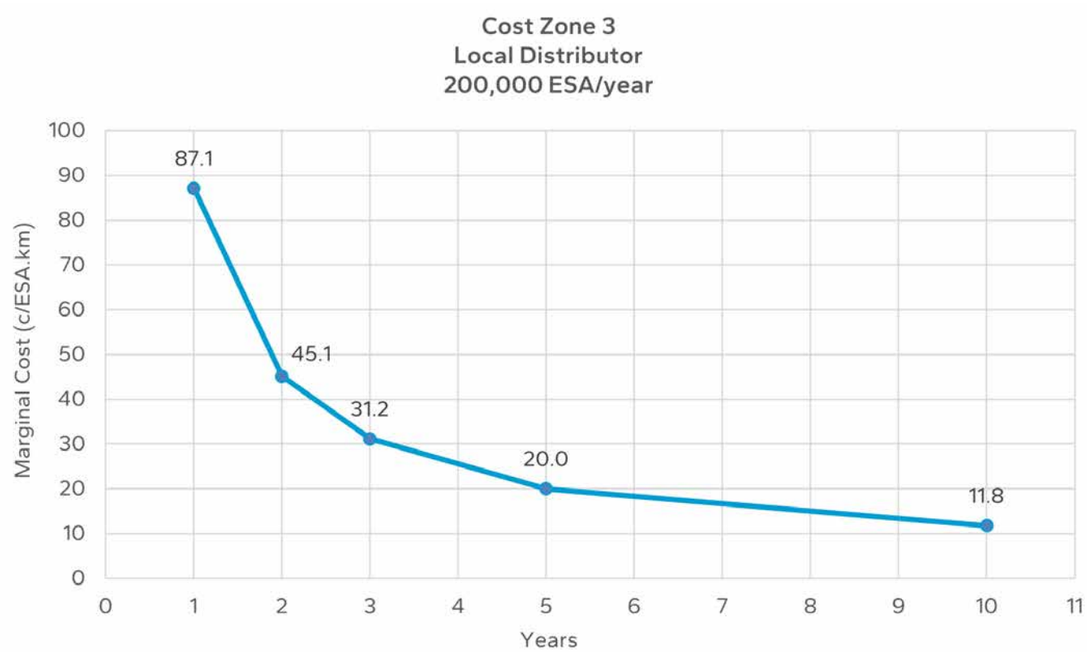

Figure B 10.4: Marginal cost chart for cost zone 3 local distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.3.3 Cost Zone 3 – Regional distributor

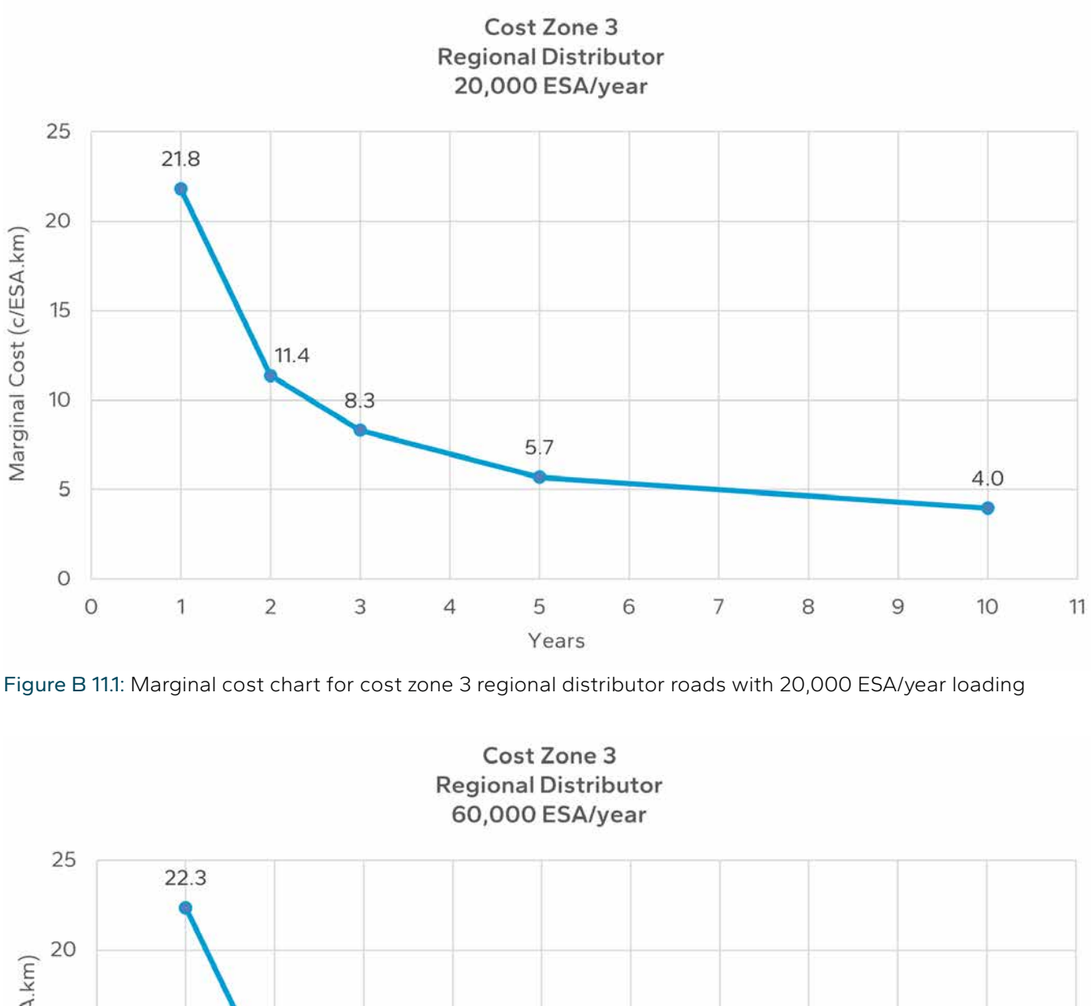

Figure B 11.1: Marginal cost chart for cost zone 3 regional distributor roads with 20,000 ESA/year loading

Figure B 11.2: Marginal cost chart for cost zone 3 regional distributor roads with 60,000 ESA/year loading

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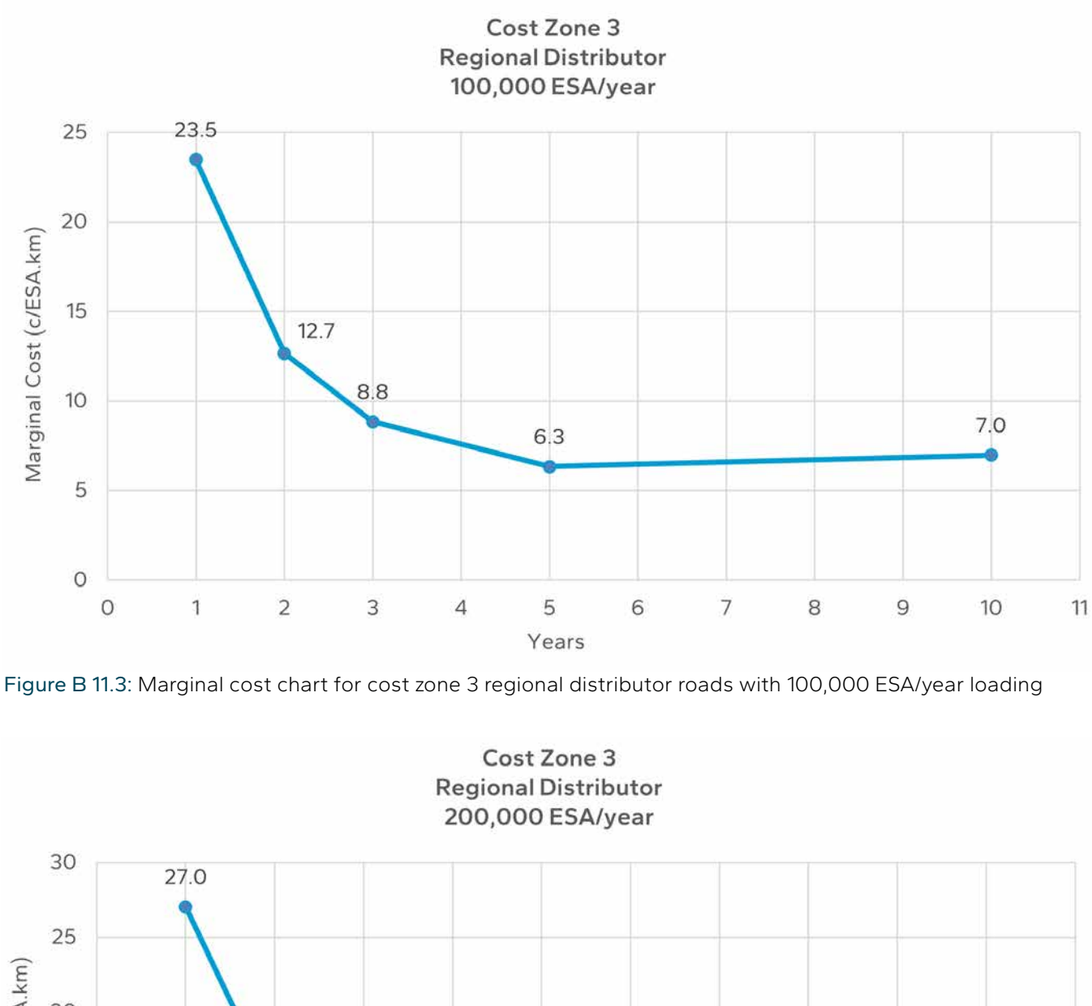

Figure B 11.3: Marginal cost chart for cost zone 3 regional distributor roads with 100,000 ESA/year loading

Figure B 11.4: Marginal cost chart for cost zone 3 regional distributor roads with 200,000 ESA/year loading

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B.3.4 Cost Zone 3 – District distributor

Figure B 12.1: Marginal cost chart for cost zone 3 district distributor roads with 20,000 ESA/year loading

Figure B 12.2: Marginal cost chart for cost zone 3 district distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

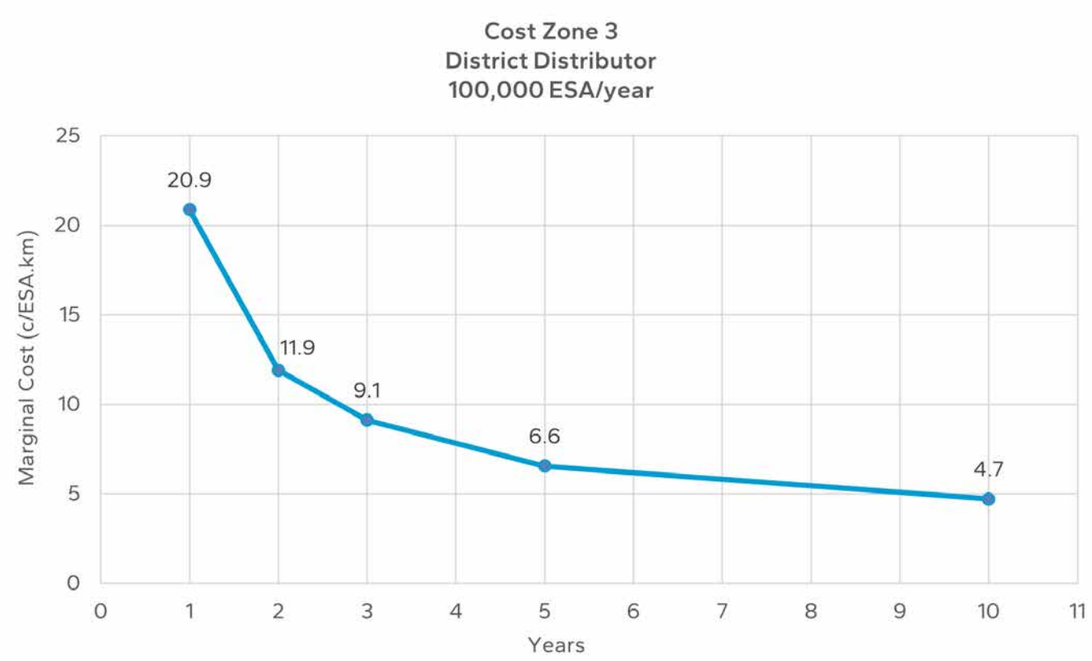

Figure B 12.3: Marginal cost chart for cost zone 3 district distributor roads with 100,000 ESA/year loading

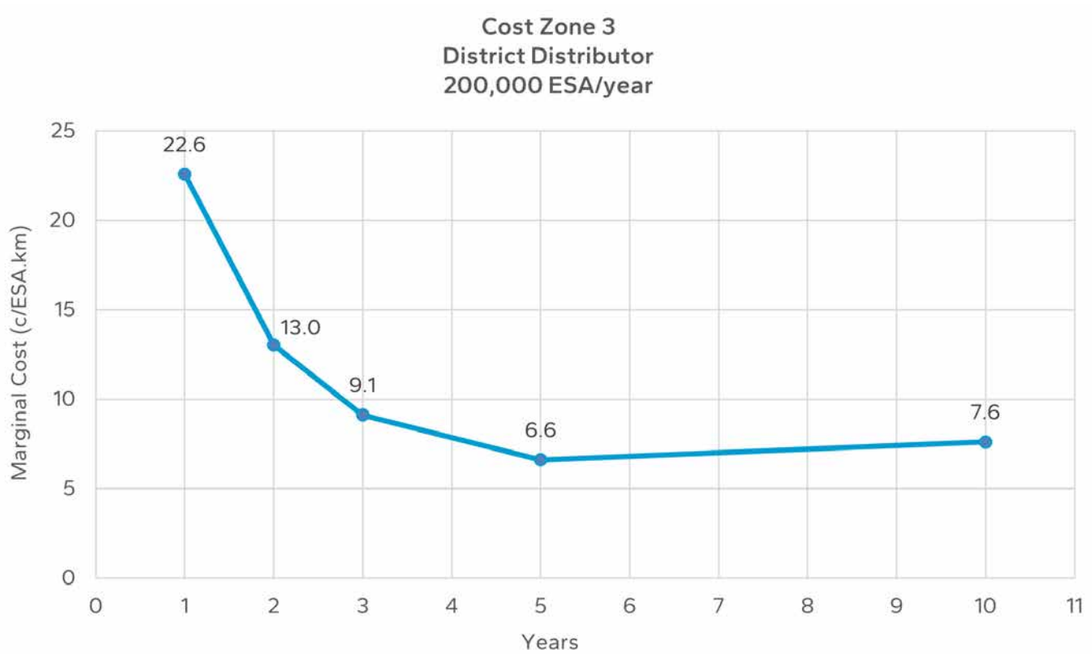

Figure B 12.4: Marginal cost chart for cost zone 3 district distributor roads with 200,000 ESA/year loading

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Marginal Cost Charts

B.4 Cost Zone 4

B.4.1 Cost Zone 4 – Access roads

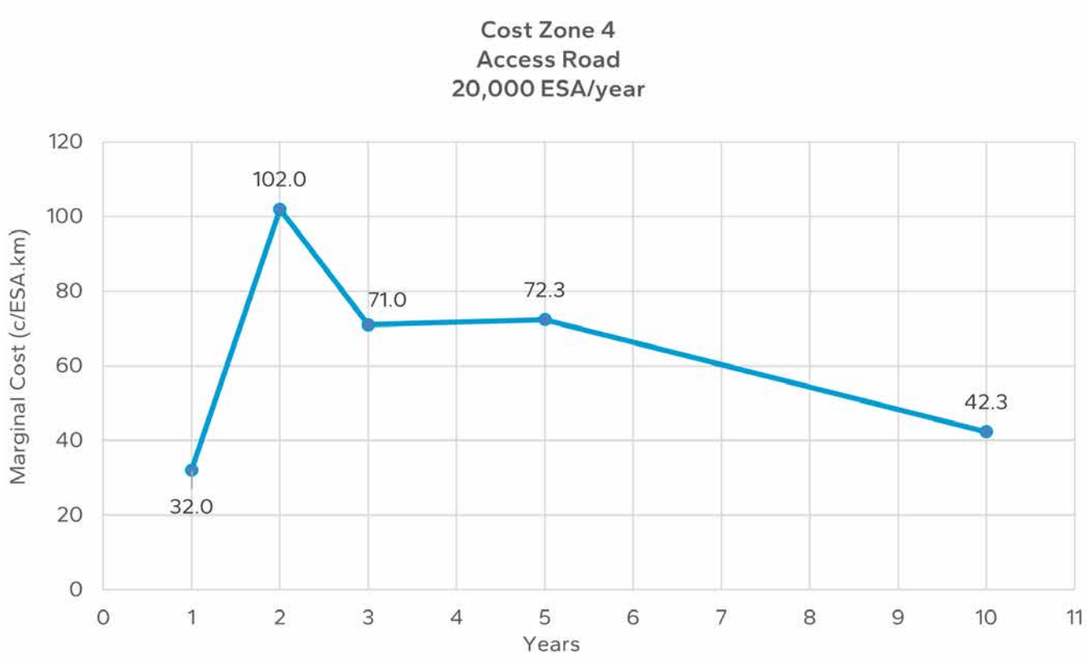

Figure B 13.1: Marginal cost chart for cost zone 4 access roads with 20,000 ESA/year loading

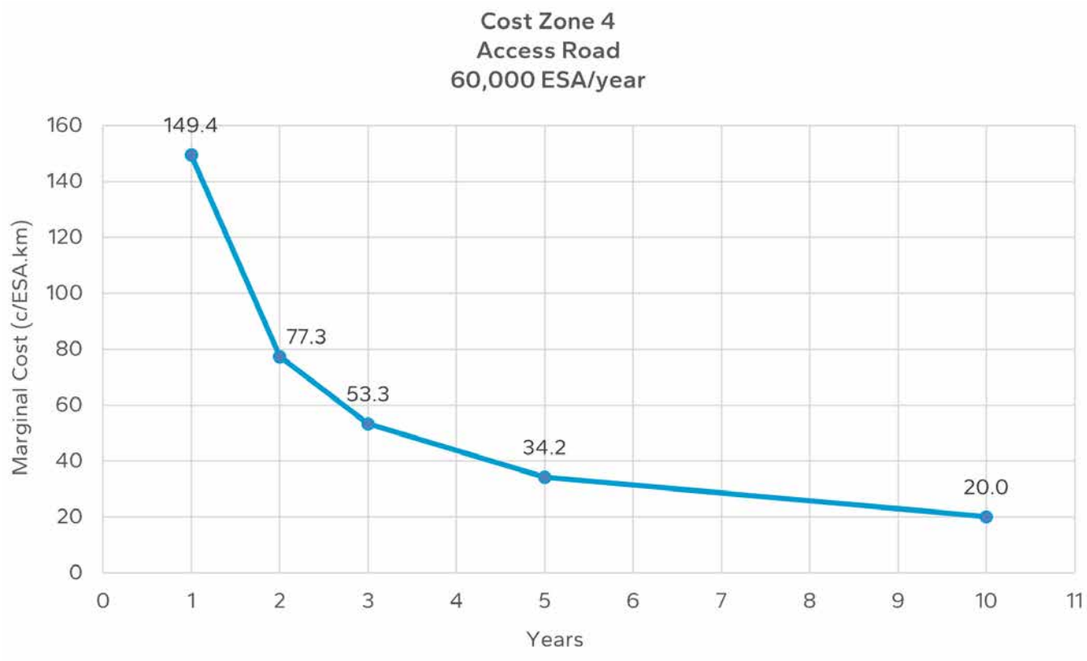

Figure B 13.2: Marginal cost chart for cost zone 4 access roads with 60,000 ESA/year loading

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Figure B 13.3: Marginal cost chart for cost zone 4 access roads with 100,000 ESA/year loading

Figure B 13.4: Marginal cost chart for cost zone 4 access roads with 200,000 ESA/year loading

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B.4.2 Cost Zone 4 – Local distributor

Figure B 14.1: Marginal cost chart for cost zone 4 local distributor roads with 20,000 ESA/year loading

Figure B 14.2: Marginal cost chart for cost zone 4 local distributor roads with 60,000 ESA/year loading

Appendix B
Marginal Cost Charts

Figure B 14.3: Marginal cost chart for cost zone 4 local distributor roads with 100,000 ESA/year loading

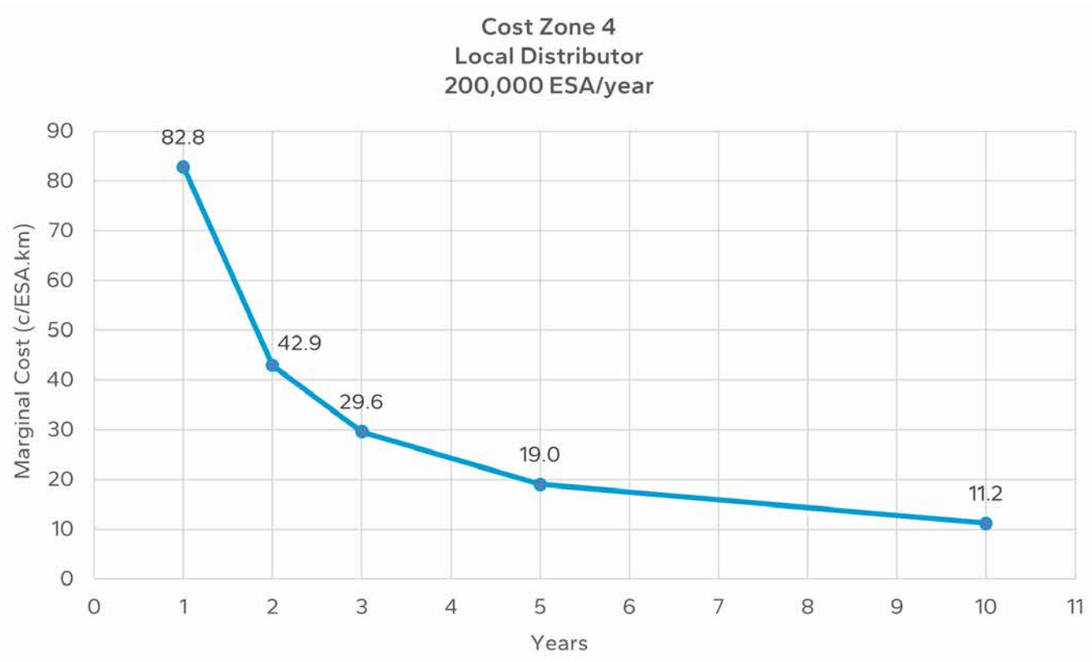

Figure B 14.4: Marginal cost chart for cost zone 4 local distributor roads with 200,000 ESA/year loading

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Marginal Cost Charts

B.4.3 Cost Zone 4 – Regional distributor

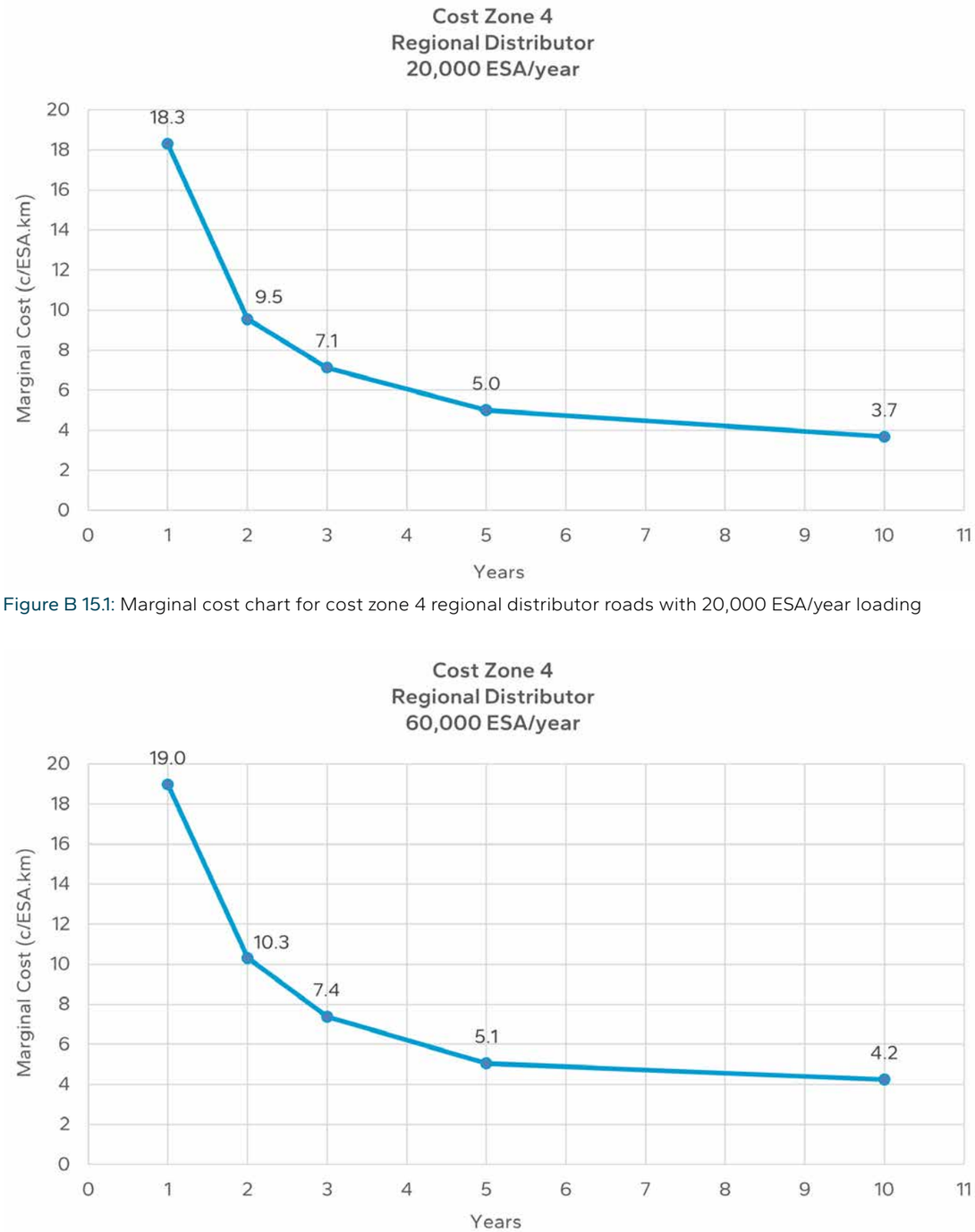

Figure B 15.1: Marginal cost chart for cost zone 4 regional distributor roads with 20,000 ESA/year loading

Figure B 15.2: Marginal cost chart for cost zone 4 regional distributor roads with 60,000 ESA/year loading

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Marginal Cost Charts

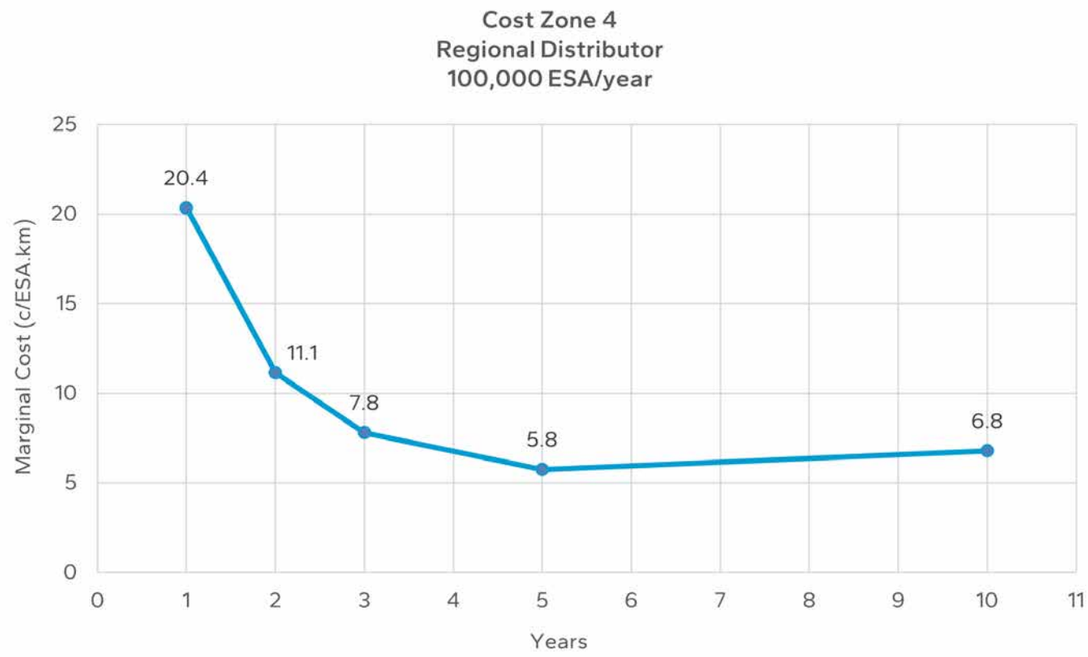

Figure B 15.3: Marginal cost chart for cost zone 4 regional distributor roads with 100,000 ESA/year loading

Figure B 15.4: Marginal cost chart for cost zone 4 regional distributor roads with 200,000 ESA/year loading

Appendix B
Marginal Cost Charts

B.4.4 Cost Zone 4 – District distributor

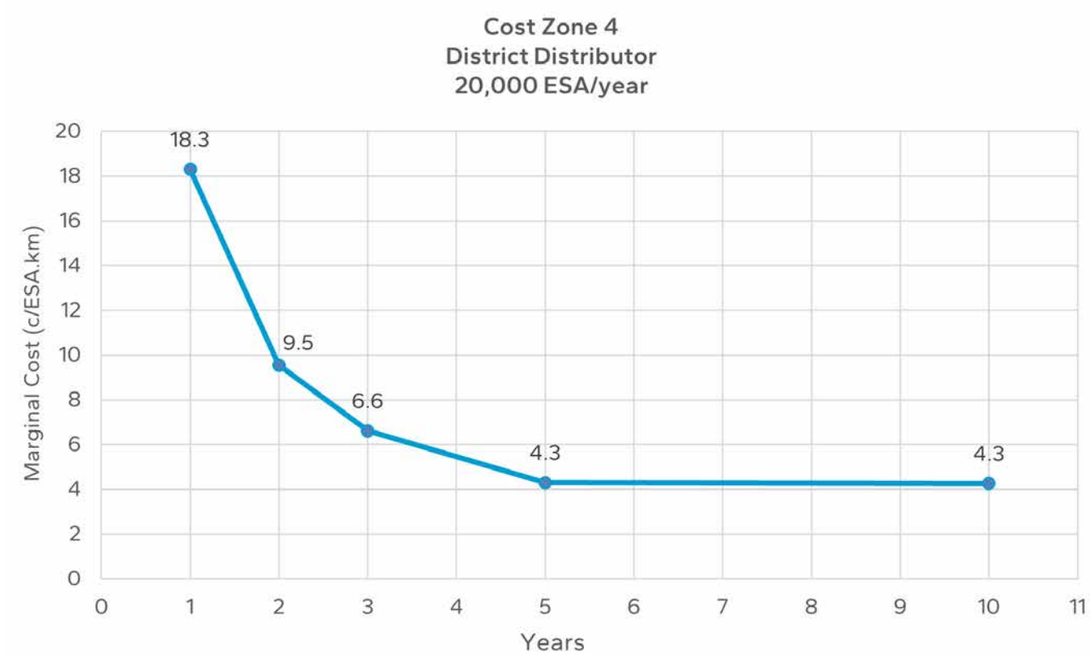

Figure B 16.1: Marginal cost chart for cost zone 4 district distributor roads with 20,000 ESA/year loading

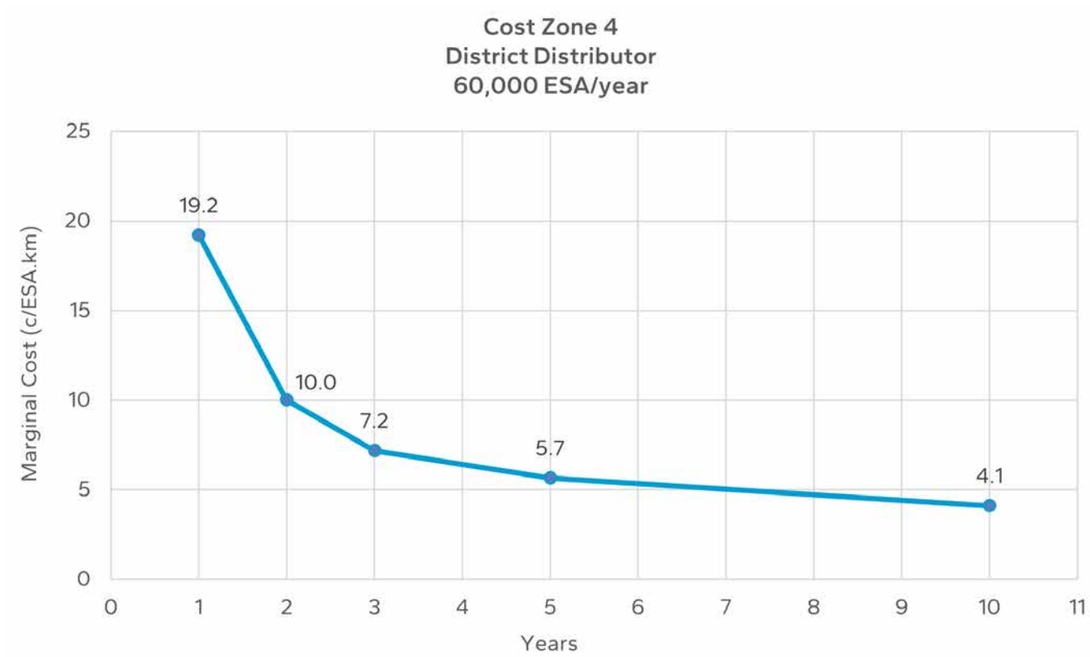

Figure B 16.2: Marginal cost chart for cost zone 4 district distributor roads with 60,000 ESA/year loading

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Marginal Cost Charts

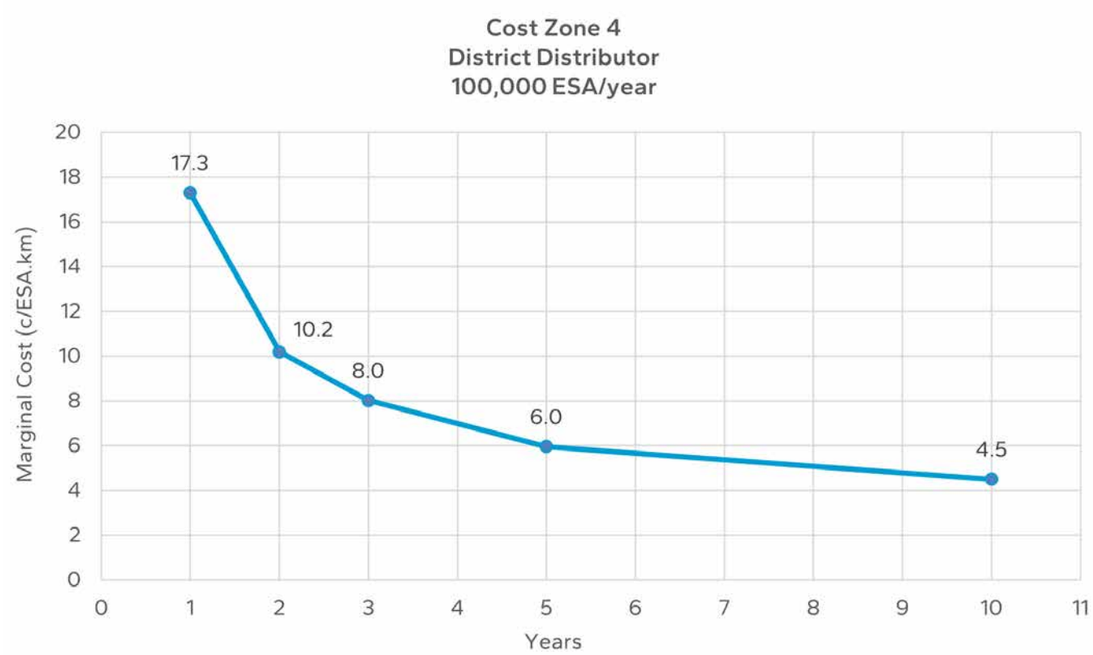

Figure B 16.3: Marginal cost chart for cost zone 4 district distributor roads with 100,000 ESA/year loading

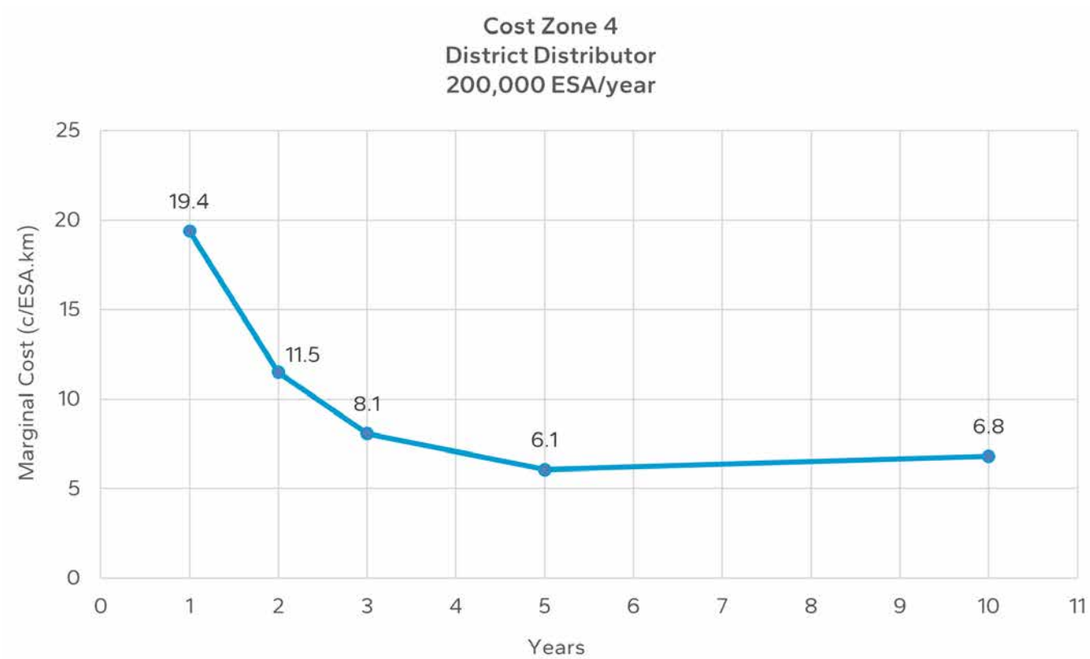

Figure B 16.4: Marginal cost chart for cost zone 4 district distributor roads with 200,000 ESA/year loading

Appendix C
Technical Background and Explanations

This appendix outlines some of the more relevant technical background that is associated with the development of the content presented in this user guide.

C.1 What is an ESA?

An Equivalent Standard Axle (ESA) is a measure which standardises the damage done to a road pavement by an axle group of a heavy vehicle.

For simplicity, design traffic loading is often described as the number of Standard Axle Repetitions (SAR) that a pavement structure will carry. To calculate the design SAR for a pavement, the damage associated with each axle group of each vehicle configuration is estimated in terms of Standard Axle Repetitions.

A standard axle is a single axle with dual tyres (referred to as SADT) applying an axle load of 80 kN (approximately 8.16 tonne) to the pavement. The number of SARs that an axle group with a certain load applies to a pavement can be determined using Equation 1:

$$SARm_{ij} = \left[\frac{L_{ij}}{SL_i}\right]^m$$

where

$SARm_{ij}$ = number of Standard Axle Repetitions (or passages of the Standard Axle) which causes the same amount of damage as a single passage of axle group type $_i$ with load L_{ij}, where the load damage exponent is m

SL_i = Standard Load for axle group type $_i$

L_{ij} = $_j$th load magnitude on the axle group type $_i$

m = load damage exponent for the damage type.

The SAR calculated with a load damage exponent of 4 is commonly referred to as an ESA and is applied to granular pavements with a thin bituminous surfacing designed using an empirical methodology, which forms the basis for the examples in this guide. Throughout this guide ESA are used, but if the type of pavements differs from that used in this guide the SAR should be determined using an alternative load exponent of 5 for asphalt surfaced pavements and 12 for cement stabilised pavements. It is evident therefore that, axle mass applications in excess of standard axle masses have an exponentially increasing effect on pavement wear.

For different axle configurations, the Austroads *Guide to Pavement Technology Part 2: Pavement Structural Design* shows how to convert the different loadings into a unit that is equivalent across all axle groups.

C.2 What is a Marginal Cost?

Marginal costs are associated with the difference in expenditure required to maintain a pavement under different loading. The base traffic represents a traffic volume that would consume the structural capacity of the selected pavement structures over a 50 year period, i.e. the pavement's service life. A road may be subjected to a defined period of additional loading (see Figure C.1.). This user guide has been developed by modelling the effect of four typical additional loading scenarios.

The effects of this additional loading on costs to the agency to meet and deliver the same levels of services as determined for the base traffic are estimated by modelling the structural performance of the road over time. The costs included provision for routine maintenance, resurfacing, and pavement rehabilitation and reconstruction activities to be undertaken by the road agency to deliver these levels of service.

Appendix C
Technical Background and Explanations

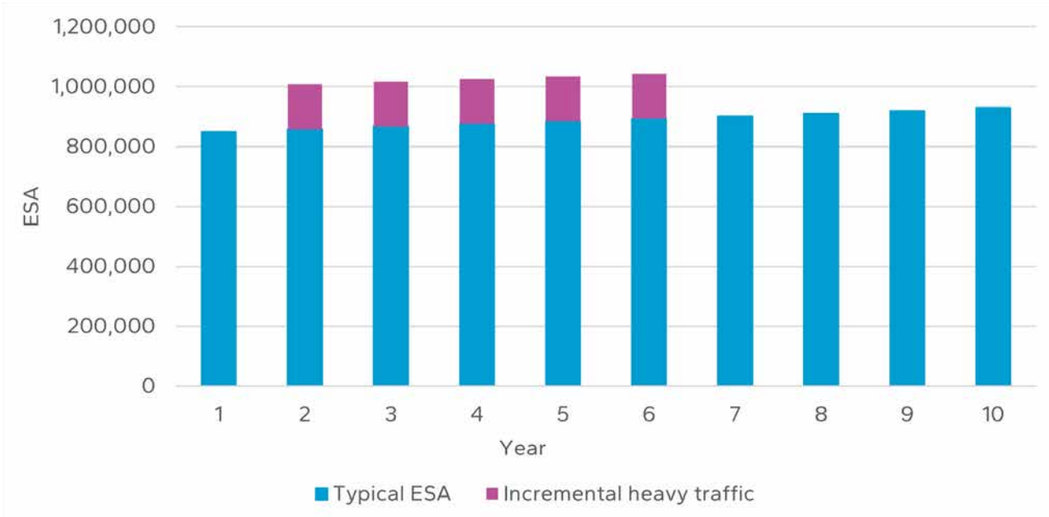

Figure C.1: Traffic load versus time showing a typical additional load for a set duration

The marginal cost of road wear in this context, is defined as the difference in cost of maintaining a road in a serviceable condition, between an increased load of traffic and a base traffic load.

C.3 Road Category Definitions

The road categories applied in this analysis have been nominally designed to accommodate a range of traffic loadings relative to their different service levels. Therefore, the higher order roads should be capable of accommodating larger cumulative loading than the lower order road types. Table C.1 shows the different design traffic ranges anticipated on these road categories and the mid-point cumulative design ESA for each of the road types that were selected for inclusion in the analyses.

Table C.1: Design ESA and adopted mid-point ESA

Road Category	Design traffic (ESA x 10^6)	Adopted design traffic (ESA x 10^6)
Access road	< 0.08	0.04
Local distributor	0.08 – 0.4	0.2
Regional distributor	0.4 – 2.0	1.2
District distributor	2.0 – 6.0	4.0

In some cases, a road may have been designed and constructed to a level that is different to the adopted design traffic and the user should then adjust the selected category accordingly.

Appendix D
User Guide for the WALGA Road Wear Cost Calculator

D.1 Accessing the Calculator

To effectively use the newly released WALGA Marginal Cost Calculator v1.0, users are recommended to download a copy here.

This file should be saved to a known location, users should check the link to ensure it is the current version of the tool.

D.2 Enabling the Macros

The WALGA MC Calculator consists of some Visual Basic Applications (VBA) code to enable the various functionality and features that are contained within the tool. These need to be **enabled** on the computer for the tool to work correctly.

If the MC Calculator has been sourced from an email or as a download from the WALGA website, based on general IT protocols to protect users, files with Macros may be automatically blocked to prevent malicious software from operating.

When a file sourced from the internet is opened, such as from an email attachment, and that file contains macros, the following message is generally displayed:

The 'Learn More' button will open an article that explains the security risk of enabling Macros, safe practices to prevent any malicious activity and instructions on how to enable these Macros (if it is needed). The article is available through this link:

https://support.microsoft.com/en-us/topic/a-potentially-dangerous-macro-has-been-blocked-0952faa0-37e7-4316-b61d-5b5ed6024216

D.3 Unblocking the File

For files that are blocked, the most common way to unblock the file is by modifying the properties of the file as follows:

1. Open Windows File Explorer and go to the folder where the file is saved.
2. Right-click the file and choose 'Properties' from the context menu.

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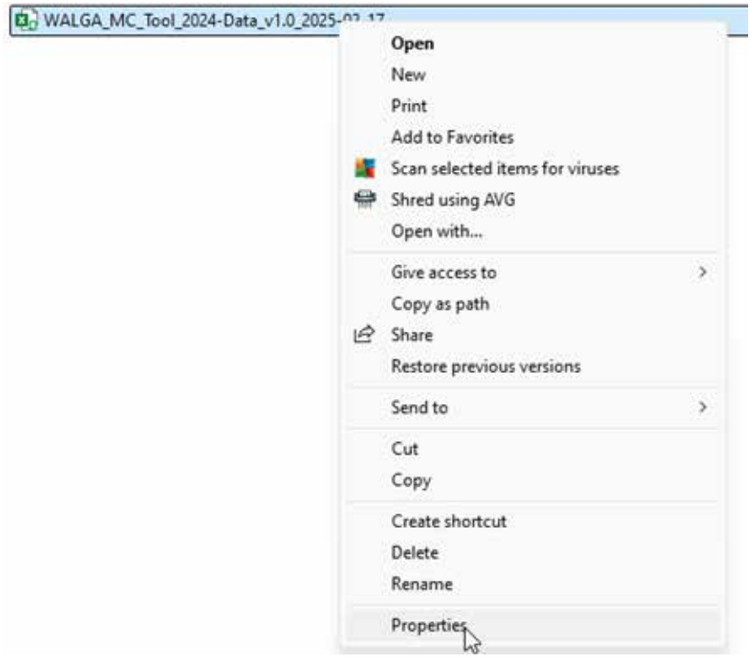
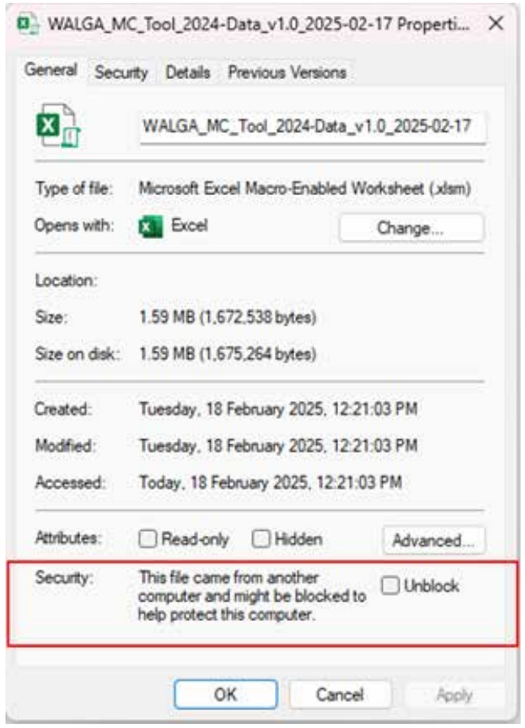


3. At the bottom of the 'General' tab, select the 'Unblock' checkbox and select 'OK'.



Once the file is unblocked, it will then become a trusted source, and users of the file will not be required to complete this step again.

User Guide: Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

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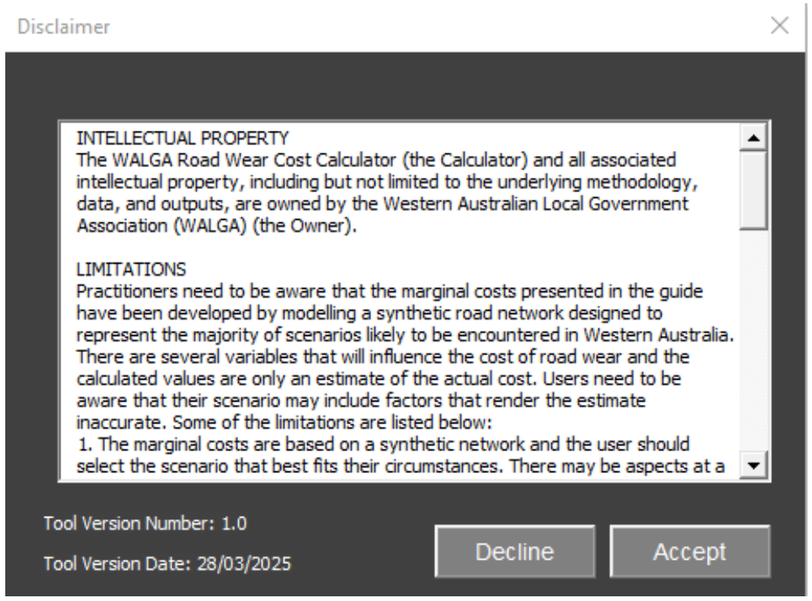
User Guide for the WALGA Road Wear Cost Calculator

D.4 Opening the Tool

With an unblocked file, opening the MC Calculator is like opening any standard Excel file.

If the following message appears below the Excel ribbon, select 'Enable Editing'.

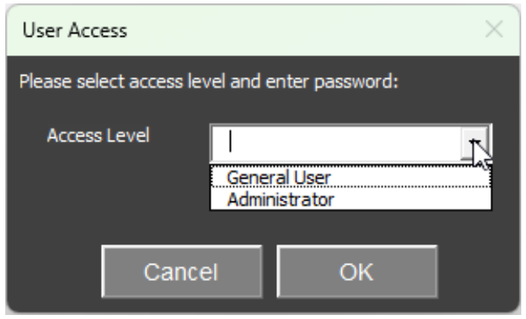
Once the file is opened in Excel, users will be presented with the WALGA Road Wear Cost Calculator disclaimer as shown.



To gain access to the tool, users will need to accept the disclaimer.

Declining the disclaimer will automatically close the Excel application and it will need to be restarted/re-launched to progress to undertake an analysis.

Once accepted, users will be prompted with a 'User Access' interface as shown.



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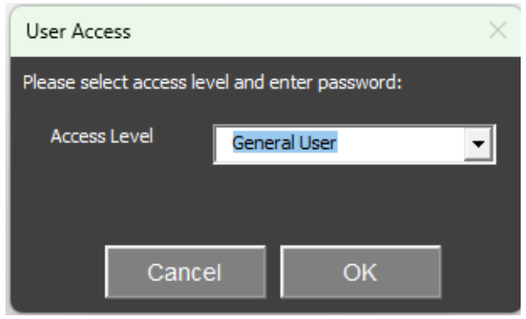
Select "General User" from the Access Level drop down menu.

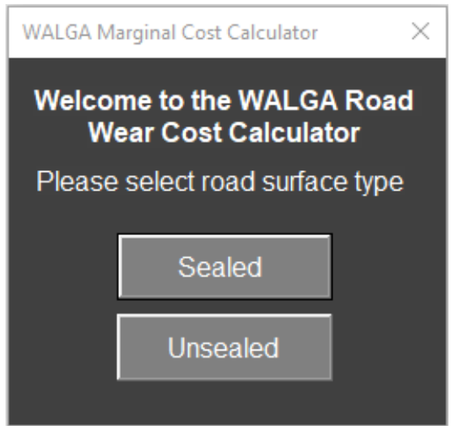
Note that a password is not required to gain access to the tool as as general user.



Once 'General User' is selected, press 'OK' to continue to launch the application.

If 'Cancel' is pressed at this point, users will not be authenticated, and the workbook will close automatically.

To ensure that users can undertake their desired analysis, each time the application is opened, users are prompted to select the type of analysis they are undertaking i.e., either for a sealed road or for an unsealed road analysis as shown.



Once the analysis type is selected, the tool will display the appropriate menu to guide the user through the analysis as shown.

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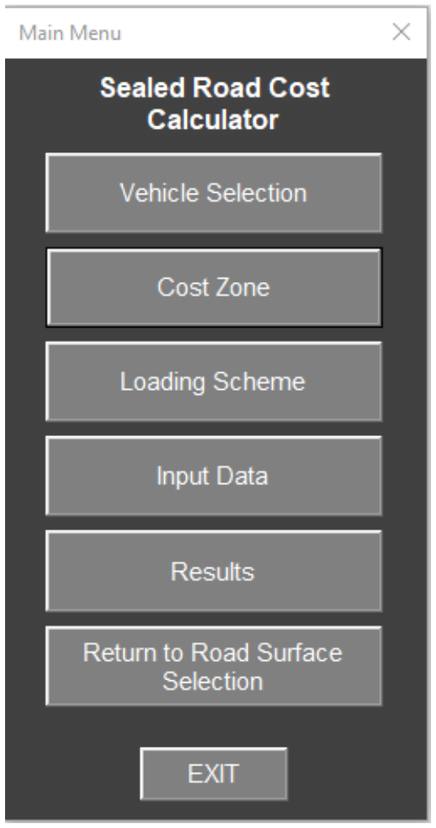
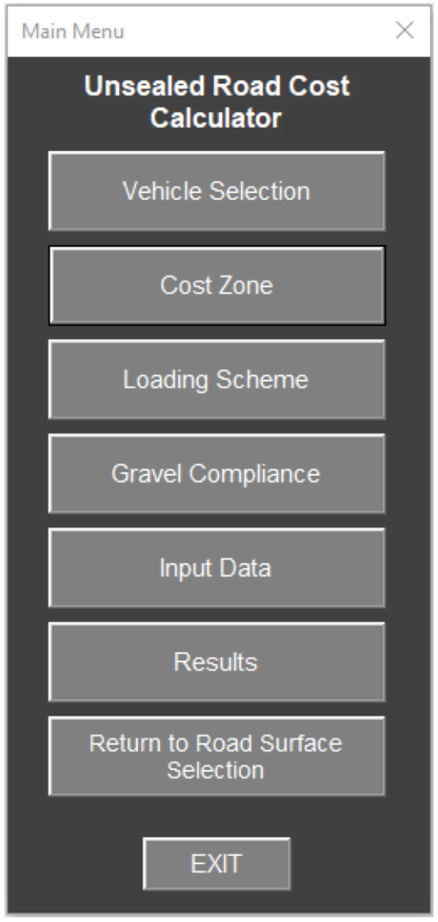
Sealed Roads



Unsealed Roads



D.5 Running an Analysis

The WALGA MC Calculator has been developed to digitise the hardcopy form of the updated user guides for both sealed roads and unsealed roads, being *Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks* and *Estimating the Incremental Cost Impact on Unsealed Local Roads from Additional Freight Tasks*.

The simple user menu created in the tool facilitates logical data entry and user selections that are aligned with the manual processes defined in the relevant User Guide. Navigation through the various menu and data entry forms is facilitated through the easy click buttons provided at the bottom of the form.

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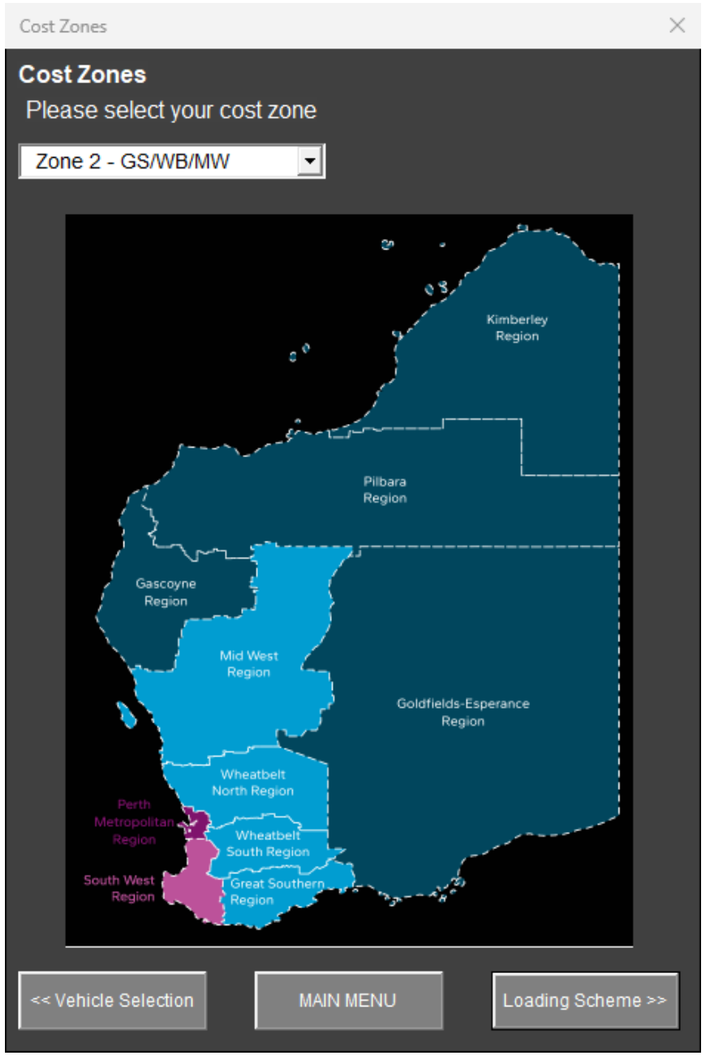

Users of the WALGA MC Calculator are recommended to familiarise themselves with the appropriate User Guide to confirm data entry and user selection requirements to generate an analysis outcome.

D.6 General Guidance for File Management

The WALGA MC calculator is a standalone Excel Application and so it is recommended that users apply the following good practices in terms of both file management and naming convention, to ensure that multiple analyses undertaken are organised and managed adequately:

1. Always keep a blank tool as a backup.
2. Adopt clear file naming conventions to differentiate between files/analyses.
3. Always use the blank tool to create a new analysis.
4. Ensure to always document the substance of the analysis undertaken in the 'Comments' section provided in the Input Data form of the analysis setup for either sealed or unsealed analyses.

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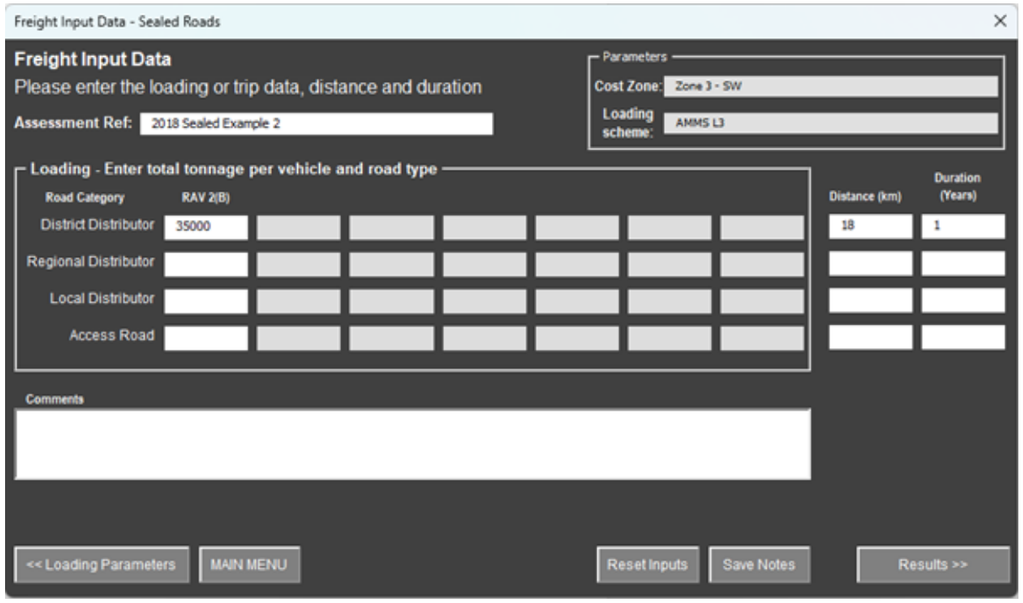
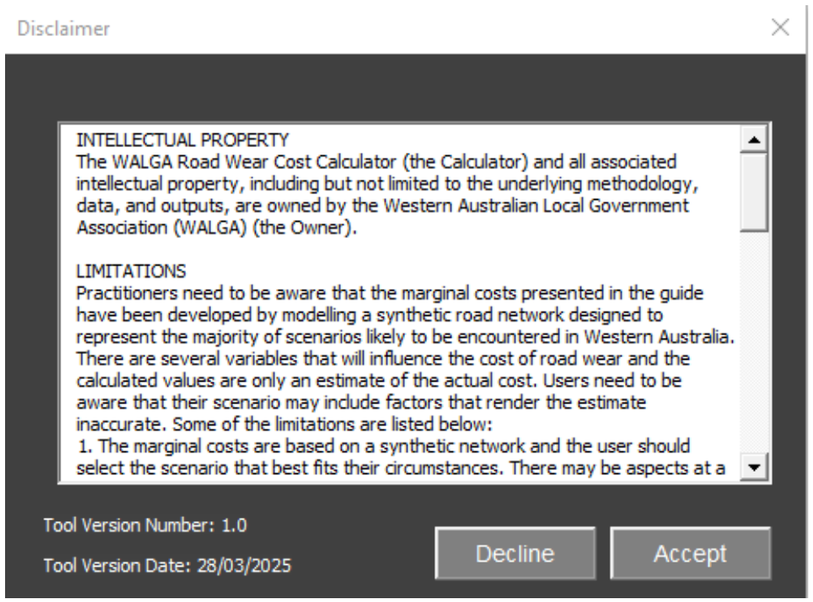


5. Always check the currency of the version and release date to ensure that the most up to date tool is being applied (visible on the Disclaimer and the Welcome page).



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User Guide for the WALGA Road Wear Cost Calculator

User Guide: Estimating the Incremental Cost Impact on Sealed Local Roads from Additional Freight Tasks

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