



7 June 2022

# Programme Level Carbon Considerations for Let's Get Wellington Moving

Programme and Options Breakdown

Let's Get Wellington Moving

## Revision History

| Revision No | Prepared by   | Description       | Date       |
|-------------|---------------|-------------------|------------|
| v.01        | s 9(2)(a)     | Draft Outline     | 1/02/2022  |
| v.02        | s 9(2)(a)     | Draft Outline II  | 14/02/2022 |
| v1.0        | Andrew Bowman | Draft development | 3/03/2022  |
| v1.6        | Andrew Bowman | Draft final       | 9/03/2022  |
| v1.9        | Andrew Bowman | Update charts     | 31/03/2022 |
| v2.0        | Andrew Bowman | TAG updates       | 28/04/2022 |
| V3.0        | Andrew Bowman | TAG updates       | 7/06/2022  |

## Document Acceptance

| Action       | Name          | Signed | Date     |
|--------------|---------------|--------|----------|
| Prepared by  | Andrew Bowman |        | 9/3/2022 |
| Reviewed by  | Carbon TAG    |        |          |
| Approved by  | Adam Nicholls |        |          |
| On behalf of |               |        |          |

## Introduction

This technical note applies a carbon reduction lens to the overall programme and to the four transformational programme options. It draws together an overview of the work undertaken to understand the carbon reduction implications of investment in Let's Get Wellington Moving (LGWM).

Prior to the public engagement at the end of 2021, a range of tools and approaches were used to consider the impact on carbon reduction that might be expected from the LGWM investment proposals. The multi criteria assessment of the four options was informed by initial transport modelling outputs, together with qualitative tools to provide a fuller picture. They included the Climate Assessment of Transport Investment, a qualitative tool used to assess the level of climate positive and climate negative elements within a programme, and a Comparative Cities analysis which compares Wellington to 15 other cities with comparable populations, densities and in some cases topography, that have invested in mass rapid transit (MRT).

Further work has now been completed, incorporating refinements to the approach to transport modelling to further reflect the transformational nature of the programme.<sup>1</sup> This report details the revised carbon emissions impacts of the LGWM programme in order to support decision makers identify their preferred option for the completion of the MRT and State Highway Improvements combined Indicative Business Case – the Transformational Programme.

## Background

LGWM is an initiative between Wellington City Council, Greater Wellington Regional Council and Waka Kotahi New Zealand Transport Agency, together with mana whenua partners Taranaki Whānui ki Te Upoko o Te Ika and Ngāti Toa. LGWM seeks to deliver an investment that supports Wellington's aspirations for how the city and region looks, feels and functions.

The LGWM programme's geographical scope extends from Ngauranga Gorge to Miramar in the east, including connections to the central city, port, regional hospital and international airport, and a number of core multi-modal corridors connecting the central city with suburbs to the north, south, east and west. However, the programme is set within a wider city and regional context when it comes to trips, networks, land use and outcomes.

**Our** vision is: "A great harbour city, accessible to all, with attractive places, shared streets, and efficient local and regional journeys."

The following objectives and weightings have been agreed for the LGWM programme:

- Carbon emissions and mode shift: 40% - Reduces carbon emissions and increases mode shift by reducing reliance on private vehicles
- Liveability: 20% - Enhances urban amenity and enables urban development outcomes
- Safety: 15% - Improves safety for all users
- Access: 15% - Provides more efficient and reliable access for users
- Resilience: 10% - Is adaptable to disruptions and future uncertainty

---

<sup>1</sup> Information about the approach to transport modelling is contained in the Preferred Option Report – Modelling Appendix.

While all the above objectives are critical for the programme, the significant relative weighting given to carbon emissions and mode shift signals the importance of this objective to LGWM partners in the context of a climate emergency and national, regional, and local carbon reduction targets.

The LGWM programme comprises:

- a 3-year programme of early bus priority and active mode improvements (including Golden Mile, Thorndon Quay & Hutt Road);
- City Streets – rolling out bus reliability and active mode improvements in the central city and on key routes to suburbs; and
- a Transformational Programme of larger elements that will help shape future growth, transform our city and significantly change how we get around, including MRT.

The key differences between the four programme options within the Transformational Programme are identified in Table 1 below

**Table 1: Summary of the differences between the four options for the LGWM Transformational Programme**

|                           | Option 1                      | Option 2                             | Option 3                              | Option 4                              |
|---------------------------|-------------------------------|--------------------------------------|---------------------------------------|---------------------------------------|
| <b>Basin Reserve</b>      | Grade separated               | Grade separated                      | Grade separated                       | At-grade                              |
| <b>Mt Victoria Tunnel</b> | New tunnel                    | New tunnel                           | Existing tunnel                       | Existing tunnel                       |
| <b>MRT City to South</b>  | Light rail, via Cambridge Tce | Bus rapid transit, via Cambridge Tce | Light rail, via Cambridge Tce         | Light rail, via Taranaki St           |
| <b>MRT East</b>           | Enhanced bus, via new tunnel  | Bus rapid transit, via new tunnel    | Enhanced bus, via Hataitai bus tunnel | Enhanced bus, via Hataitai bus tunnel |

For greater detail about the Transformational Programme options as well as the wider LGWM programme, please refer to the LGWM Programme Affordable Short List Options Report.<sup>2</sup>

## Why is reducing carbon emissions and increasing mode shift away from private vehicles such an important objective for LGWM?

At the national level, the government has declared a climate change emergency, and has committed to urgent action on reducing emissions. Enactment of the Climate Change Response (Zero Carbon) Amendment Act in 2019 has set a target for NZ to achieve net zero emissions by 2050 (for carbon dioxide emissions) and the government is currently developing an emissions reduction plan (ERP) that will set out the policies and actions needed to meet this target.

Transport is responsible for around 43 percent of total domestic carbon dioxide (CO<sub>2</sub>) emissions, and 20 percent of total greenhouse gas (GHG) emissions<sup>3</sup>. Therefore, transport emissions need to fall significantly, and quickly, to achieve our emissions reductions commitments and targets.

<sup>2</sup> Available at: <https://lgwm.nz/all-projects/mass-rapid-transit/related-documents/>

<sup>3</sup> Emissions Reduction Plan discussion document 2021 - MfE

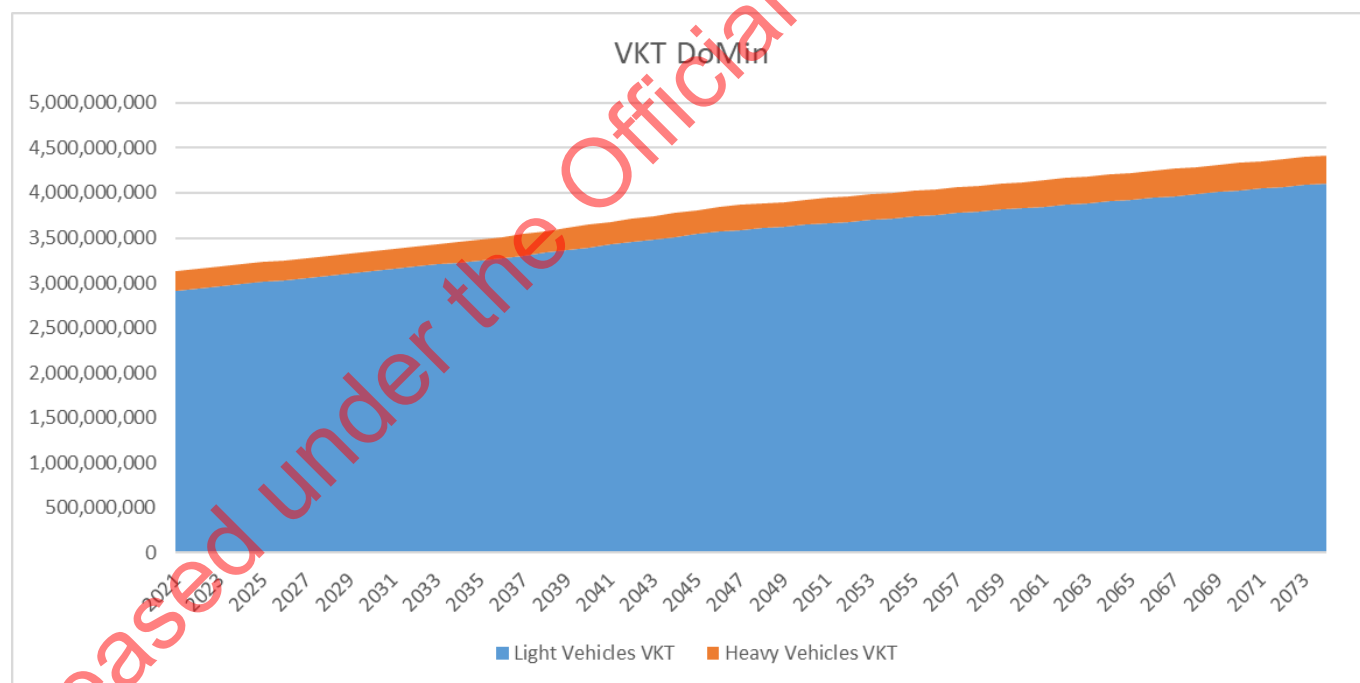
The government's draft ERP includes three focus areas for reducing transport emissions by 2035, the first of those being 'Reducing reliance on cars and supporting people to walk, cycle and use public transport' with an associated target: *Reduce vehicle kilometres travelled (VKT) by cars and light vehicles by 20 per cent by 2035 through providing better travel options, particularly in our largest cities.* A key action identified in the draft ERP within this focus area is to 'progress Let's Get Wellington Moving, including the delivery of bus priority measures and the planning of mass rapid transit'. The final ERP is due to be released in May.

At the regional level, the Wellington Regional Land Transport Plan 2021 targets seek a 35% reduction in transport-generated emissions, alongside a 40% increase in the mode share of public transport and active modes, by 2031.

Wellington City Council has adopted Te Atakura – First to Zero, a blueprint to make Wellington City a zero-carbon capital by 2050. As part of this, WCC has committed to a 57% reduction in emissions by 2030. Both councils have declared a climate emergency to reflect the urgency of this problem.

Action is needed now to meet these carbon commitments. Transport is the biggest source of emissions in the Wellington region, accounting for 40% of all emissions in the region, and 48% of emissions in Wellington city<sup>4</sup>. Between 2001 and 2019, total transport emissions rose by 14%, with road emissions from petrol and diesel use increasing by 8 percent.<sup>5</sup> The current pathway does not put the city or region on track to meet any of these emissions targets.<sup>6</sup>

**Figure 1: Doing nothing – the problem does not just go away: Wellington region VKT<sup>7</sup>**



<sup>4</sup> LGWM Programme Report

<sup>5</sup> Wellington Region Greenhouse Gas Inventory 2020

<sup>6</sup> Emissions Reduction Plan discussion document 2021 - MfE

<sup>7</sup> Data from Wellington Transport Strategic Model, Wellington Analytics Unit.



Figure 1 above shows that, under the do-minimum scenario, regional VKT for light vehicles is projected to increase by more than 55% from 2.8 to 4.4 billion kms from 2021 to 2074. For heavy vehicles, regional VKT is projected to more than double from 180 million to 375 million kms over the same period.<sup>8</sup>

Figure 1 shows why the LGWM objective seeks both to reduce carbon emissions directly and to increase mode shift away from a reliance on private vehicles. As identified in the draft ERP, a focus only on reducing carbon emissions does not account for the ongoing impact of fossil fuel powered vehicles in the New Zealand vehicle fleet, or the impact that congestion has on producing emissions. New Zealand's vehicle fleet is comparatively old and turns over comparatively slowly.

We cannot rely on the transition to electric vehicles and decarbonising the vehicle fleet – this will not be fast enough, even with current incentives.<sup>9</sup>

**Figure 2: Doing nothing – light vehicle emissions drop, but not fast enough<sup>10</sup>**

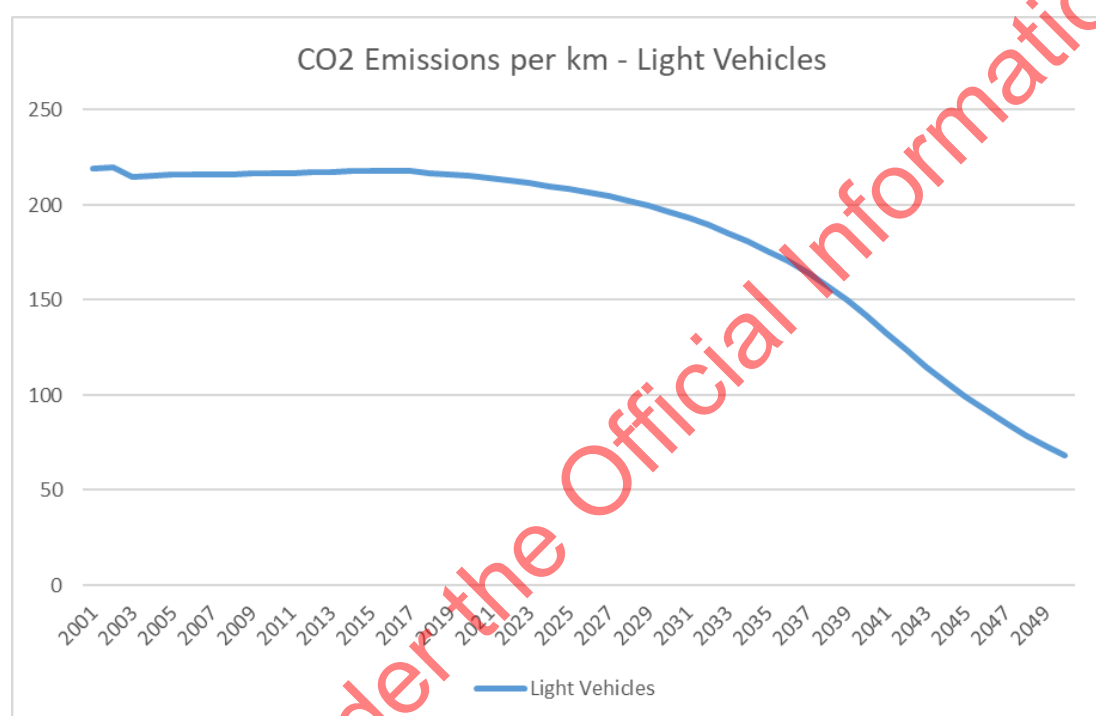


Figure 2 above shows that across time, CO2 emissions per km from light vehicles are projected to decrease due to a mix of efficiency improvements and electrification. However, this doesn't start to accelerate until after around 2030. This is not fast enough to meet Wellington City's commitments, Wellington's regional commitments, or New Zealand's national commitments.

<sup>8</sup> Results are based on interpolation of 2013, 2036, and 2046 results from the Wellington Transport Strategic Model and assumes 0.5% annual VKT growth post 2046.

<sup>9</sup> Ibid

<sup>10</sup> Data from Wellington Transport Strategic Model, Wellington Analytics Unit.

**Figure 3: Doing nothing – heavy vehicle emissions are on a slow decline<sup>11</sup>**

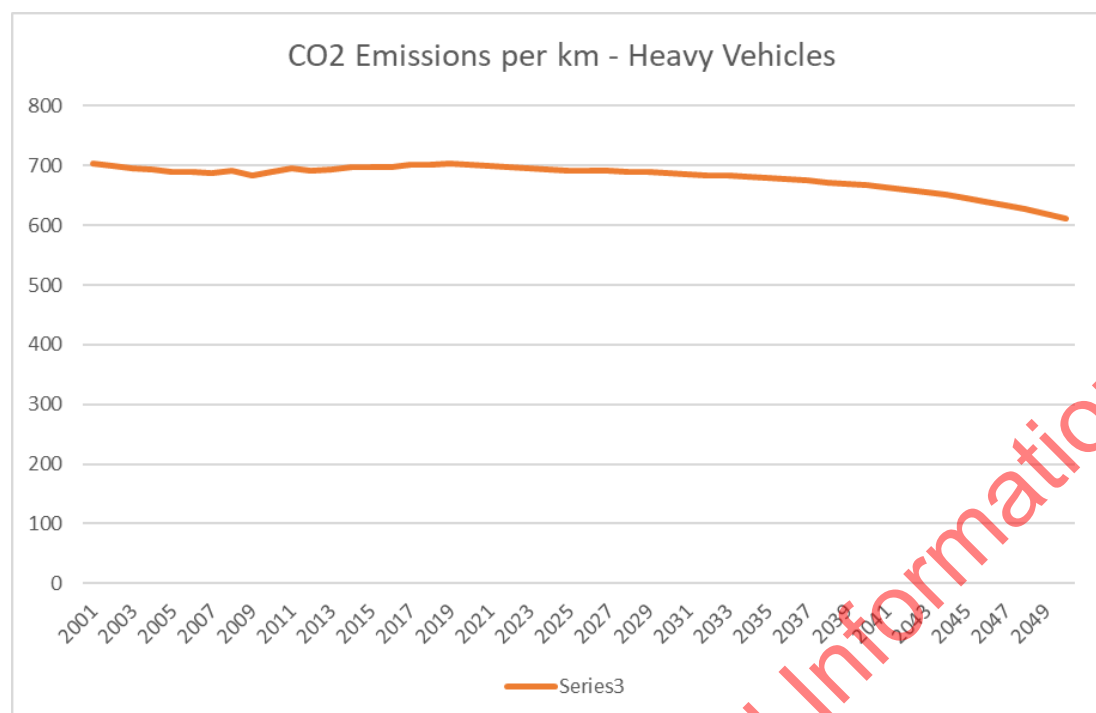


Figure 3 above highlights the slow expected decline in carbon emissions per km from heavy vehicles.

Transport investment, and the denser urban form that it enables, have an important role to play in reducing carbon emissions. Not only does investment in infrastructure for active modes and for zero-emissions public transport reduce emissions, MRT can stimulate a change in urban form to greater density living, which further reduces demand for private motor vehicle use – electric or fossil-fuel powered.

Reducing the amount of travel that people do in fossil-fuelled vehicles is key. The greatest opportunity for transport emission reductions comes from our large cities where population densities provide economies of scale for public transport and people are likely to have more choice. By improving public transport, walking and cycling options and managing demand we also realise much wider benefits such as travel choice and accessibility, better health and safety, and less congestion, which all improve the liveability of Wellington.

### **What's the role of LGWM in contributing to carbon reduction and mode shift goals?**

The LGWM programme sits alongside a much broader regional investment programme to significantly improve public transport and active modes, and shape urban form. Examples include: Te Ara Tupua, enabling many more active mode trips between our two largest cities; the regional rail programme, with associated opportunities for more intensive transit-oriented development around stations; and other major land use transport integration projects like RiverLink, Access Kenepuru and the Eastern Porirua regeneration programme. Together these projects and other programmes are expected to cumulatively influence mode shift and emissions for the region.

Wellingtonians are already high users of public transport compared to other New Zealand cities, particularly for commuter trips to central Wellington city. Our regional rail network, relatively contained urban form and strong central employment hub in the Wellington CBD contribute significantly to this. The

<sup>11</sup> Data from Wellington Transport Strategic Model, Wellington Analytics Unit.

Wellington region has the highest mode share for public transport, walking and cycling for all trips compared with other cities in New Zealand,<sup>12</sup> and these modes account for over half of trips to the CBD during the morning peak.<sup>13</sup>

This context needs to be acknowledged when we look at the role of LGWM in reducing emissions, and the expected level of mode shift and VKT reductions from the programme. Achieving a significant increase in public transport and active mode share will be challenging starting from a high base, so investment needs to be transformative in a way that shapes future land use. As our population grows, we need even more people in the region to live in locations close to the things they need, so they can travel shorter distances and can choose active modes or public transport for more trips, seven days a week.

The MRT component of the LGWM transformational programme will provide the catalyst for significant urban development and intensification along key corridors to the south and east of the city centre. The programme options have been developed with scenarios exploring the addition of between 16,000 and 21,000 new homes in locations along the MRT corridor where people can live and access a wide range of jobs, services and facilities without needing a car.

The mode of MRT is important: light rail-based MRT is more likely to deliver greater density than bus-based MRT. This is explored in more detail in other LGWM reports.<sup>14</sup>

Achieving this level of intensification will rely heavily on other aspects like land use policies and urban development mechanisms, and supporting infrastructure being provided – like three waters and other social infrastructure.

#### *Travel demand management and congestion pricing*

To unlock the full carbon reduction benefits of the LGWM infrastructure investment, we will also need to consider travel demand management tools. The LGWM programme is investigating the potential for road pricing measures, like a congestion charge, and scaling up our travel behaviour change programmes.

Analysis suggests that a congestion charge could be expected to provide further reductions in VKT and associated carbon emissions.

More planning and detailed design is required to inform further transport modelling to quantify the impact that road pricing measures and further travel behaviour change would have on the reduction of carbon emissions. Priced travel demand management, like congestion charging, would be implemented in a similar way no matter what Transformational Programme option may be advanced, therefore, this factor is not a point of differentiation between the programme options. It is already clear, however, that a high-quality, high-capacity, extensive public transport network and active modes networks are necessary precursors to the implementation of road pricing measures.

### **Our approach to assessing the carbon reduction and mode shift contribution of the LGWM programme**

The carbon analysis work completed as part of the IBC has sought to understand the potential impact of LGWM investment on emissions at both a programme level and comparatively across the four options in the transformational programme.

The carbon emissions that arise over the whole of life of land transport infrastructure projects can be categorised into the following:

<sup>12</sup> Keeping Cities Moving 2019, Waka Kotahi NZ Transport Agency

<sup>13</sup> Wellington RLTP Annual Monitoring report 2021

<sup>14</sup> LGWM Programme Affordable Short List Options Report, Ibid.; Urban Development Summary Report, October 2021, available at: <https://lgwm.nz/all-projects/mass-rapid-transit/related-documents/>



- Construction emissions – those associated with construction materials and construction activities that occur over the duration of the construction. Together these are often referred to as embodied emissions.
- Operational emissions – those associated with the materials and activities required to operate and maintain the infrastructure over its service life
- Enabled emissions – emitted by the vehicles using the infrastructure / transport network over its service life. For this project, where vehicle use reduces due to mode shift (for example, a shift from private vehicles to public transport or cycling/walking), the reduction in vehicle emissions has been calculated (i.e. the vehicle emissions that have been avoided by the mode shift).

Emissions will reduce over time as the fuel efficiency of the vehicle fleet changes.

## Methodology for the estimation of carbon emissions

### *Transport modelling underpins our analysis*

Transport modelling for the preferred option decision has focused on two programme options from the LGWM Programme Affordable Short List Options Report as ‘bookends’ – Option 1 as the highest cost with the largest infrastructure footprint, and Option 4 as the lowest cost with smallest infrastructure footprint. Two land use scenarios have also been identified – core and intensified.

- The core land use scenario provides the base results reported for the LGWM programme option. It assumes the same level of population and employment growth along the MRT corridor as the Do Minimum, which is informed by recent regional population projections; it does not include any additional growth generated / enabled by the transport investment.
- The intensified land use scenario was created to test the impact of high density residential and commercial development occurring along the MRT corridor, assuming up to 26,000 additional dwellings. It should be considered as a ‘what if’ scenario rather than an attempt to predict the level of intensification stimulated by the infrastructure improvements.

The carbon impacts from this updated modelling work are presented in this technical note. It should be noted that these are still just scenarios and present plausible outcomes that could be achieved given a particular set of assumptions.

For the intensified land use scenario, it was assumed that the population of the Wellington region would be the same in 2046 as assumed under the Do Minimum land use scenario. The main difference is that the population distribution (i.e. where new growth would be located within the region) would change in response to the scenarios, focussing growth along the MRT corridor.<sup>15</sup>

This approach is considered best practice in order to understand the contribution that the programme itself could generate, particularly in relation to carbon emissions, compared to a Do Minimum scenario.

It is accepted, however, that the intensification scenario assumes the future population redistribution occurs without further intervention. Another plausible future scenario could be one where the transformational programme increases the overall growth rate for the Wellington region, with this additional growth being focussed on the MRT corridor. It is proposed that the detailed business case (DBC) explore these scenarios further.

<sup>15</sup> An additional 200,000 people living in the region by 2046 – Source: LGWM Programme report

Both the modelling approach and the qualitative tools provide useful insight but do all have limitations when it comes to understanding a large and complex transformative investment like LGWM. These are discussed in the Limitations section below.

### *Embodied emissions*

The embodied carbon analysis prepared for the LGWM programme was a high-level comparison between programme options using quantity estimates of concrete and steel: the materials that have the most embodied carbon.

The design team estimators provided early bill of quantities estimates of materials volumes, from which the volumes of concrete and steel on each individual project within the programme options were calculated. The emissions associated with the raw materials, manufacture and transport of these materials were calculated by applying an emissions factor (tons of CO<sub>2</sub> emitted per tonne of concrete, for example). Emission factors were developed by the design team based on local suppliers' Environmental Product Declarations and assumptions about transport distances and mode (for example, concrete was assumed to be transported by road from local plants in Wellington). Using these emissions factors, an estimate of the total emissions embodied in each option was derived by assuming that the embodied concrete and steel emissions would make up approximately 50% of the total project emissions, and that 30% of the total emissions would be attributable to fuel use during construction.

In summary:

- MRT vehicles are heavy: large amounts of carbon-intensive materials are required for foundations, regardless of mode.
- The programme options with tunnels have the biggest overall embodied emissions because of the quantity of materials involved in the tunnels and the earthworks involved.
- The estimates are considered indicative at this stage but are broadly consistent with estimates derived for other major construction projects. Please see the Limitations and Assumptions section below for further information about the assumptions made to enable estimation.

### *Operational emissions*

The main operational emissions for bus rapid transit and light rail transit – the two forms of MRT considered within LGWM – are those emissions associated with the electricity required to run the system. Based on experience with other projects, and given New Zealand's high proportion of renewable energy, these are likely to be only a small part of whole-of-life emissions. Further, as the level of operational emissions is unlikely to materially distinguish between the programme options for MRT they have not been calculated at this point. Operational emissions will be formally calculated and optimised during the DBC.

### *Enabled emissions*

The potential change in enabled emissions attributable to each programme option is calculated by comparing the modelled predicted future traffic flows (with the MRT in place, referred to as the "programme option" or "do-something" scenario) against the traffic flows expected without the programme in place (referred to as the "do-minimum" scenario).

To estimate the reduction in enabled emissions attributable to LGWM interventions, the VKT outputs from the Wellington Transport Strategic Model traffic modelling have been used as inputs to the Vehicle

Emissions Prediction Model (VEPM) which provides a prediction of the emissions profile of New Zealand's vehicle fleet over time.<sup>16</sup>

VEPM was developed by Waka Kotahi and Auckland Council to predict emissions from vehicles in the New Zealand fleet under typical road, traffic and operating conditions. VEPM relies on assumptions about the make-up of the vehicle fleet from the Vehicle Fleet Emission Model provided by the Ministry of Transport. This includes assumptions about how quickly electric vehicles will enter the New Zealand vehicle fleet, as well as the level of carbon emissions from vehicles powered by internal combustion engines.

Further information about the limitations of the analysis using VEPM is contained in the Limitations and Assumptions section below.

### *Application of the quantified analysis*

The following steps have been followed to produce the quantified results below:

1. The Wellington Transport Strategic Model produces VKT estimates (light vehicles only) by:
  - a. Preferred option Modelling Scenario
  - b. Daily AM / interpeak / PM 2 hour peak
  - c. Transport model sector
2. VKT for each sector/scenario extrapolated to yearly using annualisation factors
3. Average network speeds for each sector also extracted from Wellington Transport Strategic Model for later use in VEPM to obtain emission rates– speeds kept consistent across options
4. VKT per year interpolated between modelled years
5. Emission rates [CO<sub>2</sub> e g/km] from VEPM 6.2 applied to VKT [km] to produce outputs in CO<sub>2</sub> e tons<sup>17</sup>
  - a. VEPM emission rates for light vehicles vary by year and speed
  - b. Light vehicle speeds for each Wellington Transport Strategic Model sector applied to get yearly average emission rates for each sector
6. Embodied emissions introduced at 2028, split evenly over construction period

The estimates for volumes of embodied carbon emissions are assumed to be emitted at the same average rate across the period of construction assumed for each programme option. We do not have sufficient detail to accurately estimate when construction emissions would in fact be produced.

Enabled carbon emissions savings for each programme option are assumed to ramp up across the construction period progressively, with 2.5% of the savings achieved each year across the construction period. Upon opening, enabled emissions savings increase progressively across the first three years of operation to 100%.

<sup>16</sup> More information about VEPM can be accessed at: <https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/air-quality-climate/planning-and-assessment/vehicle-emissions-prediction-model/>

<sup>17</sup> VEPM 6.3 was released after this analysis was completed. Analysis during the DBC will use the most up-to-date version available.

As noted early, operational emissions have not been quantified at this stage of the analysis because of insufficient information about the source of energy for MRT. Operational emissions are not expected to distinguish between programme options.

Bringing embodied and enabled emissions together, carbon emissions are produced during construction, while comparatively small amounts of carbon emissions savings are experienced as benefits from the City Streets active modes projects are delivered progressively across the transformational programme construction period. The 'peak' in carbon emissions will be experienced at the end of the construction period, after which the new transport options stimulate change in travel behaviour, resulting in enabled carbon emissions savings growing across time.

## Programme-level carbon emissions estimate for LGWM

The performance of the LGWM programme options modelled is displayed in Figure 4 below, showing the projected cumulative carbon reduction in kilotons of carbon emissions compared to the do minimum scenario for the entire Wellington Region.

**Figure 4: Carbon emissions 'payback' – programme options and land use scenarios compared**

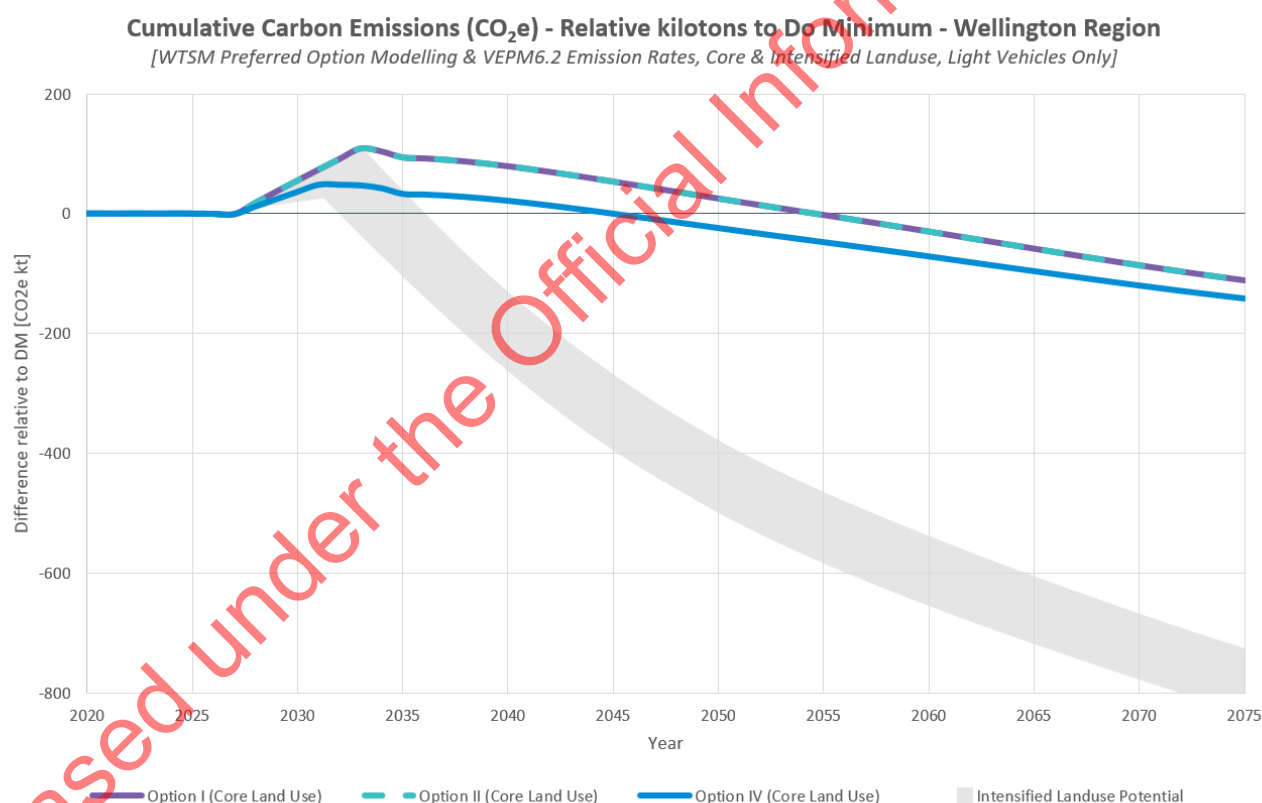
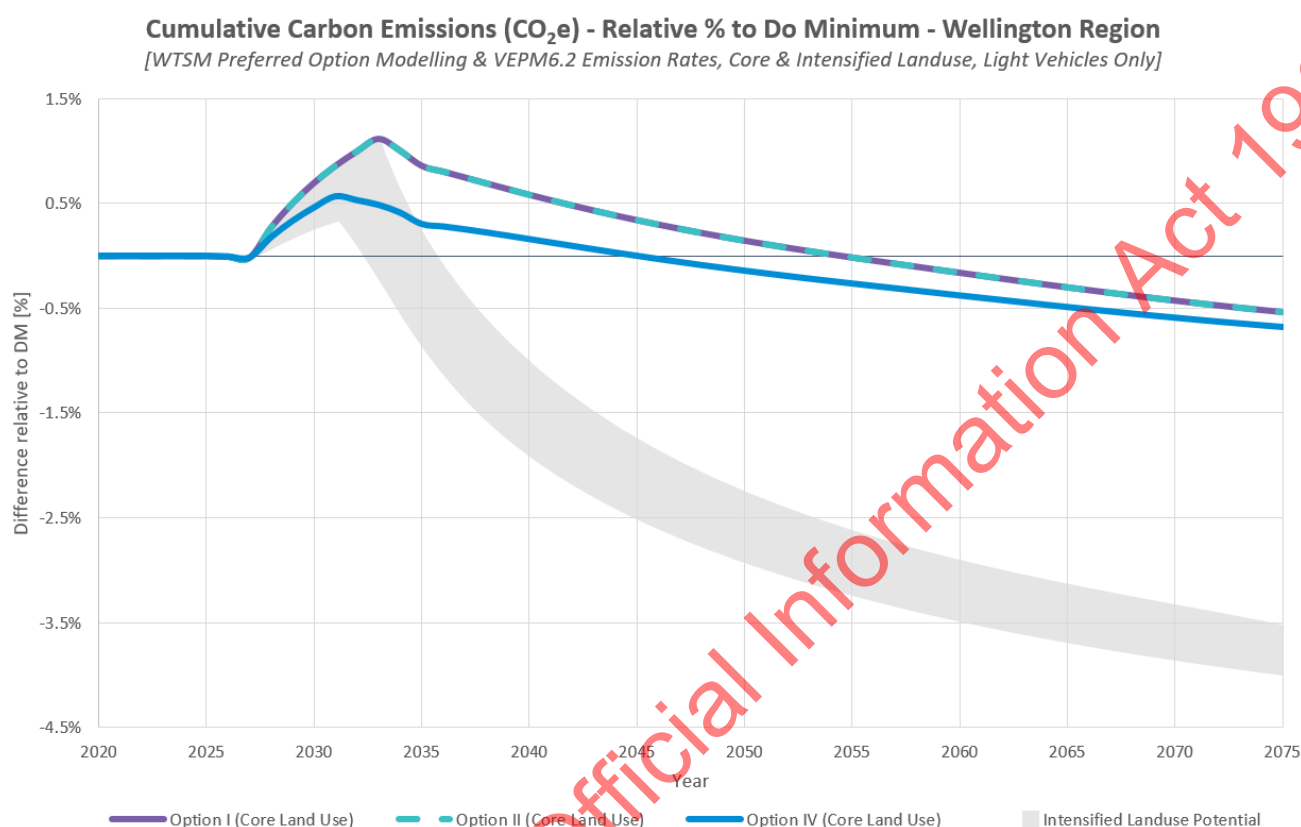


Figure 5 below displays the same information but displays the y-axis as the percentage of regional emissions reduced by the LGWM programme options.

**Figure 5: Carbon emissions ‘payback’ in regional emissions percentages – programme options and land use scenarios compared with a different lens**



Both figures show that, under the core land use scenario, Option 4 shifts sufficient journeys to active modes and zero carbon public transport to recover the enabled carbon consumed through construction by 2045. Options 1 and 2 pay back their enabled carbon by 2055, taking longer due to the higher level of carbon assumed to be required to construct the additional infrastructure in these two options.

Under the core land use scenario, all options perform in a broadly similar way. While Option 4 is projected to deliver net zero carbon ahead of Options 1 and 2, we can see that the gap between these options narrows across time as the performance of Options 1 and 2 gradually catch up to Option 4.

On the other hand, the intensified land use potential ‘range’ shows a substantially faster payback period, along with substantially greater total enabled carbon savings.<sup>18</sup> In the best-case scenario, payback is predicted to be achieved in 2033 while in the lower-case scenario, payback is reached in 2036. The intensified land use projections show the potential to deliver a reduction of more than 700 kilotons CO<sub>2</sub>e, or approximately 3 – 4% of cumulative regional emissions compared to the Do Minimum scenario.

The Intensified Land Use Scenario was built around Option 1 and is also considered to be broadly representative of the performance of Option 2 in a similar situation. Option 1 is considered to perform more towards the ‘top’ of the Intensified Land Use Scenario band (most carbon emissions savings) while Option 2 is considered more likely to perform more towards the ‘bottom’ of the Intensified Land Use scenario band. We have less confidence about the accuracy of the Intensified Land Use Scenario in analysing the performance of the other programme options.

<sup>18</sup> Modelling assumptions for the Intensified Land Use Scenario are detailed in the Preferred Option Report – Modelling Appendix (page 9 onwards).



The above results, along with some additional data points are summarised in Table 2 below.

**Table 2: LGWM Option performance across outyears**

| Land use Scenario | Core         |          | Intensified |             |
|-------------------|--------------|----------|-------------|-------------|
| Year              | Option 1 / 2 | Option 4 | Lower bound | Upper bound |
| 2033              | 1.1%         | 0.5%     | 1.1%        | -0.2%       |
| 2036              | 0.8%         | 0.3%     | 0.0%        | -1.2%       |
| 2045              | 0.3%         | 0.0%     | -1.8%       | -2.5%       |
| 2055              | 0.0%         | -0.3%    | -2.6%       | -3.2%       |
| 2065              | -0.3%        | -0.5%    | -3.1%       | -3.7%       |

Key

|  |                 |
|--|-----------------|
|  | More carbon     |
|  | Break even year |
|  | Less carbon     |

### Timing tradeoffs

The analysis undertaken for LGWM has reinforced the importance of timing and sequencing for carbon reduction and supporting mode shift away from private vehicles.

The assumptions that underpin VEPM and the Vehicle Fleet Emissions Model drive the importance of timing – because the vehicle fleet contains a growing proportion of low / zero emissions vehicles, and because this proportion is expected to rise continuously, vehicle trips converted to non-car modes are only beneficial from a strict carbon perspective if they come from someone that would otherwise have driven a fossil-fuel powered vehicle. Electric vehicle trips diverted to public transport have no carbon benefit – this means the carbon benefit of vehicle trips diverted to public transport in the future declines as the models assume that the proportion of zero emission vehicles in the fleet rise year on year.

Carbon emissions need to be reduced quickly to support New Zealand to achieve its carbon reduction commitments. The various commitments of the three LGWM Partners vary from each other in timing and in scope. It is not appropriate for this programme-level analysis to make the tradeoff between these differing targets with their differing time commitments and different options for meeting their commitments.

LGWM does not deliver sufficient carbon reductions to entirely meet any of the Partners' commitments to reduce carbon emissions – an indication of the significant task to meet these objectives. Investment in LGWM programme options is also not the only intervention by any of the Partners that seeks to reduce the production of carbon emissions.

It is not within the scope of the LGWM programme analysis to identify whether investment in any of the LGWM programme options is a more or less efficient means of reducing New Zealand's carbon

emissions than any of the Partners' other carbon reduction projects (for example, faster electrification of the bus fleet, further infrastructure support for electric vehicles and / or car sharing; higher subsidies for the uptake of electric vehicles, etc).

Carbon emissions avoided in Wellington from, for example, investing in less embodied emissions (Options 3 or 4 over Options 1 or 2) are only beneficial to the extent that they are not emitted anywhere else in New Zealand – the cap on carbon emissions in the Emissions Trading Scheme is likely to be more influential than selecting a LGWM programme option on the basis of lower levels of embodied carbon. This is particularly so given that, if the density enabled by the intensification scenario is achieved, embodied emissions make up a small proportion of the total enabled emissions savings.

At the IBC stage, there remains significant uncertainty about design considerations that will substantially affect the level of carbon consumed (embodied emissions) and carbon saved (reduced enabled emissions) by LGWM programme options. Regardless of this uncertainty however, the programme analysis clearly shows increasing the density of Wellington City is more likely to deliver an urban form that is lower carbon than the alternative of enabling urban growth on greenfields sites.

Advancing a programme option that enables behavioural change sooner rather than later – for example by publicly committing to advancing MRT – will start to deliver enabled emissions reductions earlier. Our transport modelling is not able to capture this benefit (for further analysis of these under-counted benefits, the Economics Technical Report identifies these benefits from an economic perspective). These early benefits will be the subject of further investigation and quantification during the DBC phase.

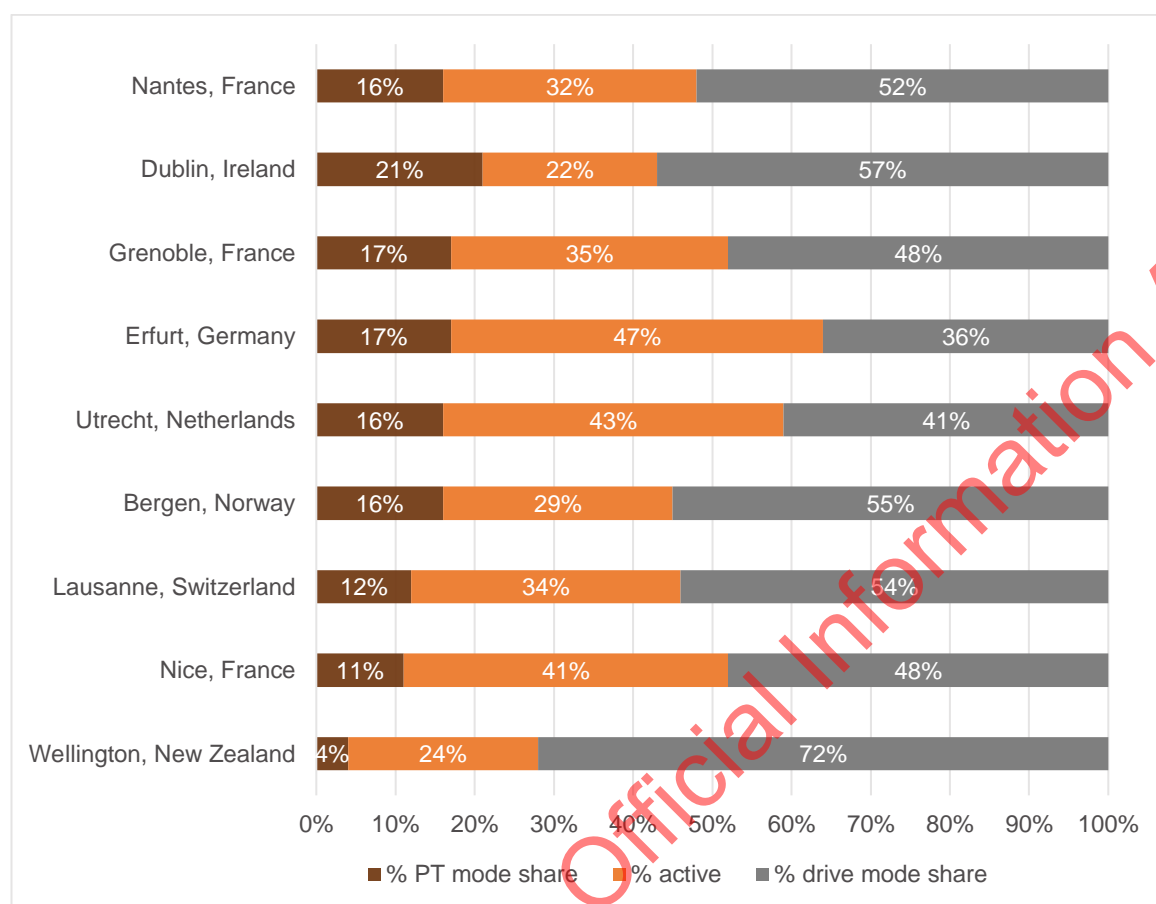
## **Comparative Cities: What can we learn from looking at similar sized cities who have implemented Mass Rapid Transit?**

Internationally, cities have experienced mode shift success through the provision of supporting transport infrastructure. Among the work reviewed by the LGWM programme is analysis undertaken by Wellington City Council that compares Wellington to 15 other cities with comparable populations, densities and in some cases topography, that have invested in MRT.

This work found that in cities where significant investments in active and public transport networks, including MRT, had been made, 'car' mode share was relatively low (all below 60% where cities have invested in light rail MRT systems) and 'non-car' mode share relatively high, compared with Wellington which had a car mode share of 72% in 2018.

It is important to note that much of the non-car mode share comes from active transport across these cities. Active modes, particularly walking trips to Wellington City CBD at peak times also make a significant contribution to Wellington's non-car mode share currently. However, looking at the comparative cities with light rail (below), all their public transport mode shares exceed 11% for public transport as compared to Wellington's 4% of all trips.

**Figure 6: Comparative Cities analysis – Wellington transport mode share compared internationally**



One of the comparative city case studies was Grenoble, France - where 700km of cycle lanes and 4 light rail lines/extensions have been completed since 1987. Grenoble, a city with 47 km of MRT network achieved a 23% reduction in carbon emissions between 2005-2018. Wellington achieved only a 7% reduction over a similar, slightly longer, period.

Comparative analysis is a useful additional tool with which to consider what might be possible with similar sorts of change in another location – it does not provide a forecast of what will happen. While the cities identified in the comparative analysis have all been chosen due to the similarity of their characteristics to Wellington, this analysis is only provided as an example of what might be possible should similar investment be undertaken in Wellington.

#### *Mass Rapid Transit investment impacts in Auckland*

In the New Zealand context, successful rapid transit investments include the 6.2 km dedicated Auckland Northern Busway which opened in 2008 with subsequent very strong patronage growth and mode shift from North Shore to the CBD. The patronage on the busway has also significantly exceeded forecast demands.

Significant investment in upgrading Auckland's rail system over the 10-year period from 2001-2011 demonstrated the willingness of Aucklanders to change their travel habits and use rail, with patronage

increasing from 2.2 million trips million per annum to 9.5 million, a growth of 332 per cent<sup>19</sup>. Prior to the Covid pandemic, Auckland's rail patronage was regularly approaching 2 million trips per month<sup>20</sup>.

Looking at case studies both overseas and at home helps to give us confidence that investment in MRT can contribute to significant improvements in mode share and carbon emissions outcomes for Wellington.

## Conclusion

### *LGWM Transformational Programme performance: carbon emissions reduction and mode shift*

The LGWM programme sits alongside a range of initiatives across the region to reduce carbon emissions by improving transport choice, managing demand, and shaping land use and urban form. We will need all these programmes and projects to cumulatively deliver emissions reductions if we are to achieve national, regional and city carbon targets.

Shaping our cities and towns is key to improving the overall efficiency of the transport system. Meeting the housing needs of a growing regional population while reducing carbon emissions will require a response both within Wellington City and across the region.

The Wellington Regional Growth Framework expects approximately two-thirds of the housing growth over the next 30 years to occur in existing urban areas through infill, urban renewal and intensification, and approximately one-third of the growth in greenfield areas, extending the current urban footprint of the region. The greater the urban densification enabled and stimulated by the LGWM programme, together with intensification in and around sub-regional centres and around rail stations, the less greenfield development will be required, and the more transport emissions will be reduced.

The LGWM 3-year programme will make travel by public transport and active modes much more attractive and support mode shift to low-carbon modes. However, it is the LGWM Transformational Programme that will provide the foundations for a fundamental change to the way urban form develops in Wellington City, with associated significant and sustained reduction in carbon emissions and other important co-benefits over the medium to long term. A new MRT system and associated infrastructure provides an important city shaping catalyst for this change.

The more, new housing provided in Wellington City along the MRT corridor, the higher the number of trips expected to be easily made by walking and cycling and public transport given the proximity and access to the region's largest centre and employment hub, Wellington City CBD.

Analysis has shown that under the core land use scenario, the embodied carbon of all of the LGWM programme options takes a long time to be 'paid off' with enabled carbon savings. On the other hand, if the density forecast under the intensified land use scenario is achieved, the Transformational Programme has the potential to deliver a reduction of over 700 kt CO<sub>2</sub>e or between 3-4% of regional emissions compared to the Do Minimum scenario. This is a significant contribution to regional emission reduction in the context of trip making across the wider region where private car is the dominant mode of travel and, on an annual basis, over 4 billion vehicle kilometres are travelled.

Opportunities to reduce the carbon emissions created during the construction phase will be a key objective for the DBC, as will be identifying specific actions that will support greater urban density to be delivered along the MRT route as quickly as is feasible.

<sup>19</sup> Auckland City Rail Link, Updated Economic Evaluation, 2011

<sup>20</sup> AT Metro patronage report web-pax-dec-2021.xlsx (live.com)

### Option differentiation

The LGWM carbon analysis shows that the degree of urban intensification achieved, followed by the level of mode shift enabled, is the key differentiator between programme options, rather than the performance of the programmes themselves. The degree to which the programme options are likely to facilitate the assumptions underpinning the intensified land use scenario is a key factor for consideration, though not the only one:

- a. Option 1 is likely to support very high levels of intensification along the southern corridor with light rail as the form of MRT and provides for direct public transport journeys and increased public transport capacity to the east to support mode shift to public transport and intensification.
- b. The bus-based form of MRT proposed in Option 2 is assumed to provide less capacity and less urban development than light rail-based MRT. However, this option includes bus-based MRT both south and east and is likely to support intensification across both these areas.
- c. The lower public transport level of service and capacity limits to the east under Options 3 and 4 are likely to constrain the degree of intensification in the east.

While the LGWM programme has found less scope for residential intensification in the east, the intensified land use scenario also supports greater employment density in the CBD, supporting more productive, higher-paying jobs.<sup>21</sup> To the extent that this supports some intensification in the east, and reinforces the primacy of the Wellington CBD as the employment centre, it supports the need to provide additional, reliable public transport capacity for current and future eastern suburbs residents. Mode shift is also important, alongside direct reduction in carbon emissions.

Infrastructure investment under Mt Victoria and at the Basin Reserve (Options 1 and 2) support mode shift to public transport from the eastern suburbs, supporting the draft Emissions Reduction Plan objective to reduce VKT by light vehicles. Average commuter journeys from the eastern suburbs are longer than from the south, which reinforces the importance of viable and reliable public transport options for residents in the eastern suburbs to have low carbon travel choices and not to be reliant on private vehicles.<sup>22</sup>

While Options 1 and 2 both are estimated to have higher embodied carbon than Options 3 and 4, in the long run, embodied carbon emissions are less important than the level of land use density each programme option is assessed to enable and achieve – greater urban density produces significantly greater carbon emissions savings than the carbon produced in construction.

The degree of mode shift predicted also cannot be ignored given LGWM's objectives, and the draft Emissions Reduction Plan. Options 1 and 2 both include substantial investment in public transport provision to the south but also to the east – the new Mt Victoria Tunnel in Options 1 and 2 delivers a threefold increase in dedicated public transport capacity to the eastern suburbs without increasing private vehicle capacity.<sup>23</sup>

The early difference in carbon emission performance between Option 1 and Option 4 is embodied emissions from construction. Option 1 embodies more carbon upfront and takes longer to construct than Option 4. Nevertheless, the enabled carbon performance of the intensified land use scenario is significantly higher than the difference between Option 1 and Option 4 – between 2026-2046 model

<sup>21</sup> Economics Technical Report.

<sup>22</sup> Preferred Programme Option Report – Modelling Appendix

<sup>23</sup> Preferred Programme Option Report – Modelling Appendix. The form for the proposed Mt Victoria Tunnel will not be determined until the DBC stage – should it be preferred. Neither of the two high-level designs provide for additional private vehicle capacity though final designs may, subject to network conditions, provide for some more direct journeys for some private vehicle users. This will be explored in detail during the DBC.



years, enabled carbon reductions each year under the intensified land use scenario are around 50 kt CO<sub>2</sub>e, or nearly half of the estimated embodied carbon for Options 1 and 2.<sup>24</sup>

## Limitations and assumptions

According to the Treasury:

“The indicative business case provides decision-makers with an early indication of the preferred way forward for high value and / or high-risk investment proposals... The information presented is indicative only [emphasis quoted]. It provides the decision-makers with just enough information to consider change and agree the short-listed options for further analysis, or to decide not to proceed with the project, before too much work is done.”<sup>25</sup>

The level of analysis – and the accuracy with which we can project future outcomes – is necessarily limited at the IBC stage. The purpose of the IBC is to provide sufficient information to narrow the range of detailed analysis, not to provide certainty.

The quantification of embodied carbon has relied on high level estimates of quantities of traditionally carbon-intensive materials: construction fuel, concrete and steel. Without detailed design for all options, these estimates are subject to wide error ranges so these calculations should be regarded as high-level estimates only. Subject Matter Experts considered the impact of embodied carbon in the Multi-Criteria Analysis undertaken to identify the Programme Affordable Shortlist Options. Through this process, the Subject Matter Experts identified that Options 1 & 2 were broadly similar to option V1A, and that Options 3 & 4 were broadly similar to Option V3A. Consequently, for the embodied emissions quantification, Options 1 & 2 are assumed to be the same, while Options 3 & 4 are also assumed to be the same.

This is a simplifying assumption to enable quantification: the LGWM programme team acknowledges that the programme options will have different levels of embodied carbon. At this stage in an IBC, however, the embodied carbon estimates for the programme options are not sufficiently different to alter the overall carbon analysis between the options because the level of embodied carbon emissions is much lower than the emissions they enable or discourage from the use of infrastructure. Using VEPM and estimates of VKT from the Wellington Analytics Unit models, embodied carbon is estimated to be between 0.2% and 0.5% of enabled carbon emissions savings from the programme options over 40 years.

Design finalisation introduces opportunities for embodied carbon reduction through improvements in materials and design practice, which is required under the Waka Kotahi Sustainability Rating Scheme. Tradeoffs will be possible in the use of materials. Some emissions-reducing technologies are already market-ready, such as lower-emissions concrete mixes with Supplementary Cementitious Materials replacing Portland Cement, the use of recycled steel for reinforcing, and the increasing availability of electric construction machinery. The DBC phase will investigate the viability and likely cost of such tradeoffs.

The Wellington Transport Strategic Model, augmented with additional microsimulation modelling, provides the basis for assessing the quantitative impacts of the LGWM programme options on VKT and enabled carbon reductions. In general, strategic models will struggle to represent transformational change – such as that proposed with investment in MRT. The Wellington Transport Strategic Model outputs forecast the impact of the programme options on demand for different transport modes. There are inherent limitations forecasting future behaviour, particularly in the outyears of the model forecasts.

<sup>24</sup> Wellington Transport Analytics Unit analysis for LGWM Programme.

<sup>25</sup> Better Business Case Indication Business Case Guidance (Sept 2020); accessed at <https://www.treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/better-business-cases-bbc/bbc-guidance/project-indicative-business-case-ibc>

This is because the model relies on underlying assumptions about transport consumers' demand / preferences for particular modes.

The LGWM programme options all introduce significant investments in city-shaping forms of transport – MRT does not currently exist as a transport choice for Wellington transport consumers south of the Wellington Railway Station, while the City Streets investments will join up previously incomplete cycling routes to create a network. These investments will fundamentally alter travel patterns and modal choices, particularly if they succeed in encouraging the faster development of denser housing options located along the MRT corridor, in close proximity to employment, education and services. It is difficult for a transport model to accurately project travel patterns in such a dynamic environment.

The impact of changes to urban form are only partially captured within the transport modelling outputs that form the inputs for the quantification of carbon emissions. This analysis is conservative in the scope of the carbon emissions savings calculated. We know, however, that denser residential development results in more public transport trips and more walking, cycling and micro-mobility. This dynamic effect is unlikely to be fully captured.

There are other carbon emissions savings that have also not been quantified in this analysis, but which we know will be supported, in part, by the expansion of high quality MRT and active mode networks:

- Denser development also makes more efficient use of other infrastructure, such as three-waters pipes, energy networks and social infrastructure such as schools, libraries, arts and cultural facilities. Less geographic spread results in less replication – less embodied and operational carbon emissions– better use – less carbon – and more PT and active transport use – less carbon per head of population.
- There is a range of evidence that identifies that the whole-of-life energy efficiency of denser housing is superior to that of standalone greenfields housing.<sup>26 27</sup> To the extent that LGWM investments enable denser housing to be developed, LGWM is contributing towards a lower carbon future.

LGWM scope does not include directly supporting the achievement of greater urban density along the MRT corridor. LGWM transport modelling identifies the transport benefits that come from the improved accessibility provided by the LGWM programme infrastructure investment, however, due to the inability of the programme to directly influence urban form, these potential benefits have not been quantified or monetised in this analysis. As noted, the intensified land use scenario should be considered a 'what if' scenario, not a prediction of what will happen. Should the scope of the DBC be expanded to include this, it can be undertaken during the DBC, ahead of any final decisions on the LGWM programme options.

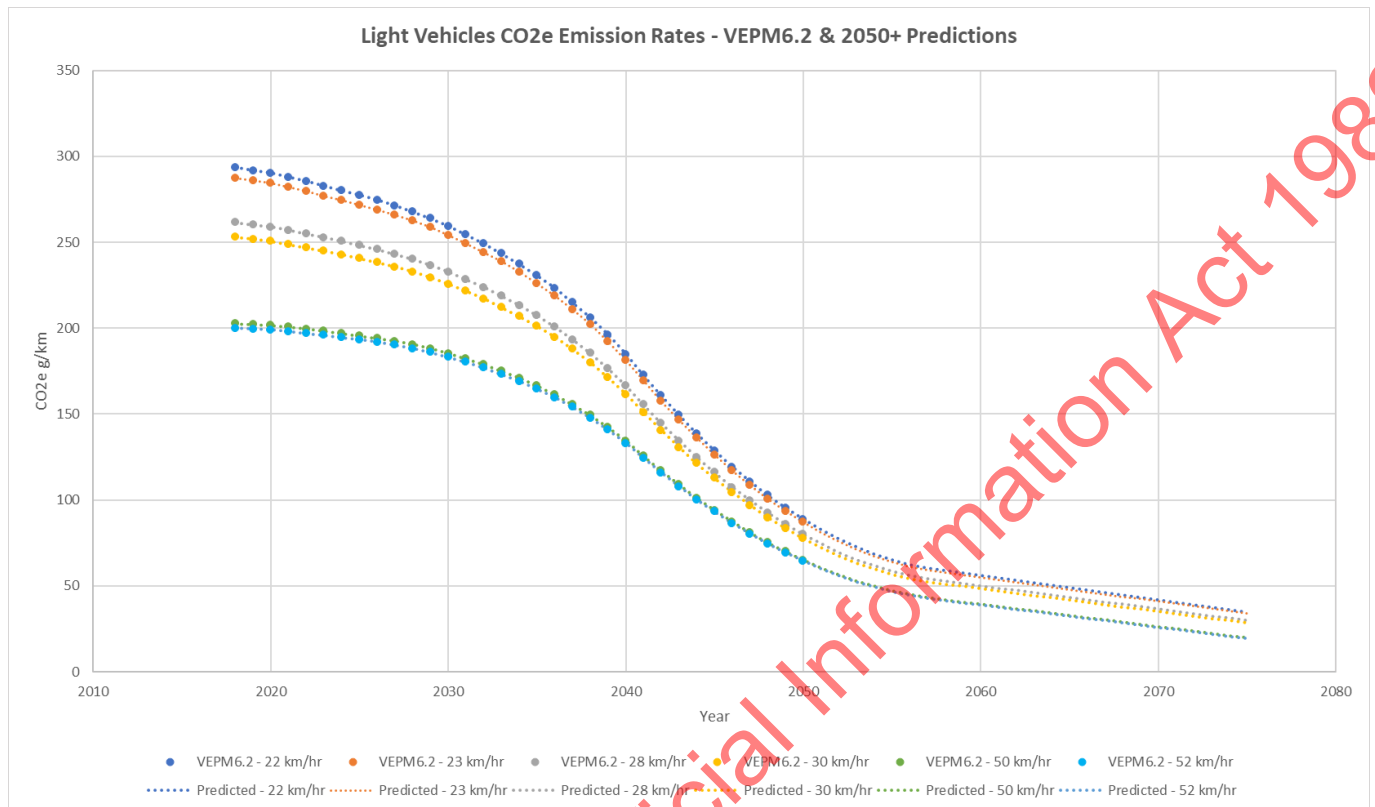
### *Vehicle Emissions Prediction Model*

The Vehicle Emissions Prediction Model (VEPM) forecasts emissions based off network average speeds for each model sector. This is a significant simplification because vehicles starting and stopping – such as in congested conditions – has a large effect on emissions production compared to constant speed travel, as is assumed in the VEPM. This suggests that the estimates of enabled carbon reduction are likely to be conservative. The effect of assumptions about vehicle speeds is shown in Figure 7 below.

<sup>26</sup> Ganda (2019). A Life Cycle Assessment of Medium Density Houses in New Zealand; available from: <https://researcharchive.vuw.ac.nz/xmlui/handle/10063/8649>

<sup>27</sup> BRANZ (2021). LCAQuick: Life cycle assessment tool.; available from: <https://www.branz.co.nz/environment-zero-carbon-research/framework/lcaquick/>

**Figure 7: Carbon emissions rates – VEPM and 2050+ predictions**



VEPM does not currently forecast emissions rates beyond 2050, primarily because of the difficulty of making accurate assumptions about vehicle fleet composition and emissions factors this far in the future. Due to the longevity of LGWM transport modelling, however, some predictions have had to be made to support the quantification of enabled emissions savings. The effect of these predictions beyond 2050 is also shown in Figure 7 above. Emissions have been predicted to continue to taper down, however have not been assumed to fully reach zero. This reflects an assumption that the vehicle fleet will be dominated by zero-carbon vehicles by 2050, but that absent some form of regulation, there will remain a pool of fossil fuel-powered vehicles (traditional internal combustion engine or hybrid vehicles).

By necessity, VEPM also makes some simplifying assumptions to support its useability. This includes the following assumptions:

- Electrification of the fleet is 100% zero carbon – no account is made of the source of electricity.
- Emissions rates are nationwide, not regional, which may not accurately reflect Wellington's regional vehicle makeup.



