N52 TULLAMORE TO KILBEGGAN LINK

Option Selection Report

Volume F – Environmental Appendices
Appendix F5 – Climate

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Contents

Tables

1 INTRODUCTION

This report outlines the comparative assessment of options in relation to climate for the seven options for the N52 Tullamore to Kilbeggan Link Scheme. Specifically, this section evaluates the potential carbon emissions associated with the construction, operation and decommissioning of each of the options under consideration.

This assessment will form part of a Phase 2 – Option Selection Report which is a deliverable under Phase 2 – Options Selection of the TII PMG 2019. The purpose of the Option Selection Report is to present the project constraints and the assessments that were undertaken in order to identify the Preferred Option for the project.

1.1 Guidance

This analysis was undertaken by means of a desktop assessment based on the following guidance and information sources:

- National Roads Authority (NRA)/Transport Infrastructure Ireland (TII) "*Guidance for the Treatment of Air Quality during Planning and Construction of National Road Projects*" (May 2011);
- Transport Infrastructure Ireland *"Project Appraisal Guidelines for National Roads Unit 7.0 - Multi Criteria Analysis"* (2016); and
- Transport Infrastructure Ireland "*Carbon Tool for Road and Light Rail Projects*" (2020).

1.2 Project Appraisal Guidelines Requirements

The TII "*Project Appraisal Guidelines for National Roads Unit 7.0 - Multi Criteria Analysis*" (PAG) includes the assessment of climate under the overall heading of air quality as follows:

- The impact on climate is measured through a number of quantitative statements relating to the amount of carbon dioxide (CO_2) likely to be produced for both the "Do Minimum" and "Do Something" scenarios.

Given the increased focus on climate impacts in national environmental policy, for this option assessment climate has been assessed as a separate stand-alone topic. In particular, Objective 10.2 of the Climate Action Plan sets out the commitment for the following in the transport sector:

To meet the required level of emissions reduction, by 2030 we will reduce $CO_{2\,eq.}$ emissions from the sector by 45–50% relative to 2030 pre-NDP projections.

This analysis seeks to quantify the lifecycle emissions of each route option to identify the impact of each option to determine which option has the greatest capacity to achieve the above target.

1.3 Assessment Criteria

The Stage 2 Appraisal Process was carried out using the full range of sub criteria recommended in PAG unit 7.0, and with regard to the objectives of the scheme, so as to take account of all the predicted impacts of each option or alternative. In many cases there is a strong overlap between the objectives of the scheme and one or more of the PAG sub criteria.

All appraisal criteria use a standard scale. Each impact is scored on a scale of 1 (major or highly negative impact) to 7 (major or highly positive impact). A score of 4 represents a neutral or not significant impact. Each impact is scored as per the system presented in **Table 1-1**.

All scores refer to impacts measured relative to the Do-Minimum. The Do-Minimum consists of doing nothing further to improve the N52 route. The Do- Minimum would therefore by definition be scored as Neutral (relative to itself) under all sub criteria.

PAG 7.0 notes that simply adding up the scores of the different sub-criteria gives an indication of the overall performance of each option under a given criterion, but this is not to be used in a mechanistic way as a decision process. The performance of each option in meeting the scheme objectives was then considered to be one of the criteria presented in **Table 1-2**.

Table 1-1: Project Appraisal Guidelines Scoring

Score	PAG Score
7	Major or highly positive
6	Moderately positive
5	Minor or slightly positive
4	Not significant or neutral
3	Minor or slightly negative
2	Moderately negative
1	Major or highly negative

Table 1-2: Qualitative Scoring

Score	PAG Score
Preferred	The choice which most fully meets the project objectives.
Good	Where project objectives are met notably better than with the intermediate choices but notably not as well as with the best choice.
Intermediate	Where project objectives are met considerably less well than with the best choice but considerably better than with the worst choice.
Poor	Where project objectives are met notably less well than with the intermediate choices but notably not as well as with the best option.
Least Preferred	The choice which does least to achieve the project objectives.

Having regard to the full range of impacts assessed in each case. This is a high level of ranking of the options or alternatives. The scoring process allows for options or alternatives to be identified as being "Good", falling between "Intermediate" and "Preferred", or as "Poor", falling between "Least Preferred" and "Intermediate".

For some options there will be very little between their impact scores and some may even have the same impact scores. In such circumstances, the author has applied expert judgement and evaluated each option comparatively against the other options, taking into account the quantitative and qualitative assessments. This has allowed the author to determine a preference for each option. In some instances, similar options may have the same preference.

2 EXISTING ENVIRONMENT

2.1 TII Carbon Tool

TII's Carbon Tool (version 2.0) has been used to estimate the global warming potential of each of the seven options. Global warming potential is a measure of the greenhouse gas emissions associated with each option scenario and the potential atmospheric warming associated with those emissions. Several different greenhouse gases are known to contribute to global warming (e.g. carbon dioxide, methane, nitrous oxide, water vapour, etc.), but for the purposes of comparison, the TII Carbon Tool normalises input data to produce a single, output metric that is used for reporting – equivalent kilogrammes of carbon dioxide (henceforth $kgCO_2e$).

Data is collected and added to the tool to determine the potential carbon footprint of each option and also, to breakdown where the most significant emissions are being generated, i.e. 'carbon hotspots'. At this stage of the option selection process, some data are not yet available, so assumptions have been made where necessary. These assumptions are noted in **Section 2.2**.

The TII Carbon Tool aligns with the project phases outlined in TII's project management guidelines (PMGs). As such, this assessment is based on Phase 2: Option Selection (specifically Options Appraisal). In terms of reporting, the Tool aggregates results as per guidance in PAS 2080 (leading guidance document on managing infrastructure carbon in the UK).

PAS 2080 suggests a modular structure when reporting results and this modular structure forms the basis of the TII Carbon Tool. Results are aggregated by life cycle stages, such as Before Use, Use and Decommissioning. The life cycle stages have sub-categories (or modules) that are more specific to certain activities during the project's life cycle which may generate carbon emissions (e.g. embodied carbon of road building materials, transport emissions and vehicular emissions during the Use stage of the road). **Table 2-1** is an example of how data are reported in the Tool.

Table 2-1: Sample Results Template from TII's Carbon Tool

	Name	Before Use (kgCO2e)				Use (kgCO2e)		Decommissioning (kgCO2e)	Total (kgCO2e)
		Pre-Construction	Embodied Carbon	Construction Activities	Construction Waste	Road Use	Vehicles using the infrastructure	End of Life	
Option 1									
Option 2									
Option 3									
Option 4									
Option 5									
Option 6									
Option 7									
Option 8									
Option 9									
Option 10									

2.2 Assumptions

The following assumptions are made in the Tool where specific data are unavailable:

- The design life of the scheme is assumed to be 60 years. This is used to inform maintenance schedules and frequency of material replacement, refurbishment, etc.
- Annual average daily traffic (AADT) figure for the 2019 'do nothing' scenario is assumed to be 14,264, which provides a baseline to which modelled traffic figures for each option can be compared.
- Rate of traffic increase per year estimated by subtracting AADT 2019 (14,264) from AADT 2050 Horizon Year (18,232), which is 3,968. This represents an increase of 28% over the 30 year period (2050 – 2019), which is an average increase of approximately 1% per year.
- A high-level assumption of land-take area for Options 1-6 has been made by multiplying the option length by 21 metres (estimated cross section of a Type 2 dual carriageway with all associated separation distances, verges and cycle tracks). These areas are used for calculating site clearance and land use change. The existing road cross section varies between the northern and southern end, which have been upgraded, and a middle 5km section which has not been upgraded. As such, the existing

road width varies throughout the scheme but an average width of 10 metres for the full 8.2km length has been employed, which is used to calculate site clearance and demolition for online sections of each option.

- The estimated land-take for the Management Option follows the same methodology. However, only 5 km of the total 8.54 km option length is assumed to require upgrading (both the northern and southern ends of the existing route are excluded from the modelling on the basis that minimal works will be required). Additionally, the Management Option will be a Type 1 single-carriageway, so the cross section is assumed to be 18.6 metres (including all separation distances and hard strips).
- Apart from site clearance of existing infrastructure (i.e. online sections of the existing road), all other site clearance is assumed to be carried out on land principally occupied by agriculture.
- In calculating product stage (materials) emissions, road pavement area is calculated by multiplying the length of Options 1-6 by 16.5 metres (the assumed road width of a Type 2 dual-carriageway including central reserve and hard strip). Surface treatment/dressing is based off an assumed width of 14 metres (4 no. 3.5 metre wide lanes). For the Management Option, the 5 km middle section is multiplied by 12.3 metres as opposed to 16.5/14 metres. The road building materials are assumed to be sourced within 50 km of the scheme area and transported to site via HGV.
- The assumed road pavement layers are based off a typical composite pavement design. The base layer is assumed to be generic, cement bound granular material (CGBM), the binder course layer is dense asphalt concrete (AC) 14 mm nominal size and 40 mm depth and the surface course is a generic, bituminous surface dressing. The same pavement layer structure is assumed for all options in this assessment.
- Earthworks volumes for Options 1-6 have been provided by the design team. Earthworks volumes have not been calculated for the Management Option, so a 40% reduction in volume compared to Option 1 (the other online option) is used as an estimate. The 40% reduction compared to Option 1 reflects the Management Option only requiring significant works along a 5 km middle section, as opposed to the entire 8.54 km length. The total cut volumes are used in each scenario which represent all excavation. These volumes are captured in the Before Use Construction section of the tool. Fill volumes are captured in Before Use Embodied Carbon impacts section of the tool. These volumes represent the amount of excavated material on-site that can be directly used as fill. At this stage of the project, all fill is assumed to be generic (i.e. no specific materials) and transported via rigid HGV for 2km (average distance based on site size).
- Waste incurred during construction is estimated on the basis of industry-average assumptions for very large (> €10 million) projects, as included in the TII tool.
- Other categories of the Use stage (plant fuel use, operational energy use and water use) have not been estimated due to unavailability of data. This section of the tool will be updated as the design progresses to the next phases of the project
- No estimate for decommissioning of the asset is made at this stage of the project due to unavailability of data. This section of the tool will be updated as the design progresses to the next phases of the project.

3 OPTION SELECTION

3.1 Results

Results from modelling carried out in the TII Carbon Tool are detailed in this section. These results have been generated from a mixture of preliminary design data and where no data are available, assumptions listed in **Section 2.2**.

The graphs below offer a snapshot of the results from the modelling exercise. The Tool is used to aggregate results that either include or exclude vehicle use of the finished asset. As evident from **Figure 3-1**, when vehicle use is excluded, all options are relatively close in terms of carbon footprint. This is due to similar assumptions with regard to the construction process, materials, waste and transport distances and this early stage of the project.

Figure 3-2 includes the impact of vehicle use on the total amounts of carbon emissions. The inclusion of vehicle use results in a visible difference in carbon emissions between each option. The estimated carbon footprint of vehicle use for each option was calculated in TUBA traffic modelling software and included in the relevant part of the Tool (as per TII guidance). The results of the modelling are further discussed in the following sections.

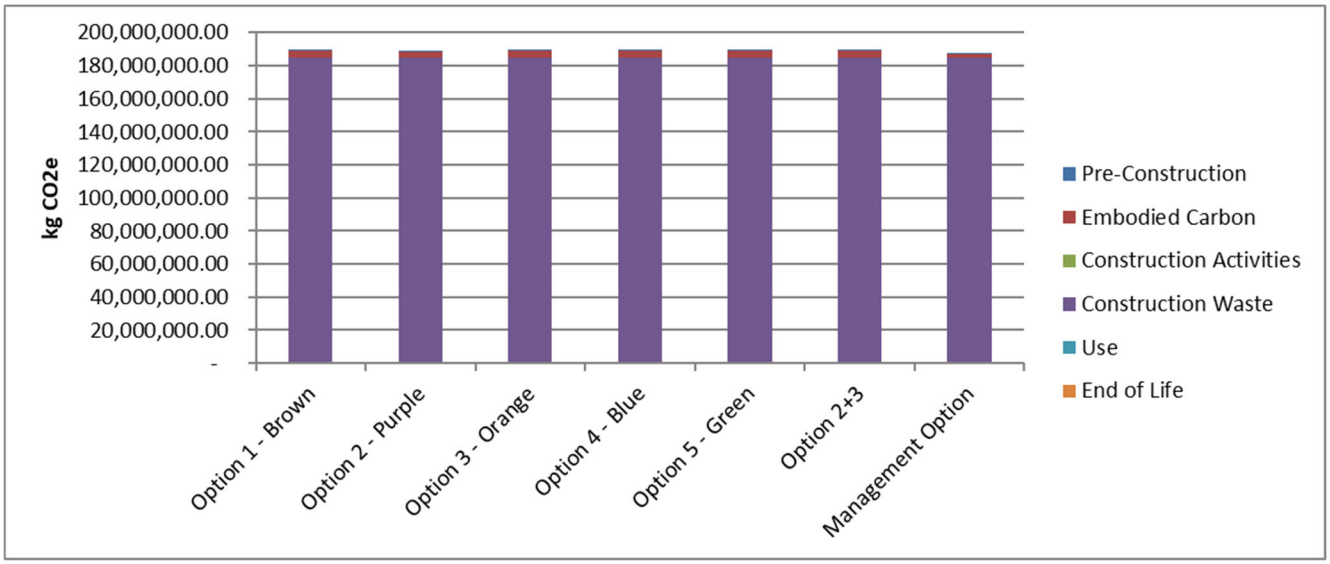

Figure 3-1: Total Carbon Footprint of each Option Excluding Vehicle Use

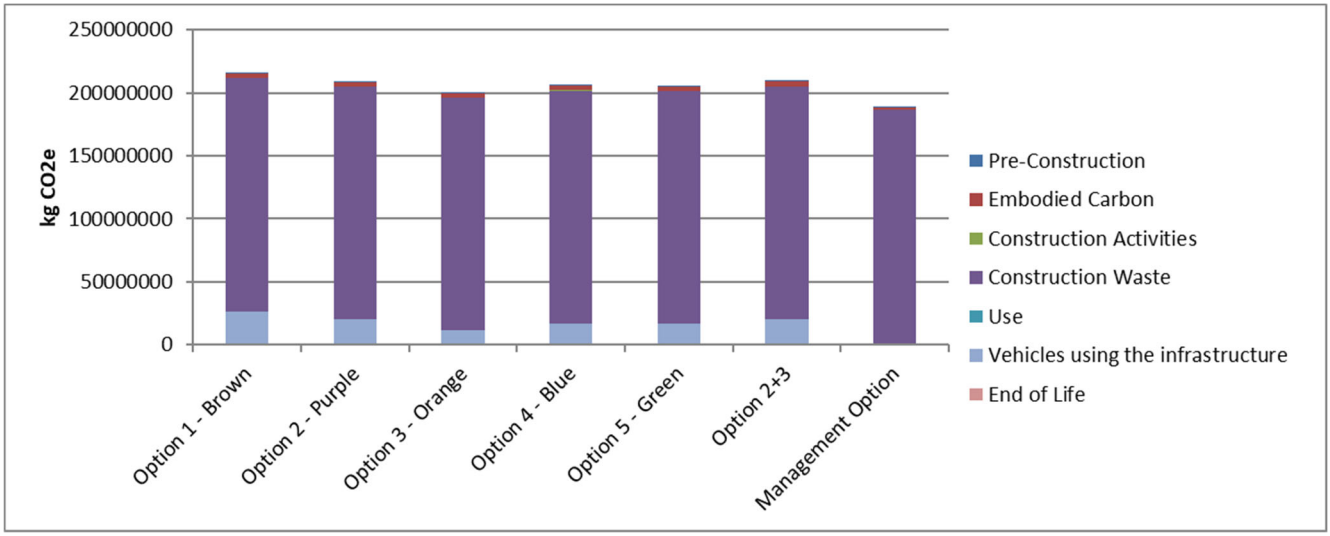

Figure 3-2: Total Carbon Footprint of each Option Including Vehicle Use

3.2 Discussion

Table 3-1 shows the total carbon emissions of each option by life cycle stage and this data is graphically presented in **Figure 3.3**.

The option with the highest carbon footprint is Option 1. Option 1 closely follows the alignment of the existing route, involving significant widening of the road up to the current design standards. Of all the options, Option 1 is the longest at 8,54km. This indicates that there are slightly more materials required for construction and site clearance activities (see **Table 3-1**), which contributes to overall carbon emissions. Option 1 also has the greatest impact from vehicles using the infrastructure during the Use stage. The data in **Table 3-1** indicates that Option 1 will have the greatest impact during the operation stage, generating 26,613,030 kgCO_2e. This is 6,692,000 kgCO_2e (33%) more than the next highest option (Options 2 and 2-3) and 25,278,000 higher than the lowest option (Management Option).

Option 2-3 has the second highest carbon footprint and, as a hybrid of Option 2 and Option 3, has only a slightly higher carbon footprint than Option 2. Option 2-3 has the highest embodied carbon of all options (mainly due to the higher volumes of fill required for import, as evident in **Figure 3-3**). Option 2-3 also has the highest impact from construction activities (high level of excavation required). This option has the same vehicle use impact as Option 2, given that both options are very similar in terms of alignment and length.

Option 2 is third in terms of carbon footprint. As mentioned in the previous paragraph, it is closely linked to Option 2-3, so emissions are expectedly similar. The Option 2 carbon footprint is slightly lower than that of Option 2-3 mainly due to the lower volumes of cut and fill required for this option.

Option 4 and Option 5 have very similar carbon footprints. While Option 4 has a lower impact from construction activities, this is offset by the slightly lower impact from vehicles using the Option 5 infrastructure. Accordingly, both options are treated equally in terms of climate impacts.

Option 3 has the second lowest carbon footprint of all options. It is the shortest option at 7.90 km, thus requires slightly less site clearance and materials. Although it doesn't have the lowest impact from construction activities, it has a low impact from emissions generated by vehicles using the infrastructure.

The Management Option has the lowest carbon footprint of all options. Although it is the same length as Option 1 (8.54 km), the requirement for materials and site clearance is less, as only the central 5 km section of the option requires upgrading. Significant carbon savings for this option are derived from the vehicle use phase, as the TUBA modelling data projects much lower emissions compared to the other options. This is largely due to the Management Option's proposed design as a Type 1 single-carriageway as opposed to Type 2 dual-carriageway, thus a lower volume of road users over the life of the asset.

In terms of real world comparisons, the total embodied carbon footprint from the construction of an average 3-bed semi-detached house is in the order of 40,000kgCO2e (40 tonnes). The equivalent cost of carbon within the EU is currently approximately €50 per tonne. These metrics have been built into Table 3-1 overleaf to equate the carbon use for each scheme option to an equivalent no of houses and equivalent cost.

Table 3-1: Option Comparison by Total Carbon Emissions ($kgCO_2e$)

Option	Before Use ($kgCO_2e$)				Use ($kgCO_2e$)	Total Carbon Use ($kgCO_2e$)	Total Carbon Use (tonne CO_2e)	Equivalent No. of Houses (3-bed semi)	Equivalent Cost (based on €50 per tonne)
	Pre-Construction	Embodied Carbon	Construction Activities	Construction Waste	Vehicles using the infrastructure				
Option 1	7,882	3,698,949	86,873	184,960,000	26,613,030	215,366,734	215,367	5,384	€ 10,768,337
Option 2	7,793	3,550,811	203,404	184,960,000	19,921,030	208,643,038	208,643	5,216	€ 10,432,152
Option 3	7,287	3,634,152	214,312	184,960,000	11,259,030	200,074,781	200,075	5,002	€ 10,003,739
Option 4	7,459	3,666,530	117,275	184,960,000	16,887,030	205,638,294	205,638	5,141	€ 10,281,915
Option 5	7,429	3,617,595	198,368	184,960,000	16,584,030	205,367,422	205,367	5,134	€ 10,268,371
Option 2-3	7,473	3,895,402	256,046	184,960,000	12,906,000	202,024,921	202,025	5,051	€ 10,101,246
Management Option	4,086	1,638,075	52,124	184,960,000	1,335,030	187,989,315	187,989	4,700	€ 9,399,466

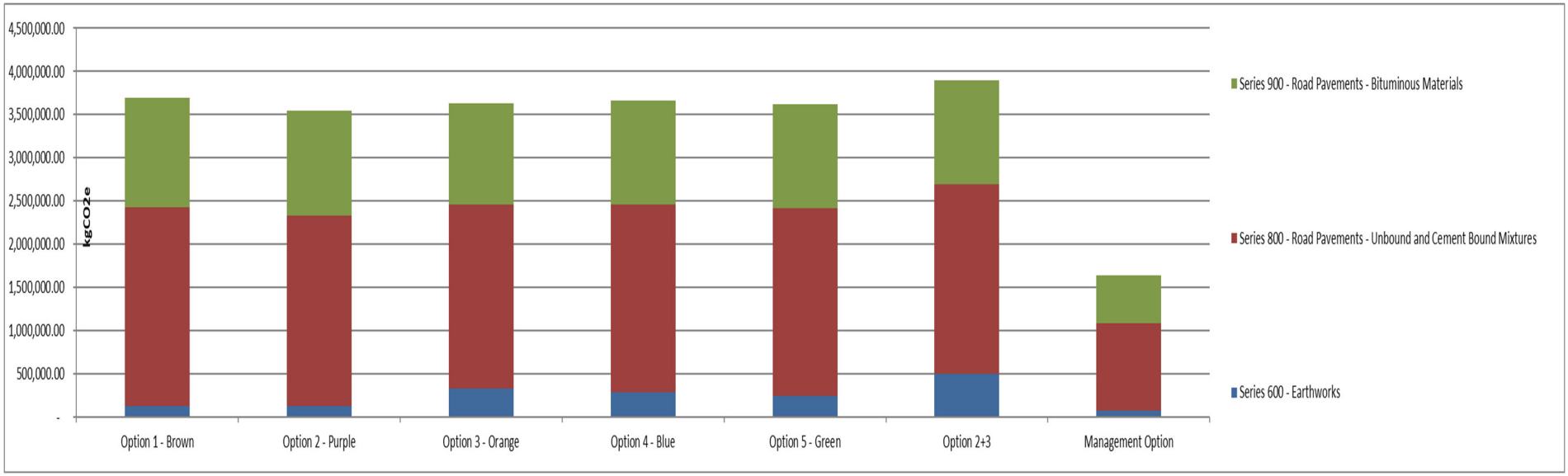

Figure 3-3: Option Comparison by Embodied Carbon of Materials ($kgCO_2e$)

4 OPTION SUMMARY

Table 4-1 summarises the findings of the TII Carbon Tool and outlines the impact scores and preference of each option. Given the high amount of energy and resources required in the construction of any large infrastructure asset, such as this road scheme, all options are determined to have a minor or moderately negative impact is applied to all routes relative to the Do-Minimum scenario (utilising the existing asset with no works).

All carbon footprints show a similar carbon footprint with a relatively small difference between the preferred and least preferred options (of the order of 15% difference). For this reason, there is limited difference between the routes on a climate basis and no clear preferred or least preferred options.

Nevertheless, preference rankings have been assigned to each option, given the differences outlined in **Section 3.2**. The Management Option is considered "good" given that this option has the lowest overall carbon footprint and offers a saving of 15% (27,377 tonnes of CO_2e) over the highest option (Option 1). On that same basis, Option 1 is classed as "poor" given that this option presents the highest carbon footprint of all options. All other options are classed as "intermediate" in terms of climate, given that all will generate significant carbon emissions during the construction and operation phase, relative to the Do-Nothing.

Table 4-1: Climate Impact Score Matrix

Option	Potential for Impact	Impact Level	Impact Score	Preference
Management Option	• Shortest overall distance requiring significant construction (5km from 8.54 km total length) • Lowest footprint from site clearance, materials and earthworks. • Lowest construction footprint. • Lowest emissions from vehicles using the infrastructure over the project's lifetime. • Lowest overall carbon footprint.	Minor or slightly negative	3	Good
Option 1	• Longest route option so more materials required for construction and higher embodied carbon emissions. • Lowest impact regarding construction activities given the online nature. • Highest footprint during operation as highest kilometres travelled. • Highest overall footprint.	Moderately Negative	2	Poor
Option 2	• High impact from construction activities due to high level of excavation required. • Relatively low embodied carbon. • Second only to Option 1 on operational emissions.	Moderately Negative	2	Intermediate
Option 3	• Shortest route option so lowest impact from site clearance and materials. • Highest impact from construction activities. • Lowest footprint during operation as lowest kilometres travelled during operation. • Lowest overall footprint.	Moderately Negative	2	Intermediate
Option 4	• Moderate level of construction phase impact with low construction activity impact and moderate embodied carbon. • Moderate operational impacts.	Moderately Negative	2	Intermediate
Option 5	• Moderate level of construction phase impact with moderate construction activity impact and moderate embodied carbon. • Moderate operational impacts.	Moderately Negative	2	Intermediate
Option 2-3	• Highest embodied carbon of all options due to the higher volumes of fill required for import. • Highest impact from construction activities due to high level of excavation required.	Moderately Negative	2	Intermediate