M60/M62/M66 Simister Island Interchange

TR010064

ENVIRONMENTAL STATEMENT APPENDICES

APPENDIX 14.1 ESTIMATION OF GREENHOUSE GAS EMISSIONS

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ENVIRONMENTAL STATEMENT APPENDICES
APPENDIX 14.1 ESTIMATION OF GREENHOUSE GAS EMISSIONS

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Appendix 14.1 Estimation of greenhouse gas emissions

1 Introduction

1.1.1 This appendix outlines the methodology, inputs and results of the assessment of greenhouse gas (GHG) emissions for the Scheme. A summary of these findings is provided in Chapter 14: Climate of the Environmental Statement (TR010064/APP/6.1).

1.1.2 This assessment has been undertaken in accordance with the Design Manual for Roads and Bridges (DMRB) LA 114 Climate (Highways England, 2021).

1.1.3 The GHG assessment includes the estimation of GHG emissions associated with the following activities, each of which is discussed in detail within the subsequent sections of this appendix:

- Construction and operational maintenance
- Operational energy consumption
- Operational road users
- Land use change and forestry

1.1.4 GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6), each with differing global warming potentials. In this assessment, the term 'GHG emissions' describes the amount of carbon dioxide equivalent (CO_2e) released into the atmosphere. CO_2e is the amount of carbon dioxide emission that would produce an equivalent global warming effect to an amount of other greenhouse gas emission. It is a standardised metric for measuring carbon footprints.

2 Construction and operational maintenance

2.1 Methodology

2.1.1 This assessment applied the National Highways Carbon Tool v2.5 (National Highways, 2022a) to estimate construction and operational maintenance emissions. National Highways has developed this tool to estimate GHG emissions associated with operational, construction and maintenance activities undertaken across the strategic road network.

2.1.2 It is primarily designed for use during the construction process to calculate actual GHG emissions associated with construction activities (e.g. site energy/utilities consumption, plant machinery energy consumption, employee transport); embodied emissions (i.e. the carbon embodied in the extraction and processing of the raw materials used for construction); emissions associated with the transport of materials to the construction site; and emissions from construction waste treatment and transport. The tool can also, however, be used throughout the design process, from preliminary through to detailed design stages, to understand and compare the likely implications of the design of highway schemes on GHG emissions. It can also be used to compare the effectiveness of potential mitigation options for reducing GHG emissions (e.g. through the use of different materials).

2.1.3 The tool can also be used to estimate GHG emissions associated with routine operational maintenance activities.

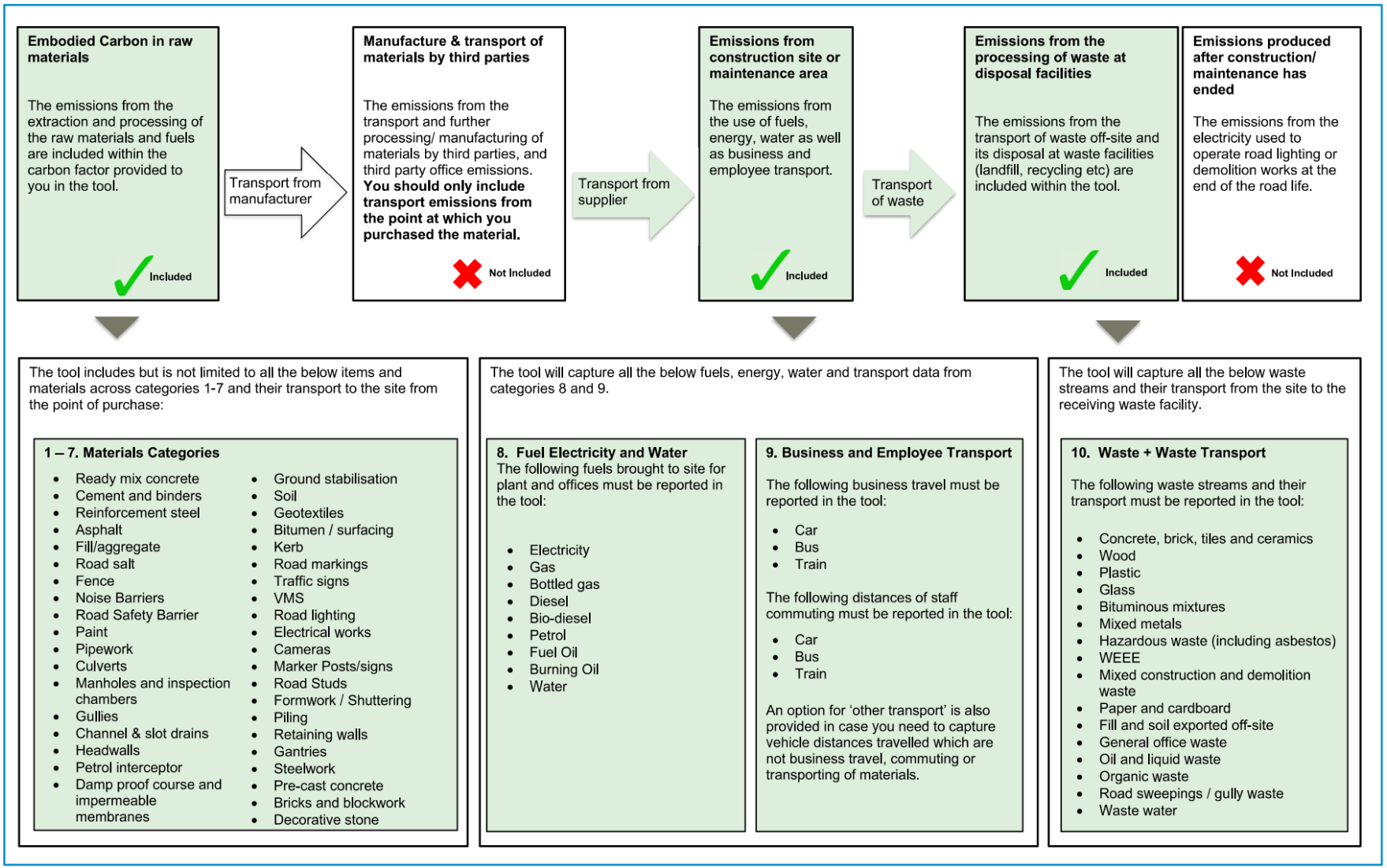
2.1.4 It should be noted that during the course of this assessment an error was found within the National Highways Carbon Tool v2.5 relating to the calculation of GHG emissions associated with the transportation of raw and waste materials. As such, GHG emissions associated with the transportation of raw and waste materials have been calculated separately using the correct methodology.

2.1.5 For this assessment, the relevant construction and material quantities were compiled based on input from the highways and design teams for the Scheme. The following sections outline the assessment boundary, the information and assumptions applied, and the resulting emissions for construction and operational maintenance emissions.

2.2 Scheme boundary for the assessment

2.2.1 As shown on Plate 2.1, the National Highways Carbon Tool (National Highways, 2022a) recommends a Scheme boundary that includes embodied carbon in raw materials, transport from the supplier, emissions from construction site/maintenance areas and emissions from the transport to and processing of waste at disposal facilities. The tool specifically excludes the manufacture and transport of materials by third parties to suppliers, and emissions associated with decommissioning of the Scheme (in line with DMRB LA 114).

Plate 2.1 Scope of carbon emissions included in the National Highways Carbon Tool



2.2.2 The assessment adopted the National Highways Carbon Tool for the calculation of GHG emissions associated with the emission sources set out in Plate 2.1, which aligns to the life cycle stages and sub-stages defined in Table 3.11.1 of DMRB LA 114:

- **Construction phase emissions** – including the product stage and construction process stage but excluding emissions associated with land-use change and forestry, which were assessed separately (see Section 5 of this appendix).
- **Operational phase ('use stage')** – including operational maintenance (including repair, replacement and refurbishment), but excluding operational energy usage, use of the infrastructure by the end user (road user) and emissions associated with land use change and forestry, which were assessed separately (see Chapters 3, 4 and 5 of this appendix, respectively).
- **Opportunities for reduction** – through the tool's ability to provide comparisons of multiple design options and perform sensitivity testing by adjusting quantities (e.g. to demonstrate the impact of reuse/'designing out' of assets) and material specifications (e.g. to demonstrate the impact of substitution of virgin raw materials with those from recovered sources).

2.3 Information used and assumptions

2.3.1 Entries into the tool were based on a Bill of Quantities (BoQ) for the Scheme, which was produced in June 2023. It is noted that the design will continue to be refined throughout the design process, which could result in changes in material quantities and associated GHG emissions to that presented herein. As a result of this uncertainty, and in order to provide a conservative assessment, a contingency factor of 15% has been applied to the material quantities provided within the BoQ. Furthermore, where information is incomplete or unknown at this stage, a number of assumptions have been made, which are detailed below.

2.3.2 It should also be noted that the initial step towards carbon management is to identify and map out the emissions sources that can be attributed to a project through its life cycle. Management and reduction of emissions can only occur after this. Whilst the aim of this assessment is to identify and account for as much project related carbon as possible, a proportionate approach has been taken, whereby some carbon sources have been prioritised over others. This is because many components will have a negligible impact on carbon emissions and offer limited opportunities for mitigation compared to the time, effort and cost involved in determining their carbon impact. Where potential sources of carbon emissions have been excluded from this assessment it is noted and justified below.

Embodied carbon in raw materials

2.3.3 The design information and related material quantities that were incorporated into the GHG assessment of construction phase emissions are summarised in Table 2.1 and Table 2.2 for temporary and permanent works, respectively. These material quantities were derived from the relevant BoQ associated with the Scheme.

2.3.4 The design information and material quantities used in the GHG assessment include:

- Bulk materials
- Information on earthworks quantities
- Fencing, barriers and road restraint systems
- Drainage pipework and associated items (e.g. manholes)
- Road pavements and markings
- Street furniture, including signs, lighting and road studs
- Materials for structures, such as bridges and retaining walls

Table 2.1 Material quantities used in GHG assessment (temporary works)

Scheme element	Material - item	Material - type	Units	Quantity	Quantity with 15% contingency applied
Bulk Materials	Ready mix concrete	General - C8/10 (Gen 1, ST 2)	m^3	90.5	104.0
		General - C20/25 (ST 5)	m^3	99.0	113.9
	Reinforcement steel	Steel bar and rod	tonnes	5.9	6.8
	Asphalt	General Asphalt	tonnes	2,853.0	3,281.0
	Fill and aggregate	Virgin land won resources	tonnes	138,388.7	159,147.0
Earthworks	Geotextiles	Polypropylene geotextile / matting	m^2	68,454.0	78,722.1
Fencing, Barriers and Road Restraint Systems	Fence	Timber rail fence (all types, includes posts)	metres	4,500.0	5,175.0
		Steel/wire/chain fence (includes posts)	metres	400.0	460.0
Drainage	Plastic pipework (HDPE)	150mm diameter	metres	125.0	143.8
		225mm diameter	metres	50.0	57.5
		900mm diameter, up to 3m depth	no.	8.0	9.2
	Precast concrete manholes	900mm diameter, 3m - 6m depth	no.	2.0	2.3
	Gullies	Plastic gully pots - PVC	no.	28	32.2
	Slot Drain	Plastic (Polypropylene) channel (light duty)	metres	230.0	264.5
	Headwalls	Precast Concrete	no.	4.0	4.6
	Petrol interceptor	Plastic (Polyethylene)	no.	1.0	1.2

Scheme element	Material - item	Material - type	Units	Quantity	Quantity with 15% contingency applied
	Flow Control Device	-	no.	1.0	1.2
Road Pavements	Kerb	Pre-cast concrete 125x150mm	metres	35.0	40.3
		Pre-cast concrete 125x255mm	metres	175.0	201.3
Street Furniture and Electrical Equipment	Traffic signs	Aluminium	m^2	40.0	46.0
	Road lighting and columns	Aluminium columns 8m	no.	15.0	17.3
	Cable	Armoured cable / Power cable	metres	200.0	230.0
		Miscellaneous cable	metres	290.0	333.5
	Plastic cable	150mm diameter	metres	490.0	563.5
	Cabinets	Any type	no.	2.0	2.3
Civil Structures and Retaining Walls	Formwork	Plywood	m^3	2,284.1	2,626.7

Table 2.2 Material quantities used in GHG assessment (permanent works)

Scheme element	Material - item	Material - type	Units	Quantity	Quantity with 15% contingency applied
Bulk Materials	Ready mix concrete	General	m^3	7,208.7	8,290.0
		General - C8/10 (Gen 1, ST 2)	m^3	1,963.5	2,258.0
		General - C32/40	m^3	3,909.2	4,495.6
		General - C40/50	m^3	3,579.1	4,116.0
	Reinforcement steel	Steel bar and rod	tonnes	1,032.3	1,187.2
	Asphalt	General Asphalt	tonnes	60,103.5	69,119.0
	Fill and aggregate	Site-won	tonnes	126,280.6	145,222.7
		General mixture	tonnes	155,993.8	179,392.8
		Virgin land won resources	tonnes	227,758.8	261,922.7
Earthworks	Site won soil/ muck shift	General soil	tonnes	81,378.0	93,584.7
	Geotextiles	Polypropylene geotextile / matting	m^2	85,700.0	98,555.0
Fencing, Barriers and Road Restraint Systems	Fence	Timber rail fence (all types, includes posts)	metres	13,044.2	15,000.8
	Noise Barriers	Timber barrier 3m	metres	2,573.9	2,960.0
	Road Restraint System/ Safety Barrier	Steel RRS barrier single sided	metres	5,408.3	6,219.5
		Pre-cast concrete step barrier	metres	2,751.0	3,163.0
		Steel RRS terminals	metres	677.6	779.2

Scheme element	Material - item	Material - type	Units	Quantity	Quantity with 15% contingency applied
Drainage	Plastic pipework (high density polyethylene (HDPE))	150mm diameter	metres	3,661.0	4,210.2
		225mm diameter	metres	7,178.0	8,254.7
		300mm diameter	metres	3,298.0	3,792.7
		375mm diameter	metres	1,595.0	1,834.3
		450mm diameter	metres	1,606.0	1,846.9
		525mm diameter	metres	412.0	473.8
		600mm diameter	metres	471.0	541.7
		675mm diameter	metres	1,022.0	1,175.3
		750mm diameter	metres	1,520.0	1,748.0
		825mm diameter	metres	69.0	79.4
		900mm diameter	metres	1247.0	1434.1
	Precast concrete circular pipework	1200mm diameter	metres	766.0	880.9
	Precast concrete manholes	900mm diameter, up to 3m depth	no.	3.0	3.5
		1050mm diameter, up to 3m depth	no.	77.0	88.6
		1050mm diameter, 3m - 6m depth	no.	1.0	1.2
		1200mm diameter, up to 3m depth	no.	124.0	142.6
		1200mm diameter, 3m - 6m depth	no.	2.0	2.3

Scheme element	Material - item	Material - type	Units	Quantity	Quantity with 15% contingency applied
		1350mm diameter, up to 3m depth	no.	62.0	71.3
		1350mm diameter, 3m - 6m depth	no.	3.0	3.5
		1500mm diameter, up to 3m depth	no.	17.0	19.6
		1500mm diameter, 3m - 6m depth	no.	27.0	31.1
		1800mm diameter, up to 3m depth	no.	42.0	48.3
		1800mm diameter, 3m - 6m depth	no.	6.0	6.9
		2100mm diameter, up to 3m depth	no.	10.0	11.5
		2100mm diameter, 3m - 6m depth	no.	8.0	9.2
		3000mm diameter, up to 3m depth	no.	1.0	1.2
		3000mm diameter, 3m - 6m depth	no.	2.0	2.3
	Gullies	Plastic gully pots – polyvinyl chloride (PVC)	no.	400.0	460.0
		Precast concrete gully pots	no.	115.0	132.3
	Slot drain	Precast concrete channel (heavy duty)	metres	674.8	776.0
	Surface water channel	Concrete slipform	metres	2,363.3	2,717.8
	Combined drainage kerbs	Precast units	metres	2,937.7	3,378.4
	Headwalls	Precast Concrete	no.	15.0	17.3

Scheme element	Material - item	Material - type	Units	Quantity	Quantity with 15% contingency applied
	Flow Control Device	-	no.	6.0	6.9
	Damp proof course and impermeable membrane	Polyethylene membrane	m^2	5,671.8	6,522.6
Road Pavements	Kerb	Pre-cast concrete 125x255mm	metres	1,500.0	1,725.0
	Road markings	Thermoplastic road marking	tonnes	20.7	23.8
Street Furniture and Electrical Equipment	Traffic signs	Aluminium	m^2	1764.8	2029.5
		Sign post (length)	m	468.8	539.1
	Variable Message Signs (VMS)	Motorway Signal Mark 4 (MS4) Sign	no.	10.0	11.5
		Motorway Signal Mark 3 (MS3) Sign	no.	4.0	4.6
		Lane signals	no.	10.0	11.5
		AMI (advanced motorway indicator)	no.	42.0	48.3
	Road lighting and columns	Light Emitting Diode (LED) light	no.	316.0	363.4
		Steel columns 10m	no.	53.0	61.0
		Steel columns 12m	no.	178.0	204.7
	Cable	Armoured cable / Power cable	metres	1,506.0	1,731.9
		Miscellaneous cable	metres	30,120.0	34,638.0
	Plastic cable ducting	150mm diameter	metres	39,440.0	45,356.0

Scheme element	Material - item	Material - type	Units	Quantity	Quantity with 15% contingency applied
	Cabinets	Any type	no.	27.0	31.1
	Cameras	Hard shoulder camera and steel pole	no.	11.0	12.7
		Camera unit	no.	11.0	12.7
	Marker Posts/signs	Plastic marker post	no.	72.0	82.8
	Road studs	Any type	no.	4,914.0	5,651.1
	Handrail	Galvanised steel	tonnes	30.0	34.5
Civil Structures and Retaining Walls	Retaining walls	Steel sheet piles	tonnes	908.81	1,045.1
		Gabion wall (stone and wire mesh)	tonnes	5.0	5.8
	Gantries	MS3 Cantilever Gantry	no.	2.0	2.3
		19m Sign/Signal Cantilever	no.	3.0	3.5
		Up to 33m Portal	no.	2.0	2.3
		45m to 57m Portal	no.	2.0	2.3
	Paint	General paint	Litres	16,640.7	19,136.9
	Steelwork	General steel	tonnes	1,839.3	2,115.2
	Pre-cast concrete	General concrete	tonnes	2,253.6	2,591.6

2.3.5 Where unit conversions were required prior to inputting values to the National Highways Carbon Tool, these were undertaken using material densities and conversion factors stated in the National Highways Carbon Tool or from supplier/equivalent product information.

Transport of raw materials

2.3.6 Specific details regarding distances associated with the transportation of raw materials to the construction site were not available at the time of writing. Transport distances of 50km and 300km for locally and nationally sourced materials, respectively, were therefore assumed based on default transport scenarios for materials provided within the Royal Institution of Chartered Surveyors (RICS) professional standards and guidance (RICS, 2017). It was also assumed that all materials would be transported an additional 2.5km following arrival on site (which is an approximated maximum length from traffic entry points to working areas) and that all materials would be delivered by Heavy Goods Vehicle (HGV).

Fuel, electricity and water

2.3.7 Estimates of likely on-site fuel, electricity and water consumption during the construction phase of the Scheme were not available at the time of this assessment. Consumption was therefore estimated based on the recorded fuel consumption for a similar scheme (the A14 Cambridge to Huntingdon improvement scheme), adjusted to account for the relative difference in scale between the two projects i.e., the fuel consumption for the Scheme is conservatively estimated to be equivalent to 25% of that of the A14 Cambridge to Huntingdon improvement scheme.

2.3.8 The data used are summarised in Table 2.3.

Table 2.3 Fuel, energy and water consumption used in GHG assessment

Project element	Resource	Units	Quantity
Site offices	Electricity	kWh	517,627
	Diesel	litres	16,174
Plant	Gas oil (red diesel)	litres	4,651,335
Water used in construction	Mains	litres	250,000,000

Employee transport

2.3.9 Distances travelled by both site-based and office-based employees have been estimated based on the projected number of construction operatives and office-based staff over the entire duration of the construction phase and the following assumptions:

- 100% of employees would travel by car (20% of whom would car share)
- Employees travelling by car would travel 50km in each direction

- Each site-based employee would travel an additional 2.5km within the site to and from their work locations
- When travelling on-site, employees would share a vehicle with four other people

2.3.10 The data used are summarised in Table 2.4.

Table 2.4 Employee transport distances used in GHG assessment

Project element	Mode	Units	Quantity
Employee commuting	Private vehicle (any type)	km	16,083,120

Waste treatment and transportation

2.3.11 The materials quantities and disposal methods used in the estimation of carbon emissions associated with waste treatment and transportation are presented in Table 2.5. These quantities have been derived using the methodology described in Chapter 10: Material Assets and Waste (TR010064/APP/6.1). It should be noted that operational impacts and effects have been scoped out of the Material assets and waste assessment in accordance with the principles of DMRB LA 110. The GHG emissions associated with waste treatment and transport as a result of operational maintenance have therefore been calculated using the construction phase waste treatment and transport emissions, multiplied by the ratio of embodied carbon emissions between the operational and construction phases, respectively.

2.3.12 In the absence of specific information, the transportation distance for waste materials disposed of off-site has been assumed to be 50km, plus 2.5km to account for the transport of waste from working areas to site entry/exit points.

Table 2.5 Information incorporated into the GHG assessment for waste treatment and transport

Material type	Disposal method	Quantity (tonnes (t))	
		Temporary works	Permanent works
Mixed construction & demolition waste	Recycled	-	-
	Landfill	-	-
Plastic	Recycled	63.3	13.1
	Landfill	15.8	3.3
Concrete, brick, tiles and ceramics	Recycled	572.1	5,234.9
	Landfill	30.1	275.5
Wood/timber	Recycled	1,376.7	72.7
	Landfill	153.0	8.1

Material type	Disposal method	Quantity (tonnes (t))	
		Temporary works	Permanent works
Bituminous mixtures	Recycled	3,272.8	3,283.2
	Landfill	172.3	172.8
Mixed metals	Recycled	15.2	658.6
Aggregate and soil exported off-site	Recycled	158,749.1	265,896.7
	Landfill	8,355.2	13,994.6

Operational maintenance

2.3.13 The estimation of GHG emissions associated with operational maintenance activities during the life cycle of the Scheme relied on the materials quantities from the BoQ utilised for the construction phase calculations for permanent works (Table 2.2) and the assumed replacement frequencies for materials in accordance with their expected design life shown in Table 2.6.

2.3.14 These replacement frequencies apply assumptions regarding the likely maintenance programme for the Scheme. The frequencies are guided by experience from other highways schemes.

Table 2.6 Assumed replacement frequencies used to inform estimates of operational maintenance GHG emissions

Type	Assumed replacement frequency (years)	Number of replacements over 60-year appraisal period
Carriageway surface course	10	5
Carriageway binder course	20	2
Carriageway base course	40	1
Carriageway and footway sub-base course	> 60	-
Kerbs and edgings	20	2
Road markings	5	11
Safety barriers	15	3
Structural steel	> 60	-
Timber fence	15	3
Steel fence	15	3
Concrete components	> 60	-
Signage	30	1
Lights	10	5

Type	Assumed replacement frequency (years)	Number of replacements over 60-year appraisal period
Lighting columns	50	1
Armoured cable	> 60	-
Road studs	5	11

2.4 Results

2.4.1 Estimated construction and operational GHG emissions associated with the Scheme are summarised in Table 2.7 by element/source and by material/source type in Table 2.8.

Table 2.7 Estimated construction and operational maintenance GHG emissions by element/source

Element / source	Estimated GHG emissions (tCO_2e)					
	Temporary works		Permanent works		Operational maintenance	
	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport
Raw materials						
Ready mix concrete	53	5	5,607	472	-	-
Reinforcement steel	14	0	2,363	70	-	-
Asphalt	181	34	3,822	709	8,096	1,503
Fill, aggregate and sand	698	1,634	2,488	4,530	-	-
Geotextiles	189	1	237	1	-	-
Fence	24	4	56	13	169	38
Noise barriers	-	-	338	23	1,016	69
Road restraint system/ safety barrier	-	-	1,376	234	4,128	701
Plastic pipework (HDPE)	1	<1	840	20	-	-
Precast concrete circular pipework	-	-	181	73	-	-
Precast concrete manholes	7	2	486	133	-	-
Gullies	2	0	37	4	-	-

Element / source	Estimated GHG emissions (tCO_2e)					
	Temporary works		Permanent works		Operational maintenance	
	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport
Headwalls	2	1	9	5	-	-
Channel & slot drains	20	<1	158	31	-	-
Petrol interceptors and flow control devices	3	<1	9	<1	-	-
Damp proof course and impermeable membrane	-	-	16	<1	-	-
Kerb	2	1	49	22	33	15
Road markings	-	-	136	<1	1,493	3
Traffic signs	15	<1	677	6	677	6
Road lighting and columns	12	<1	252	5	368	6
Variable message signs	-	-	76	1	76	1
Cable	1	<1	30	1	-	-
Plastic cable ducting	3	<1	270	6	-	-
Cabinets	1	<1	17	<1	-	-
Cameras	-	-	39	1	-	-
Marker posts/signs	-	-	<1	<1	<1	<1
Road studs	-	-	1	<1	10	<1

Element / source	Estimated GHG emissions (tCO_2e)					
	Temporary works		Permanent works		Operational maintenance	
	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport
Handrail	-	-	95	2	-	-
Formwork / shuttering	966	15	-	-	-	-
Retaining walls	-	-	2,885	62	-	-
Gantries	-	-	633	14	-	-
Paint	-	-	86	<1	-	-
Steelwork	-	-	3,279	125	-	-
Pre-cast concrete	-	-	316	27	-	-
Fuel, electricity and water						
Site offices, site vehicles and plant energy	-	-	15,924	48	9,523	29
Water	-	-	37	-	22	-
Employee transport						
Employee commuting	-	-	2,745	-	1,642	-
Waste treatment						
Plastic	1	1	<1	<1	1	1
Concrete, brick, tiles and ceramics	1	6	5	57	4	38

Element / source	Estimated GHG emissions (tCO_2e)					
	Temporary works		Permanent works		Operational maintenance	
	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport
Wood/timber	156	16	8	1	98	10
Bituminous mixtures	3	35	3	35	4	42
Mixed metals	<1	<1	14	7	9	4
Aggregate and soil exported off-site	167	1,715	279	2,873	267	2,744

Table 2.8 Estimated construction and operational maintenance GHG emissions by material/source type

Material / source type	Estimated GHG emissions (tCO_2e)					
	Temporary works		Permanent works		Operational maintenance	
	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport
Concrete	64	9	7,763	991	2,869	689
Steel	20	<1	9,963	288	1,514	32
Asphalt and Bitumen	181	34	3,822	709	8,096	1,503
Fill, aggregate and sand	698	1,634	2,489	4,530	-	-
Plastic	218	1	1,533	28	1,503	3
Timber	985	19	395	36	1,185	107

Material / source type	Estimated GHG emissions (tCO_2e)					
	Temporary works		Permanent works		Operational maintenance	
	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport	Embodied carbon / direct emissions	Transport
Aluminium	27	<1	706	6	822	7
Electrical equipment	1	<1	107	2	76	1
Paint	-	-	86	<1	-	-
Energy and Fuel	-	-	15,962	48	9,546	29
Employee transport	-	-	2,745	-	1,642	-
Waste	328	1,773	311	2,973	382	2,838

2.5 Opportunities for reduction

2.5.1 Potential opportunities to further reduce construction and operational GHG emissions are discussed in Section 14.9 of Chapter 14: Climate of the Environmental Statement (TR010064/APP/6.1).

3 Operational energy consumption

3.1 Methodology

3.1.1 This assessment used estimated energy consumption figures and projected electricity emissions factors from the Green Book supplementary guidance for valuation of energy use and greenhouse gas emissions (Department for Energy Security and Net Zero (DESNZ), 2023a) in order to estimate GHG emissions associated with operational phase electricity usage.

3.1.2 Year specific, grid average, commercial/public sector consumption-based emission factors were used. Over the 60-year appraisal period (2029 to 2088), the emission factors range from 0.053kgCO_2e/kWh in the Opening Year to 0.002kgCO_2e/kWh in 2050, reflecting increased decarbonisation of the national grid over time. The emission factors used were held constant from 2050 until 2088, as this is the latest year for which emission factors are currently available.

3.2 Information used and assumptions

3.2.1 The electricity consumption associated with the scheme lighting was provided, based on 320 luminaires using 290W on average for an assumed average operating time of 8 hours per day. This yielded an estimated average consumption of 270,976kWh per year for scheme lighting. The electricity consumption for variable message signage and cameras was estimated as 545,850kWh per year, assuming continuous operation at maximum demand.

3.3 Results

3.3.1 The GHG emissions associated with operational phase electricity consumption are estimated to be 406.8tCO_2e over the 60-year appraisal period.

3.4 Opportunities for reduction

3.4.1 The Scheme would use LED lights, which have greater energy efficiency than conventional streetlights and are dimmable, therefore minimising GHG emissions. The GHG emissions associated with operational phase energy consumption would be further reduced by using a Central Management System (CMS) to actively control lighting levels.

3.4.2 The installation and use of renewable energy sources, such as solar panels linked to lighting or signage, could be considered to further reduce operational electricity emissions. National Highways' Net Zero Plan (National Highways, 2021) commits to developing a plan to deploy solar panels on the Strategic Road Network (SRN), implementing the first pilot site by 2024. National Highways aims to generate 10% of its energy from renewable sources on or near to their sites by 2030, subject to suitable site availability.

4 Construction and operational road users

4.1 Methodology

4.1.1 DMRB LA 114 states that '*GHG emissions calculation for the project life cycle shall be completed using an industry recognised carbon calculation tool(s) in accordance with the Overseeing Organisation requirements.*' No further guidance is, however, provided on which tools should be used to estimate road user GHG emissions.

4.1.2 For the purposes of this assessment, road user GHG emissions have been estimated for the construction and operation phase using the speed band emission factors contained within Version 9 of the DMRB Screening Method spreadsheet (National Highways, 2022b). which are derived from the latest version of Defra's Emissions Factors Toolkit v11.0 (Defra, 2021).

4.2 Information used and assumptions

4.2.1 The study area for the appraisal of road user GHG emissions comprises the area of the traffic model that is deemed by the competent expert for traffic to be reliable for environmental assessment (as shown on Figure 14.1: Study Area for Operational Road User Greenhouse Gas Emissions of the Environmental Statement Figures (TR010064/APP/6.2)). The study area includes separate traffic networks for the Opening Year (2029) and Design Year (2044) Do-Minimum (DM) and Do-Something (DS) scenarios. The traffic networks for the modelled Construction Years (2025 to 2029) are based on the Opening Year DM network.

4.2.2 For each road link within the reliable area of the traffic model, the following data were applied:

- Total Annual Average Daily Traffic (AADT) flow
- Annual average daily percentage of Heavy Duty Vehicles (HDVs)
- Annual average daily vehicle speed band

4.2.3 Further information on the traffic modelling is provided in the Transport Assessment (TR010064/APP/7.4).

4.2.4 The Scheme would take over three years to construct, with mobilisation to the site in Q4 2025 and demobilisation in Q2 2029, as described in Section 2.6 of Chapter 2: The Scheme of the Environmental Statement (TR010064/APP/6.1). Construction phase road user emissions were therefore calculated over each calendar year (2025 – 2029) of the construction period and then factored to reflect the duration of construction works within each calendar year, before being distributed over the relevant Carbon Budget periods.

4.2.5 Operational road user emissions were estimated over a 60-year appraisal period and distributed over the relevant Carbon Budget periods. In order to do this, road user GHG emissions were calculated for the Opening Year (2029), Design Year (2044) and Future Year (2061). Emissions between the Opening Year, Design Year and Future Year were linearly interpolated, whilst emissions beyond the Future Year to the end of the 60-year appraisal period were assumed to remain constant.

4.2.6 To understand the potential impact of the Transport Decarbonisation Plan (TDP) (Department for Transport (DfT), 2021) on the magnitude of operational road user emissions, two sensitivity tests have been undertaken based on the 'upper' and 'lower' bounds of the projected rate of improvement in road user GHG emissions shown in Figure 2 of the TDP, the results of which are presented in Table 4.3.

4.3 Results

4.3.1 Estimated road user GHG emissions for each construction year DM and DS scenario, and the net emissions for the full construction period and over each relevant carbon budget period, are shown in Table 4.1.

Table 4.1 Estimated construction period road user GHG emissions (tCO_2e)

Year/period	Estimated road user GHG emissions (tCO_2e)		
	DM	DS	Net change
2025 (Q4) [a]	127,960	127,973	13
2026	504,228	501,275	-2,953
2027	496,228	493,226	-3,003
2028	488,150	483,197	-4,953
2029 (Q1 – Q2) [b]	239,951	238,933	-1,018
Construction period (Q4 2025 – Q2 2029)	1,856,516	1,844,603	-11,913
4th Carbon Budget period (2023 – 2027)	1,128,415	1,122,473	-5,942
5th Carbon Budget period (2028 – 2032)	728,100	722,129	-5,971

[a] Estimated annual emissions for the year 2025 have been multiplied by a factor of 0.25 to reflect emissions which would occur in Q4 of 2025, when construction activities are to be undertaken.

[b] Estimated annual emissions for the year 2029 have been multiplied by a factor of 0.5 to reflect emissions which would occur in Q1 to Q2 of 2029, when construction activities are to be undertaken.

4.3.2 The construction of the Scheme is estimated to result in a negligible (<1 %) reduction in total road user GHG emissions within the study area over the five calendar years during which construction activities would be undertaken. The largest reduction in emissions occurs in 2028 with a reduction of -4,953tCO_2e between the DM and DS scenario, equivalent to a reduction of 1% relative to the road user GHG emissions in the DM scenario of 488,150tCO_2e. There is a negligible increase in emissions in the first Construction Year (2025) of 13tCO_2e (<0.1%).

4.3.3 The overall reduction in road user GHG emissions within the study area during the construction phase is attributable to the redistribution of traffic and reduced speed limits (from 70mph to 50mph).

4.3.4 Estimated road user GHG emissions during the operational phase for the Base Year, Opening Year, Design Year and Future Year under the DM and DS scenarios, and the net emissions for the 60-year appraisal and distributed over relevant carbon budget periods, are shown in Table 4.2.

Table 4.2 Estimated operational road user GHG emissions (tCO_2e)

Year/period	Estimated road user GHG emissions (tCO_2e)		
	Baseline / DM	DS	Net change
2019	482,858	-	-
2029	479,901	484,228	4,327
2044	366,479	368,640	2,161
2061	358,240	360,318	2,078
60-year appraisal period (2029 – 2088)	22,599,511	22,743,511	144,000
5th Carbon Budget period (2028 – 2032)	1,874,237	1,890,678	16,441
6th Carbon Budget period (2033 – 2037)	2,172,663	2,189,965	17,302
All carbon budget periods	4,046,901	4,080,644	33,743

4.3.5 The Scheme is estimated to result in an overall increase in operational road user GHG emissions within the study area, with increases in GHG emissions of 4,327tCO_2e, 2,161tCO_2e and 2,078tCO_2e in the Opening Year (2029), Design Year (2044) and Future Year (2061), respectively. Relative to the relevant DM scenario, the increase in emissions with the Scheme is equivalent to a 0.9%, 0.6% and 0.6% increase in road user GHG emissions in the study area in the Opening Year, Design Year and Future Year, respectively. These increases in emissions are primarily associated with an increase in vehicle kilometres travelled within the study area between the DM and DS scenarios.

4.3.6 Between the Opening and the Design Years, operational road user GHG emissions for the DM and DS scenarios within the study area considered are estimated to decrease by approximately 24%, despite the total vehicle kilometres travelled increasing by 11% in both scenarios. This illustrates the overriding influence government policy (e.g. the future ban on the sales of petrol and diesel cars and light duty vehicles) and the associated increased use of low and zero-emission vehicles and related technological advances is expected to have on future year road user GHG emissions.

4.3.7 Over the 60-year appraisal period, the Scheme is estimated to result in an increase in operational road user GHG emissions of 144,000tCO_2e. Within the 5th and 6th carbon budget reporting periods, the Scheme is estimated to result in an increase in GHG emissions of 16,441tCO_2e and 17,302tCO_2e, respectively. The increase in emissions between the 5th and 6th carbon budget periods arises because the Scheme would be operational for four years of the 5th budget period and the full five years in the 6th budget period.

4.3.8 It should be noted that this assessment is considered likely to be worst case as the estimated operational road user GHG emissions presented in this appendix (estimated using the DMRB Screening Method spreadsheet (National Highways, 2022b) which contains speed band emission factors derived from EFT v11 (Defra, 2021)) do not fully account for the most recent projections for the uptake of electric cars and vans described in the latest version of the DfT TAG data book (DfT, 2023). Nor do they take account of the projected reductions in GHG emissions depicted in Figure 2 of the TDP (DfT, 2021, page 45). The impacts of the TDP are expected to lead to a substantive decrease in GHG emissions from all forms of road transport between now and 2050. As the TDP has been published relatively recently, vehicle composition projections and emission factors have not yet been updated to reflect the emerging policy position described by the TDP. DfT have advised National Highways that a sensitivity test based on the impact of the policy measures set out in TDP can now, however, be undertaken for schemes. The DfT have approved a sensitivity test based on the rate of improvement shown in Figure 2 of the TDP which can be applied to road user GHG emissions calculated for the Scheme assessment.

4.3.9 Table 4.3 presents estimated operational road user GHG emissions, for the TDP sensitivity test (upper and lower bounds), for the Opening Year, Design Year and Future Year under the DM and DS scenarios, and the net emissions for the 60-year appraisal and distributed over relevant carbon budget periods.

Table 4.3 TDP sensitivity test estimated operational road user GHG emissions (tCO_2e)

Year/period	Estimated road user GHG emissions (tCO_2e)					
	DM		DS		Net change	
	Upper	Lower	Upper	Lower	Upper	Lower
2029	452,670	331,682	456,752	334,679	4,083	2,997
2044	94,167	33,829	94,749	34,061	582	232

Year/period	Estimated road user GHG emissions (tCO_2e)					
	DM		DS		Net change	
	Upper	Lower	Upper	Lower	Upper	Lower
2061	29,373	5,951	29,578	6,022	205	71
60-year appraisal period (2029 – 2088)	5,701,978	2,670,547	5,746,155	2,693,508	44,177	22,961
5th Carbon Budget period (2028 – 2032)	1,695,688	1,130,059	1,710,584	1,140,030	14,896	9,971
6th Carbon Budget period (2033 – 2037)	1,503,902	785,036	1,515,962	791,409	12,060	6,373
All carbon budget periods	3,199,590	1,915,095	3,226,546	1,931,439	26,957	16,344

4.3.10 The results in Table 4.3 indicate that the implementation of the TDP will result in substantially lower operational phase road user GHG emissions and changes in operational phase road user GHG emissions than presented in Table 4.2 within both the fifth and sixth carbon budget periods and in future years.

4.4 Opportunities for reduction

No opportunities have been identified to further reduce changes in road user GHG emissions as a result of the Scheme.

5 Land use change, peat and forestry

5.1 Methodology

Construction phase – land use change

5.1.1 The GHG emissions associated with land-use change during the construction phase (i.e. GHG emissions mobilised from the loss of vegetation and soil during construction) were calculated based on carbon stock average estimates by broad habitat provided in the Natural England NERR094 report (Natural England, 2021). The area affected by construction activities (which was assumed to be the Order Limits for the Scheme, excluding areas that are to be undisturbed was divided into different land use types using the UK Habitats Map derived for the biodiversity assessment (see Figure 8.3: UK Habitats Map of the Environmental Statement Figures (TR010064/APP/6.2)) and presented in Figure 14.2: Construction Areas Used for Land Use Change Greenhouse Gas Emissions Calculations of the Environmental Statement Figures (TR010064/APP/6.2). The average carbon stocks in the soil and vegetation based on the current land use, in tonnes of carbon per hectare, were factored by 0.25 and 1.0, respectively, to reflect an assumed 25% loss/emission of carbon from disturbed soil and 100% loss/emission of carbon from vegetation. The factored carbon stocks were then multiplied by the area of each land use type that will potentially be disturbed during construction and then by 3.6667 (the ratio of the molar mass of CO_2 to the atomic mass of carbon) to estimate total CO_2e emissions.

Operational phase – land use change

5.1.2 The GHG emissions associated with operational phase land use change (i.e. the change in GHG emissions that would occur on an ongoing basis due to changing existing land uses to highways infrastructure, for example) applied net changes in equilibrium soil carbon density from DESNZ's UK Annual National Inventory Report (DESNZ, 2023b). The area of permanent land use associated with the Scheme was divided into different land use types using the UK Habitats Map (see Figure 8.3: UK Habitats Map of the Environmental Statement Figures (TR010064/APP/6.2)) and presented in Figure 14.3: Operational Areas Used for Land Use Change Greenhouse Gas Emissions Calculations of the Environmental Statement Figures (TR010064/APP/6.2). The areas corresponding to each land use type with the Scheme in place were derived from planting schedules. The area occupied by each initial land use type was then multiplied by the reduction in equilibrium soil carbon density for each land use, assuming a proportionate change in land use to each land use type, and then by 3.6667 to estimate total CO_2e emissions.

Construction phase – peaty soil excavation

5.1.3 The GHG emissions associated with the excavation of peaty soil utilised the volume of peat arisings (18,221m^3) provided by the highways and design team for the Scheme. The average carbon density of the peat soils was taken to be 47kg of carbon per cubic metre of peat, based on Cannell *et al.* (1993). The volume of excavated peaty soil was multiplied by the average carbon density and then by 3.667 to estimate the total CO_2e emissions. The calculation assumed that the full carbon content of the peaty soil would be lost/emitted when the soil is excavated.

Construction and operational phase – forestry

5.1.4 Changes in carbon sequestration (i.e. the removal of CO_2 from the atmosphere by vegetation) as a result of changes in forestry associated with the Scheme were estimated using the Woodland Carbon Code's Carbon Calculation Spreadsheet (Woodland Carbon Code, 2021). The tool allows the amount of carbon sequestered by woodland (in tonnes CO_2e) to be estimated over a 100-year period, accounting for differences in the rate of carbon sequestration over time as tree species mature. Carbon sequestration was estimated for the DM and DS scenarios respectively, based on the area of different tree species present, tree spacing and yield class. The outputs of these calculations were combined to estimate the net change in carbon sequestration as a result of the Scheme.

5.1.5 The areas of each tree species used in these calculations are shown in Table 5.1. It should be noted that these data should be considered indicative as the exact quantities of different types of tree species which are currently present, and which will be planted in future, are not known. Assumptions have therefore been made about the existing mix of tree species on-site and those which will be planted within the Scheme extents (i.e. by assuming the existing distribution of species is similar to that in the planting schedule).

Table 5.1 Areas of woodland used in Woodland Carbon Code calculations

Tree species	Area of woodland (ha)		
	DM	DS (retained)	DS (new planting)
Alder	1.8	0.9	0.4
Hawthorn	2.3	1.1	1.2
Hazel	2.3	1.1	0.9
Holly	<0.1	<0.1	0.3
Pedunculate oak	2.0	1.0	0.4
Scots pine	<0.1	0.0	0.3
Silver Birch	2.7	1.4	0.5
Bird Cherry	1.5	0.8	0.6

Tree species	Area of woodland (ha)		
	DM	DS (retained)	DS (new planting)
Blackthorn	1.5	0.8	0.9
Rowan	1.1	0.5	0.2
Total	**15.2**	**7.6**	**5.6**

5.2 Information used and assumptions

Land use change

5.2.1 The land use types for the construction and operational phase assessments were derived from the habitat codes provided in the UK Habitat maps derived for the biodiversity assessment (see Figure 8.3: UK Habitats Map of the Environmental Statement Figures (TR010064/APP/6.2)). Table 5.2 shows the land use types applied in the construction and operational stage calculations. Figure 14.2: Construction Areas Used for Land Use Change Greenhouse Gas Emissions Calculations and Figure 14.3: Operational Areas Used for Land Use Change Greenhouse Gas Emissions Calculations of the Environmental Statement Figures (TR010064/APP/6.2) show the study area and spatial coverage of the land use types used for construction and operation respectively.

Table 5.2 Land use categories applied in the GHG assessment

Habitat code and Habitat Type	Construction stage land use category	Operation stage land use category
w1g - Other woodland; broadleaved	100 year mixed native broadleaved woodland on mineral soil (to 1m)	Forestland
u1d - Suburban/ mosaic of developed/natural surface e.g. housing and gardens in suburban areas	Urban	Settlements
g4 - Modified grassland	Arable/cultivated land	Grassland
u1b - Developed land; sealed surface	Urban	Settlements
r1a - Eutrophic standing waters	Water	Water
h3h - Mixed scrub	Upland and lowland heathland	Forestland
h3f - Hawthorn scrub	Upland and lowland heathland	Forestland
w1f - Lowland mixed deciduous woodland	100 year mixed native broadleaved woodland on mineral soil (to 1m)	Forestland
g3c - Other neutral grassland	Neutral grassland	Grassland

Habitat code and Habitat Type	Construction stage land use category	Operation stage land use category
h3 - Dense scrub	Upland and lowland heathland	Forestland
h3d - Bramble scrub	Upland and lowland heathland	Forestland
c1d - Non-cereal crops	Arable/cultivated land	Cropland
w2c - Other coniferous woodland	100 year mixed native broadleaved woodland on mineral soil (to 1m)	Forestland
r2b - Other rivers and streams	Water	Water
w1g7 – Other broadleaved woodland types	100 year mixed native broadleaved woodland on mineral soil (to 1m)	Forestland
r1a – Eutrophic standing waters	Water	Water
u1 - Built-up areas and gardens	Urban	Settlements
w1f7 - Other lowland mixed deciduous woodland	100 year mixed native broadleaved woodland on mineral soil (to 1m)	Forestland
u1c – Artificial unvegetated, unsealed surface	Urban	Urban

5.2.2 The construction phase land use change GHG emission calculations assumed that an area of approximately 46.8ha would be disturbed as a result of construction. This is based on the fact that there are some areas (approximately 39.2ha) within the Order Limits where soil and vegetation would not be disturbed, as indicated by the Environmental Masterplan (Figure 2.3 of the Environmental Statement Figures (TR010064/APP/6.2)).

5.2.3 The construction phase GHG calculations assumed that the disturbance of topsoil led to a 25% loss of the carbon stock in the soil (i.e. emitted as CO_2 to the atmosphere) and removal of the existing vegetation led to a 100% loss in carbon stock. The Natural England average carbon stock estimates for soil and vegetation, applied in the calculation of CO_2 emissions during the construction phase, are shown in Table 5.3 (Natural England, 2021).

Table 5.3 Natural England average carbon stock estimates in soil and vegetation per habitat (Natural England, 2021)

Broad habitat type	Carbon stock in soils (t C ha^{-1})	Carbon stock in vegetation (t C ha^{-1})
100 year mixed native broadleaved woodland on mineral soil (to 1m)	151	203

Broad habitat type	Carbon stock in soils (t C ha^{-1})	Carbon stock in vegetation (t C ha^{-1})
100 year mixed native broadleaved woodland (to 15cm soil depth)	0	0
30 year mixed native broadleaved woodland on mineral soil (to 1m)	151	114
30 year mixed native broadleaved woodland (to 15cm soil depth)	0	0
Minimal/ unmanaged hedgerows	99	46
Traditional orchards	74	21
Upland and lowland heathland	94	6
Acid grassland	87	-
Calcareous grassland	69	-
Neutral grassland	60	-
Arable/cultivated land	120	-
Improved grassland	130	-
Urban	0	0
Water	0	0

5.2.4 The study area for the operational phase land use change GHG emission calculations was based on the area of permanent land use, which was deemed to be approximately 71ha. The weighted average change in equilibrium soil carbon density (t ha^{-1}) to 1m deep for changes between different land types in England (DESNZ, 2023b) are shown in Table 5.4. The greatest carbon emission is expected from the near surface layer (i.e. up to 1m deep). For these calculations, all land types within the area of permanent construction were assumed to be converted to 'settlements', 'forestland', 'grassland' or 'cropland' according to the relative proportions of each land use type with the Scheme in place.

5.2.5 For a change in land use type to 'settlements', for example, the timescale range for the reductions in equilibrium soil density set out in Table 5.4 is 50 to 150 years (DESNZ, 2023b). Taking a largely conservative approach, the values in Table 5.4 are therefore considered to be representative of the change which would occur over the 60-year appraisal period of the Scheme. The change in land use from forestland, grassland and cropland to settlements was therefore associated with a carbon emission of 79t ha^{-1}, 73t ha^{-1} and 50t ha^{-1}, respectively over the operational phase of the Scheme.

Table 5.4 Weighted average change in equilibrium soil carbon density (t ha^{-1}) to 1m deep for changes between different land types in England (DESNZ, 2023b)

Change in equilibrium soil carbon density (t ha^{-1})	Initial land use			
Final land use	**Forestland**	**Grassland**	**Cropland**	**Settlements**
Forestland	0	5	30	79
Grassland	-5	0	24	75
Cropland	-30	-24	0	49
Settlements	-79	-73	-50	0

5.3 Results

5.3.1 The construction phase GHG emissions associated with changes in land use, peaty soil excavation and forestry as a result of the Scheme are estimated to be 9,034tCO_2e, 3,140tCO_2e and 266tCO_2e, respectively.

5.3.2 The operational phase GHG emissions associated with changes in land use and forestry over the 60-year appraisal period are estimated to be -566tCO_2e and -962tCO_2e (i.e. a net benefit), respectively.

5.4 Opportunities for reduction

5.4.1 Within this assessment, a worst-case approach has been undertaken whereby it is assumed that all land affected by construction activities within the Order Limits will be disturbed and all existing vegetation in these areas lost as a result of the construction of the Scheme. Actions taken to minimise the area of land disturbed and amount of existing vegetation removed during construction activities will, however, reduce GHG emissions associated with land use change.

Acronyms and initialisms

Acronym or initialism	Term
AADT	Annual Average Daily Traffic
BoQ	Bill of Quantities
CH_4	Methane
CMS	Central Management System
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
Defra	Department for Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero
DfT	Department for Transport
DM	Do-Minimum scenario
DMRB	Design Manual for Roads and Bridges
DS	Do-Something scenario
EFT v11	Emission Factors Toolkit Version 11.0
GHG	Greenhouse gas
GWP	Global-warming potential
HDPE	High Density Polyethylene
HDV	Heavy Duty Vehicle
HFCs	Hydrofluorocarbons
HGV	Heavy Goods Vehicle
km	Kilometres
kWh	Kilowatt hours
LED	Light emitting diode
MS3	Motorway Signal Mark 3
MS4	Motorway Signal Mark 4
N_2O	Nitrous oxide
NF_3	Nitrogen trifluoride
PAS	Publicly Available Specification
PFCs	Perfluorocarbons

Acronym or initialism	Term
PVC	Polyvinyl chloride
RICS	Royal Institution of Chartered Surveyors
SF_6	Sulphur hexafluoride
SRN	Strategic Road Network
t	Tonnes
tCO_2e	Tonnes of carbon dioxide equivalent
TDP	Transport Decarbonisation Plan
UK	United Kingdom
VMS	Variable Message Signs

Glossary

Term	Definition
Carbon budgets	A carbon budget, defined in accordance with the Climate Change Act 2008, places a restriction on the total amount of greenhouse gases the UK can emit over a defined five-year period.
Carbon dioxide equivalent (CO_2e)	Carbon dioxide equivalent (abbreviated as CO_2e) is a metric used to compare the emissions of various greenhouse gases, based on their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of CO_2 with the same GWP. For example, the GWP for methane (CH_4) is 25, and for nitrous oxide (N_2O) it is 298. This means that an emission of 1 tonne of CH_4 is equivalent to an emission of 25 tonnes of CO_2 and an emission of 1 tonne of N_2O is equivalent to 298 tonnes of CO_2.
Carbon emissions	Shorthand for emissions of any of the seven GHGs that contribute to climate change under the Kyoto Protocol, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3)
Climate	Long-term weather conditions prevailing over a region.
DM	A future year scenario including other committed developments and infrastructure schemes, but not the Scheme.
DS	A future year scenario including other committed developments and infrastructure schemes together with the Scheme.
Embodied carbon	Carbon (GHG) emissions associated with energy consumption and chemical processes during the extraction, transport and/or manufacture of construction materials or products.

Term	Definition
Greenhouse gases (GHGs)	A gaseous compound that absorbs infrared radiation and traps heat in the atmosphere. Greenhouse gases are usually expressed in terms of carbon dioxide equivalent (CO_2e).
Life cycle stage	PAS 2080:2023 a modular approach for the quantification of infrastructure related GHG emissions over a number of stages over the 'life cycle' of a project, namely 'before use (A)', 'use (B)' and 'end of life (C)'. These stages are further disaggregated into modules (e.g. product stage (A1–A3) and construction process stage (A4–A5)).
Net zero	Net zero means any emissions would be balanced by schemes to offset an equivalent amount of greenhouse gases from the atmosphere, such as planting trees or using technology like carbon capture and storage.
PAS 2080	PAS 2080:2023 'Carbon Management in Buildings and Infrastructure' specifies requirements for the management of whole-life carbon in buildings and infrastructure.

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