NSW GOVERNMENT
Transport
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Services

Foxground and Berry bypass

Princes Highway upgrade

Volume 2 – Appendix O

Greenhouse gas and climate change

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Appendix O: Detailed GHG assessment results, GHG emissions activity data and calculation methodology

Detailed GHG assessment results

Table O-1 gives the Greenhouse gas (GHG) assessment results for the GHG emissions estimated to occur during construction of the project, reported according to Scope 1, Scope 2, Scope 3 and total emissions.

Table O-1: Detailed construction GHG emissions assessment results

Emission source category	Emission source	Quantity	Unit	GHG emissions (t CO_2-e)				
				Scope 1	Scope 2	Scope 3	Total	% Total
Fuel - diesel	Mobile equipment	17,315.1	kilolitres (kL)	46,658.4	0.0	3,542.3	**50,200.7**	**50.41**
	Transport - site vehicles	489.6	kilolitres (kL)	1,319.3	0.0	100.2	**1,419.5**	**1.43**
	Transport - material delivery	463.1	kilolitres (kL)	0.0	0.0	1,342.8	**1,342.8**	**1.35**
	Transport - equipment delivery	1.5	kilolitres (kL)	0.0	0.0	4.2	**4.2**	**0.00**
	Transport - earthworks	364.0	kilolitres (kL)	980.9	0.0	74.5	**1,055.4**	**1.06**
	Transport - spoil removal	191.1	kilolitres (kL)	0.0	0.0	554.0	**554.0**	**0.56**
	Transport - vegetation removal	4.9	kilolitres (kL)	0.0	0.0	14.1	**14.1**	**0.01**
Materials	Pavement - aggregate	214,414.0	tonnes (t)	0.0	0.0	857.7	**857.7**	**0.86**
	Concrete	107,886.6	tonnes (t)	0.0	0.0	13,701.6	**13,701.6**	**13.76**
	Pavement - cement	6,304.2	tonnes (t)	0.0	0.0	5,169.4	**5,169.4**	**5.19**
	Sand	45,740.0	tonnes (t)	0.0	0.0	137.2	**137.2**	**0.14**
	Structural Steel	14,726.3	tonnes (t)	0.0	0.0	15,462.6	**15,462.6**	**15.53**
	Pavement - hot mix asphalt	113,032.8	tonnes (t)	0.0	0.0	6,555.9	**6,555.9**	**6.58**
	Pavement - bitumen	525.2	tonnes (t)	0.0	0.0	330.8	**330.8**	**0.33**
	Pavement - lime	2,547.7	tonnes (t)	0.0	0.0	2,777.0	**2,777.0**	**2.79**
	Gravel	600.0	tonnes (t)	0.0	0.0	2.6	**2.6**	**0.00**
Totals				**48,958.6**	**0.0**	**50,626.9**	**99,585.5**	**100**
% Total				**49.2**	**0.0**	**50.8**	**100.0**	

Table O-2 gives the GHG emissions associated with the use of electricity in site offices and the clearing of vegetation. These emissions sources were removed from the GHG assessment boundary, based on materiality criteria. Table 3.3 in the Supporting Document for the *Greenhouse Gas Assessment Workbook for Road projects* (the Workbook) (Transport Authorities Greenhouse Group (TAGG), 2011) lists vegetation removal as an emission source that may be insignificant and removed from the GHG assessment boundary on a project specific basis. Additionally, Table 3.3 of the Supporting document recommends excluding the use of electricity in site offices from the GHG assessment boundary, as it would generally be insignificant to the assessment. The GHG emissions associated with these activities are listed below for information purposes, however they do not form part of the GHG assessment boundary of GHG emissions associated with construction of the project, as when calculated, these emission source categories represented less than five per cent of the GHG inventory.

Table O-2: Construction GHG emissions assessment results – immaterial emissions

Emission source category	Emission source	Quantity	Unit	GHG emissions (t CO_2-e)			
				Scope 1	Scope 2	Scope 3	Total
Electricity	Site offices	87,600	kWh	0.0	78.0	14.9	**92.9**
Land use Change	Vegetation removal - undisturbed	26.0	hectares (ha)	12.7	0.0	0.0	**12.7**
Land use Change	Vegetation removal - disturbed	86.4	hectares (ha)	7.8	0.0	0.0	**7.8**

Greenhouse gas emissions activity data

This section details the quantification of the GHG emission source data used for estimating the GHG emissions associated with construction, operation and maintenance of the project, including the sources of information used and assumptions made.

Table O-3 to **Table O-7** details the GHG emission source data used in the GHG assessment, including assumptions and information sources.

Table O-3: GHG emission source data used in the GHG assessment

Emission source category	Emission source	Quantity	Unit	Source	Assumptions
Fuel – diesel (construction)	Mobile equipment	17,315.1	kL	Equipment types and hours of operation: Cost Estimate (Risk Summary Rev D dated January 2012) Equipment Rate of Fuel Consumption: Workbook and California EPA OFFROAD inventory database	Refer to **Table O-3** below: Emission Source Data: Diesel Fuel Use
	Transport - site vehicles	489.6	kL	Workbook Table 5.3 Default Quantity Factors - Site offices and vehicles	Large project with 4 sites along road, each with 10 hilux utes, all diesel operated, over 36 construction months
	Transport - material delivery	463.1	kL	Vehicle capacity, haulage quantity, number of trips: FBB Traffic and Transport Assessment November 2011	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - equipment delivery	1.5	kL	Equipment Types: Cost Estimate (Risk Summary Rev D dated January 2012)	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - earthworks	364.0	kL	Vehicle capacity : FBB Traffic and Transport Assessment November 2011 Haulage Quantity: Cost Estimate (Risk Summary Rev D dated January 2012) and AECOM Quantity estimate update_120706_pavement and earthworks	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - spoil removal	191.1	kL	Excess earthworks material: Cost Estimate (Risk Summary Rev D dated January 2012) and AECOM Quantity estimate update_120706_pavement and earthworks	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
	Transport - vegetation removal	4.9	kL	Vegetation removal quantity: email from Brett Morrisey, Biosis Research, dated 12 January 2012	Refer to **Table O-4** below: Emission Source Data: Transport Fuel Use
Electricity consumption	Site offices	87,600.0	kWh	-	Five houses used as site offices, with an average electricity consumption of 7300kWh (NSW Government Power Use in NSW accessed 19/01/2012 http://www.savepower.nsw.gov.au/get-the-facts/power-use-in-nsw.aspx), over a period of 2.4 years per house.

Emission source category	Emission source	Quantity	Unit	Source	Assumptions
Vegetation Removal	Vegetation removal - undisturbed	26.0	ha	Vegetation removal quantity: email from Brett Morrisey, Biosis Research, dated 12 January 2012	-
Vegetation Removal	Vegetation removal - disturbed	86.4	ha	Vegetation removal quantity: email from Brett Morrisey, Biosis Research, dated 12 January 2012	-
Materials usage - construction	Pavement - aggregate	214,414.0	t	Cost Estimate (Risk Summary Rev D dated January 2012) and AECOM Quantity estimate update_120706_pavement and earthworks Bridge steel and concrete quantities sourced from AECOM	Refer to **Table O-5** below: Emission Source Data: Materials
	Concrete	107,886.6	t		
	Pavement - cement	6,304.2	t		
	Sand	45,740.0	t		
	Structural steel	14,726.3	t		
	Pavement - hot mix asphalt	113,032.8	t		
	Pavement - bitumen	525.2	t		
	Pavement - lime	2,547.7	t		
	Gravel	600.0	t		
Electricity consumption	Street lighting	59,130.0	kWh	Wattage of lamps: Workbook, Table 6.3, for freeway ramps and arterial roads Number of lights: AECOM design	250 Watt lamps 54 lights 12 hours of operation per day, 365 days per year
	Variable message sign	10,512.0	kWh	Wattage of variable message sign: Workbook, Table 6.3 Number of variable message signs: Cost Estimate (Risk Summary Rev D dated January 2012)	1200 Watt 1 variable message sign 24 hours of operation per day, 365 days per year
Fuel combustion – diesel – operation and maintenance	Mobile equipment	2,576.2	kL	Workbook default quantity factor for maintenance activities Table 7.3	One major rehabilitation with top 150mm replaced - once every 50 years and 5% of road replaced every 50 years for patching/repair (TAGG, 2011)
	Transport - material delivery	516.5	kL	-	10 tonne Articulated truck, with fuel efficiency of 54.6 L/100km, average return trip distance of 70km.

Emission source category	Emission source	Quantity	Unit	Source	Assumptions
Materials usage - maintenance	Pavement - aggregate	38,368.9	t	Based on construction material quantities	One major rehabilitation with top 150mm replaced - once every 50 years and 5% of road replaced every 50 years for patching/repair (TAGG 2011)
	Pavement - cement	315.2	t		
	Pavement - hot mix asphalt	95,773.0	t		
	Pavement - bitumen	551.4	t		
	Pavement - lime	127.4	t		

Table O-4: Emission source data: diesel fuel use

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
SMZ layer	70,000.0	m^3	140 grader	Grader	1,795.1	hr	6.0	5.1	Months	30.5	Class 110, Medium application, 300 hours/month (TAGG 2011)
Cut to fill	1,000,000.0	m^3	14G grader		16,666.4	hr	55.6	5.1	Months	283.3	
SMZ layer	70,000.0	m^3	14G grader		2,333.2	hr	7.8	5.1	Months	39.7	
Surcharge loading	30,000.0	m^3	14G grader		429	hr	1.4	5.1	Months	7.3	
Rip floor, trim and compact	116,125.0	m^2	Grader		774	hr	2.6	5.1	Months	13.2	
250mm DGS 40	53,983.7	m^2	Grader		540	hr	1.8	5.1	Months	9.2	
250mm DGS 40	53,983.7	m^2	Grader		416	hr	1.4	5.1	Months	7.1	
150mm DGB 20	51,413.6	m^2	Grader		386	hr	1.3	5.1	Months	6.6	
150mm DGB 20	51,413.6	m^2	Grader		428	hr	1.4	5.1	Months	7.3	
275mm heavily bound base	262,577.9	m^2	Grader		4814	hr	16.0	5.1	Months	81.8	
275mm heavily bound base	262,577.9	m^2	Grader		2387	hr	8.0	5.1	Months	40.6	
300mm DGB 20	10,500.0	m^2	Grader		79	hr	0.3	5.1	Months	1.3	
300mm DGB 20	10,500.0	m^2	Grader		88	hr	0.3	5.1	Months	1.5	
Cut to fill	1,000,000.0	m^3	25t artic dumps	-	149,999.7	hr		0.06	hr	9000.0	Assumed average rate of fuel consumption of 60L/hr
Cut to fill	1,000,000.0	m^3	825 compactor		16,666.4	hr		0.06	hr	1000.0	Assumed average rate of fuel consumption of 60L/hr
Surcharge loading	30,000.0	m^3	825 compactor		429	hr	-	0.06	hr	25.7	Assumed average rate of fuel consumption of 60L/hr

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Hay bales	1,368.0	No	Backhoe	Backhoe loader (backhoe)	45.6	hr	0.2	3	Months	0.5	4WD Class 2 to Class 5, medium application, 300 hours/month (TAGG 2011)
Subsoil drains	45,600.0	m	Backhoe		4560	hr	15.2	3	Months	45.6	
500mm drainage layer	20,000.0	m^2	CA30 roller	Vibrating Roller (asphalt, soil)	167	hr	0.6	4.8	Months	2.7	Class VR35, Medium application, 300 hours/month (TAGG 2011)
SMZ layer	70,000.0	m^3	CA30 roller 50%		1,167.1	hr	3.9	4.8	Months	18.7	
Cut to fill	1,000,000.0	m^3	CA30 roller dry		8,333.6	hr	27.8	4.8	Months	133.3	
Sediment basins	16.0	No	Roller		600.0	hr	2.0	4.8	Months	9.6	
SMZ layer	70,000.0	m^3	Roller		2,333.2	hr	7.8	4.8	Months	37.3	
SMZ layer	70,000.0	m^3	Roller		1,795.1	hr	6.0	4.8	Months	28.7	
Excavate and dispose on site to Preload area	150,000.0	m^3	Roller		2,999.9	hr	10.0	4.8	Months	48.0	
Rip floor, trim and compact	116,125.0	m^2	Roller		774	hr	2.6	4.8	Months	12.4	
250mm DGS 40	53,983.7	m^2	Roller		539.6	hr	1.8	4.8	Months	8.6	
250mm DGS 40	53,983.7	m^2	Roller		415.5	hr	1.4	4.8	Months	6.6	
150mm DGB 20	51,413.6	m^2	Roller		386	hr	1.3	4.8	Months	6.2	
150mm DGB 20	51,413.6	m^2	Roller		428	hr	1.4	4.8	Months	6.8	
275mm heavily bound base	262,577.9	m^2	Roller		4814	hr	16.0	4.8	Months	77.0	
275mm heavily bound base	262,577.9	m^2	Roller		2387	hr	8.0	4.8	Months	38.2	
300mm DGB 20	10,500.0	m^2	Roller		79	hr	0.3	4.8	Months	1.3	
300mm DGB 20	10,500.0	m^2	Roller		88	hr	0.3	4.8	Months	1.4	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Rock-extra over	103,830.0	m^3	D10150m^3/ hr	Tractor Dozer	277.0	hr	0.9	12.9	Months	11.9	Class 300C (D9 size) Medium application, 300 hours/month (TAGG 2011)
Rock-extra over	103,830.0	m^3	D10 to push		311.0	hr	1.0	12.9	Months	13.4	
Cut to fill	1,000,000.0	m^3	D6 dozer		16,666.4	hr	55.6	12.9	Months	716.7	
Surcharge loading	30,000.0	m^3	D6 dozer		429	hr	1.4	12.9	Months	18.4	
Sediment basins	16.0	No	Dozer @ 40m^3/hr		600.0	hr	2.0	12.9	Months	25.8	
Rip floor, trim and compact	116,125.0	m^2	Dozer D10		774	hr	2.6	12.9	Months	33.3	
Clear and grubb	3.0	ha	Dozer D6		14.0	hr	0.0	12.9	Months	0.6	
Excavate and dispose on site to preload area	150,000.0	m^3	Dozer D6 @ 50m^3/hr		2,999.9	hr	10.0	12.9	Months	129.0	
Clear and grubb	3.0	ha	Dozer D8		10.0	hr	0.0	12.9	Months	0.4	
Remove and stockpile topsoil	108,634.0	m^3	Dozer push up		1,358.0	hr	4.5	12.9	Months	58.4	
Clear and grubb	3.0	ha	Exc + grab	Excavator (digger, trackhoe)	48.0	hr	0.2	5.1	Months	0.8	Crawler class 100, medium application, 300 hours/month (TAGG 2011)
Clear and grubb	3.0	ha	Exc + grab		8.0	hr	0.0	5.1	Months	0.1	
Revetment	12,000.0	m^2	Excavation		3600	m^3	12.0	5.1	Months	61.2	
Transverse RCBC	60.0	m	Excavation		1380	m^3	4.6	5.1	Months	23.5	
Transverse RCBC	10.0	m	Excavation		300	m^3	1.0	5.1	Months	5.1	
Transverse RCBC	80.0	m	Excavation		672	m^3	2.2	5.1	Months	11.4	
Truck cleaning facilities	6.0	No	Excavator		48.0	hr	0.2	5.1	Months	0.8	
Sediment basins	16.0	No	Excavator		600.0	hr	2.0	5.1	Months	10.2	
Headwalls	44.0	No	Excavator		88	hr	0.3	5.1	Months	1.5	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Remove and stockpile topsoil	108,634.0	m^3	Excavator @ 80m^3/hr		1,358.0	hr	4.5	5.1	Months	23.1	
Excavate and dispose on site to Preload area	150,000.0	m^3	Excavator @50m3/hr		2,999.9	hr	10.0	5.1	Months	51.0	
Cut to fill	1,000,000.0	m^3	Excavator PC300 @ 60m^3/hr		16,666.4	hr	55.6	5.1	Months	283.3	
500mm drainage layer	20,000.0	m^2	Loader	Loader - wheeled	167	hr	0.6	4.5	Months	2.5	Class 50WL, Medium application, 300 hours/month (TAGG 2011)
Silt fence	19,950.0	m	Loader/ dozer with rip		456.0	hr	1.5	4.5	Months	6.8	
Remove and stockpile topsoil	108,634.0	m^3	Moxies x 20min hauls		4,074.0	hr	-	0.06	hr	244.4	Assumed average rate of fuel consumption of 60L/hr
Clear and grubb	3.0	ha	S/Plant		32.0	hr	-	0.06	hr	1.9	Assumed average rate of fuel consumption of 60L/hr
Clear and grubb	3.0	ha	S/Plant		40.0	hr	-	0.06	hr	2.4	Assumed average rate of fuel consumption of 60L/hr
Cut to fill	1,000,000.0	m^3	Spotter	Spotter	8,333.6	hr		0.06	hr	500.0	Assumed average rate of fuel consumption of 60L/hr
SMZ layer	70,000.0	m^3	Spotter		2,333.2	hr		0.06	hr	140.0	
500mm drainage layer	20,000.0	m^2	Spotter		167	hr	-	0.06	hr	10.0	
Surcharge loading	30,000.0	m^3	Spotter		429	hr	-	0.06	hr	25.7	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
Truck cleaning facilities	6.0	No	Truck	Truck	48.0	hr	-	0.0995		4.8	Fuel consumption for 'off-highway trucks' sourced from the California EPA OFFROAD inventory database, for 500HP (average) truck
Clear and grubb	3.0	ha	Truck		192.0	hr	-	0.0995	-	19.1	
Clear and grubb	3.0	ha	Truck		32.0	hr	-	0.0995	-	3.2	
Cut to fill	1,175,242.0	m^3	Truck haul		1,175,242.0	m^3	-	-	-	-	Already accounted for
Clear and grubb	3.0	ha	Tub grinder	Tub grinder	48.0	hr	-	0.07	hr	3.4	Fuel consumption for 'chippers/stump grinders' sourced from the California EPA OFFROAD inventory database, for 500HP (average)
Clear and grubb	3.0	ha	Tub grinder		8.0	hr	-	0.07	hr	0.6	
Sediment basins	16.0	No	Water cart	Water cart	600.0	hr	-	0.045	hr	27.0	Fuel consumption for 'hydrant truck' sourced from the California EPA OFFROAD inventory database
Cut to fill	1,000,000.0	m^3	Water cart		66,667.1	hr		0.045	hr	3000.0	
SMZ layer	70,000.0	t	Water cart		2,333.2	hr		0.045	hr	105.0	
SMZ layer	70,000.0	t	Water cart		1,795.1	hr		0.045	hr	80.8	
Excavate and dispose on site to Preload area	150,000.0	m^3	Water cart		2,999.9	hr		0.045	hr	135.0	
Rip floor, trim and compact	116,125.0	m^2	Water cart		774	hr	-	0.045	hr	34.8	
Surcharge loading	30,000.0	m^3	Water cart		857	hr	-	0.045	hr	38.6	
250mm DGS 40	53,983.7	m^2	Water cart		540	hr	-	0.045	hr	24.3	
250mm DGS 40	53,983.7	m^2	Water cart		416	hr	-	0.045	hr	18.7	
150mm DGB 20	51,413.6	m^2	Water cart		386	hr	-	-0.045	hr	17.4	

Emission Activity	Quantity	Unit	Equipment	Equipment Category	Duration of operation	Unit	Months of operation	Rate of fuel use (kL/UOM)	UOM	Quantity of Diesel Used (kL)	Assumptions
150mm DGB 20	51,413.6	m^2	Water cart		428	hr	-	0.045	hr	19.3	
275mm heavily bound base	262,577.9	m^2	Water cart		4814	hr	-	0.045	hr	216.6	
275mm heavily bound base	262,577.9	m^2	Water cart		2387	hr	-	-0.045	hr	107.4	
300mm DGB 20	10,500.0	m^2	Water cart		79	hr	-	0.045	hr	3.6	
300mm DGB 20	10,500.0	m^2	Water cart		88	hr	-	0.045	hr	4.0	
TOTAL										**17,315.1**	kL

Table O-5: Emission source data: transport fuel use

Transport category	Fuel type	Vehicle type	Vehicle load	Unit	Vehicle rate of fuel use* (L/100km)	Average trip distance (km)	Total haulage quantity	Unit	Number of trips	Total distance (km)	Fuel used (kL)	Assumptions/ source
Site vehicles	Diesel	LCV	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	489.6	GHG Assessment Workbook for Road Projects(June 2011) Table 5.3 Default Quantity Factors - Site offices and vehicles, assuming large project with 4 sites along road, each with 10 hilux utes, all diesel operated, over 36 construction months
Material delivery - dry bulk materials	Diesel	Articulated truck	30	m^3	54.6	70	330,000.0	m^3	11,000.0	770,000.0	420.4	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, haulage quantity, number of trips
Material delivery - reinforcing steel	Diesel	Articulated truck	10	tonnes	54.6	70	5,320.0	t	532.0	37,240.0	20.3	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, haulage quantity, number of trips

Transport category	Fuel type	Vehicle type	Vehicle load	Unit	Vehicle rate of fuel use* (L/100km)	Average trip distance (km)	Total haulage quantity	Unit	Number of trips	Total distance (km)	Fuel used (kL)	*Assumptions/ source*
Material delivery - pre-fabricated units	Diesel	Articulated truck	1	unit	54.6	200	205.0	units	205.0	41,000.0	22.4	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, haulage quantity, number of trips
Equipment delivery	Diesel	Articulated truck	1	unit	54.6	70	38.0	units	38.0	2660.0	1.5	One return trip per equipment unit, by articulated truck
Earthworks	Diesel	Articulated truck	30	m^3	54.6	20	1,000,000.0	m3	33,333.3	666,666.7	364.0	*FBB Traffic and Transport Assessment* (AECOM 2012): Vehicle capacity, AECOM Quantity estimate update_120706_pavement and earthworks: haulage quantity
Spoil removal	Diesel	Articulated truck	30	m^3	54.6	70	150,000.0	m3	5,000.0	350,000.0	191.1	AECOM Quantity estimate update_120706_pavement and earthworks: Excess earthworks material
Veg removal	Diesel	Truck	10	tonnes	54.6	70	1270.6	t	127.1	8893.9	4.9	-

Table O-6: Emission source data: materials used in construction

Emission activity	Quantity	Unit	Material	Quantity	Unit
250 mm DGS40	53983.7	m^2	Aggregate	29,960.9	tonnes
150mm DGB20	51413.6	m^2	Aggregate	17,120.7	tonnes
275mm stabilised base	262,577.9	m^2	Aggregate	151,300.4	tonnes
7mm seal	262,577.9	m^2	Aggregate	8,139.9	tonnes
300mm DGB20	10,500.0	m^2	Aggregate	6,993.0	tonnes
300mm selected material zone	243,715.0	m^2	Aggregate	Sourced within project	-
Concrete medians and paths - 120mm DGS 20	2,500.0	m^2	Aggregate	666.0	tonnes
Truck stops - 300mm DGB 20	350.0	m^2	Aggregate	233.1	tonnes
7mm seal	262,577.9	m^2	Bitumen	525.2	tonnes
275mm stabilised base	266,088.0	m^2	Cement	6,304.2	tonnes
Pipework 1200 RCP C16	1,100.0	m	Concrete	701.7	m^3
525mm headwalls	44.0	No	Concrete	9.0	m^3
Noise barriers 4m	6,400.0	m^2	Concrete	83.6	m^3
Pits	518.0	No	Concrete	311.0	m^3
Pits - assume 900x900 type E (up to 525∅)	518.0	No	Concrete	234.2	m^3
Open drains	18,800.0	m	Concrete	780.0	m^3
Open drains	18,800.0	m	Concrete	4,032.0	m^3
Kerbing	14,400.0	m	Concrete	2,289.0	m^3
Kerbing	14,400.0	m	Concrete	566.0	m^3
3/3.0m x 2.4m RCBC - units	60.0	m	Concrete	100.2	m^3
3/3.0m x 2.4m RCBC - base slab 300mm	420.0	m^2	Concrete	126.0	m^3
5 cells @ 2.1h*2.4w RCBC - units	10.0	m	Concrete	64.7	m^3

Emission activity	Quantity	Unit	Material	Quantity	Unit
5 cells @ 2.1h*2.4w RCBC - base slab 250mm	70.0	m^2	Concrete	17.5	m^3
2/2.4m x 1.5m RCBC - units	80.0	m	Concrete	78.3	m^3
2/2.4m x 1.5m RCBC - base slab 250mm	448.0	m^2	Concrete	112.0	m^3
Headwalls	6.0	No	Concrete	6.0	m^3
Bridge B1 (short span<20m, 10.5m wide plank) and Bridge B2 (Medium span <35m, 10.5m wide Super T)	-	m^2	Concrete	29,850.0	m^3
Concrete medians and paths	2,500.0	m^2	Concrete	315.0	m^3
Type F barrier	400.0	m	Concrete	274.8	m^3
Wire rope barrier	21,300.0	m	Concrete	1,446.3	m^3
3m x 3m culvert	100.0	m	Concrete	216.0	m^3
Longitudinal pipework - 525mm RCP (average size) pipe class 3	22,800.0	m	Concrete	2,214.2	m^3
RSS wall (approx 5m height)	1,400.0	m^2	Concrete	280.0	m^3
Truck cleaning facilities	6.0	No	Gravel	600.0	tonnes
50mm AC	48965	m^2	Hot mix asphalt	5,631.0	tonnes
135mm AC20	247,714.6	m^2	Hot mix asphalt	76,915.4	tonnes
50mm AC	240,500.0	m^2	Hot mix asphalt	27,657.5	tonnes
50mm AC Overlay	1,593.0	tonnes	Hot mix asphalt	1,593.0	tonnes
50mm AC	10,000.0	m^2	Hot mix asphalt	1,150.0	tonnes
Truck stops - 100mm AC	86.0	tonnes	Hot mix asphalt	86.0	tonnes
300mmm selected material zone	266,088.0	m^2	Lime	2,547.7	tonnes
Longitudinal pipework - 525mm RCP (average size)	22,800.0	m	Sand	18,240.0	tonnes
Pipework	1,100.0	m	Sand	5,500.0	tonnes
500mm drainage layer	20,000.0	m^2	Sand	22,000.0	tonnes
Guardrail and barriers - Armco Guardrail	8,500.0	m	Steel	198.1	tonnes

Emission activity	Quantity	Unit	Material	Quantity	Unit
pipework 1200 RCP C16	1,100.0	m	Steel	70.2	tonnes
525mm headwalls	44.0	No	Steel	0.9	tonnes
Longitudinal pipework - 525mm RCP (average size) pipe class 3	22,800.0	m	Steel	221.4	tonnes
RSS wall (approx 5m height)	1,400.0	m^2	Steel	28.0	tonnes
3/3.0m x 2.4m RCBC - units	60.0	m	Steel	10.0	tonnes
3/3.0m x 2.4m RCBC - base slab 300mm	420.0	m^2	Steel	12.6	tonnes
5 cells @ 2.1h*2.4w RCBC - units	10.0	m	Steel	6.5	tonnes
5 cells @ 2.1h*2.4w RCBC - base slab 250mm	70.0	m^2	Steel	1.8	tonnes
2/2.4m x 1.5m RCBC - units	80.0	m	Steel	7.8	tonnes
2/2.4m x 1.5m RCBC - base slab 250mm	448.0	m^2	Steel	11.2	tonnes
3m x 3m culvert	100.0	m	steel	21.6	tonnes
Concrete medians and paths - steel mesh	2,500.0	m^2	Steel reinforcement	5.5	tonnes
Type F barrier	400.0	m	Steel reinforcement	5.0	tonnes
Wire rope barrier	21,300.0	m	steel	225.8	tonnes
Bridge B1 (short span<20m, 10.5m wide plank) and Bridge B2 (medium span <35m, 10.5m wide Super T)	-	m^2	Steel structural	13,900.0	tonnes

Table O-7: Emission source data: materials used in maintenance

Pavement type	Pavement area (m^2)	Material	Material component	Thickness (mm)	Component material quantity (tonnes)	Assumption
Pavement Type 1 - local roads	48,965.0	50mm AC wearing course	Hot mix asphalt	50	5,631.0	One major rehabilitation with top 150mm replaced, once every 50 years
Pavement Type 1 - local roads	51,413.6	150 mm DGB20 Base	Aggregate	100	11,413.8	
Pavement Type 2 - flexible	240,500.0	50mm AC wearing course	Hot mix asphalt	50	27,657.5	
Pavement Type 2 - flexible	247,714.6	135mm AC20	Hot mix asphalt	100	56,974.3	
Pavement Type 2 - flexible	262,577.9	2 coat, spray seal	Aggregate	N/A	8139.913768	
Pavement Type 2 - flexible	262,577.9	2 coat, spray seal	Bitumen	N/A	525.155727	
Truck stops - 300mm DGB 20	350.0	300mm DGB 20	Aggregate	150	116.55	
Concrete medians and paths	2,500.0	120mm DGS 20	Aggregate	120	666	
50mm AC wearing course	2,448.3	50mm AC wearing course	Hot mix asphalt	50	281.5	5% of road replaced over 50 year period for patching/repair
150mm DGB20 base	2,570.7	150mm DGB20 Base	Aggregate	150	856.0	
250 mm DGS40 sub-base	2,699.2	250 mm DGS40 sub-base	Aggregate	250	1498.0	
50mm AC wearing course	12,025.0	50mm AC wearing course	Hot mix asphalt	50	1382.9	
135mm AC20	12,385.7	135mm AC20	Hot mix asphalt	135	3845.8	
275mm stabilised base	13,128.9	275mm stabilised base	Cement	275	315.2	
275mm stabilised base	13,128.9	275mm stabilised base	Aggregate	275	7565.0	
300mm selected material zone	13,128.9	300mm selected material zone	Lime	300	127.4	
300mm selected material zone	12,025.0	300mm selected material zone	Aggregate	300	7661.6	

Pavement type	Pavement area (m^2)	Material	Material component	Thickness (mm)	Component material quantity (tonnes)	Assumption
2 coat, spray seal	13,128.9	2 coat, spray seal	Aggregate	N/A	407.0	
2 coat, spray seal	13,128.9	2 coat, spray seal	Bitumen	N/A	26.3	
300mm DGB 20	17.5	300mm DGB 20	Aggregate	300	11.7	
120mm DGS 20	125.0	120mm DGS 20	Aggregate	120	33.3	

GHG calculation methodology

The following steps were taken in estimating the GHG emissions associated with the construction and operation of the project (as per the procedure outlined in **Figure 8-6** of the environmental assessment):

- The GHG emissions relevant to the stages of project construction, operation and maintenance were identified.
- The GHG inventory boundary was determined, which defines the emissions sources to be considered in the assessment and those to be excluded (as given in **Tables 8-1** and **8-2** in the environmental assessment).
- The emissions sources were quantified (as detailed in the section above).
- For the different emissions sources and sinks, emissions factors were established and the emissions calculated. This section provides the methodology used for calculating GHG emissions from fuel use, electricity use, vegetation removal, material use and from the use of the road by traffic post construction.
- Opportunities for mitigation were identified, as detailed in Section 8.5.4 of the environmental assessment.

Fuel

The method used to calculate the Scope 1 GHG emissions from the combustion of liquid fuels, for transport energy purposes is given by the formula below, as given by the *National Greenhouse Accounts* (*NGA) Factors 2011*:

GHG emissions (t CO_2-e) = ((Q x ECF) / 1000) x (EF_{CO2} + EF_{CH4} + EF_{N2O})

Where: Q is the quantity of fuel (in kL).

ECF is the relevant energy content factor (in GJ/kL).

EF_{CO2} is the relevant Carbon dioxide (CO_2) emission factor (in kg $CO_{2\text{-}e}$/GJ).

EF_{CH4} is the relevant Methane (CH_4) emission factor (in kg $CO_{2\text{-}e}$/GJ).

EF_{N2O} is the relevant Nitrous oxide (N_2O) emission factor (in kg $CO_{2\text{-}e}$/GJ).

The method used for calculating the Scope 3 GHG emissions from the combustion of liquid fuels, for transport energy purposes is given by the formula below, as given by the *NGA Factors 2011*:

GHG emissions (t CO_2-e) = (Q x ECF x $EF_{for\ scope\ 3}$) / 1000

Where: Q is the quantity of fuel (in kL).

ECF is the relevant energy content factor (in GJ/kL).

$EF_{for\ scope\ 3}$ is the relevant emission factor (in kg $CO_{2\text{-}e}$/GJ).

The Scope 1 and Scope 3 emission factors for diesel (post 2004 vehicles) are given in **Table O-8**.

Table O-8: Scope 1 and Scope 3 emission factors for diesel (post 2004 vehicles) (Source: NGA Factors 2011 Tables 4 and 38)

Fuel	Energy content factor (GJ per kL)	Scope 1 emission factor (kg CO_2-e/GJ)			Scope 3 emission factor (kg CO_2-e/GJ)	Emissions per unit quantity (t CO2-e per kL)		
		CO_2	CH_4	N_2O		Scope 1	Scope 2	Scope 3
Diesel - transport - post 2004 vehicles	38.6	69.2	0.01	0.6	5.3	2.6947	0	0.2046

Electricity

The method used to calculate the Scope 1 and Scope 3 GHG emissions from the consumption of purchased electricity is given by the formula below, as given by the *NGA Factors 2011*:

GHG emissions (t CO_2-e) = Q x ($EF_{for\ scope}$ /1000)

Where: Q is the quantity of purchased electricity (in kWh).
$EF_{for\ scope}$ is the scope 2 or 3 emissions factor for NSW (in kg CO_2-e/kWh).

The emission factors for the consumption of purchased electricity are given in **Table O-9**.

Table O-9: Scope 2 and Scope 3 emission factors for the use of purchased electricity (Source: NGA Factors 2011 Table 39)

Fuel	Emissions per unit quantity		Units
	Scope 2	Scope 3	
Electricity	0.00089	0.00017	t CO_2-e per kWh

Vegetation removal

The GHG emissions associated with the loss of CO_2 sequestration potential through the removal of vegetation were calculated according to the default method given in the Workbook. The simple method given therein is for use in cases where relevant local data is not available. The method has been established based on the National Carbon Accounting System (NCAS) and FullCAM model. The method involved the following steps:

The mean annual rainfall (mm) for the road project was identified using the Bureau of Meteorology website and is presented in **Table O-10**.

1. The total area of vegetation to be removed that has not been disturbed by human activity and the total area of vegetation to be removed that has been previously disturbed by human activity were determined.
2. Estimated the t CO_2 per hectare sequestered in the vegetation by:
    a. Multiplying the mean annual rainfall (millimetres) by 0.49 if the vegetation has not previously been disturbed by human activity.
    b. Multiplying the mean annual rainfall (millimetres) by 0.09 if the vegetation has previously been disturbed by human activity.
3. The GHG emissions associated with the loss of CO_2 sequestration potential were estimated by multiplying the area of vegetation to be cleared (hectare) by the relevant emission factor (t CO_2 per hectare) to determine.

Table O-10: Mean rainfall (at Bureau of Meteorology station 068003 Berry Masonic Village, statistics calculated over all years of data) (mm)

Month	Rainfall (mm)
January	135.8
February	154.2
March	156.8
April	133.9
May	126.6
June	135.4
July	97
August	84.1
September	79.7
October	103.4
November	102.5
December	111.5
Total annual	**1420.9**

Materials

Indirect Scope 3 GHG emissions from the use of materials have been calculated according to the formula below:

GHG emissions (t CO_2-e) = Q (t) x EF (tCO_2-e/t)

Where: Q is the quantity of material (in tonnes).
EF is the relevant Emission Factor (in t CO_2-e per tonne of material).

Material emission factors have been sourced from the Workbook and are given in **Table O-11**.

Table O-11: Material Emission Factors (TAGG 2011)

Material	Emission factor (t CO_2-e/t)
Aggregate (crushed rock)	0.004
Concrete (30 MPa concrete 1:2:4)[1]	0.127
Portland cement	0.82
Sand	0.003
Structural steel	1.05
Hot mix asphalt (400MJ/t)	0.058
Bitumen	0.63
Lime	1.09

[1] *Note that all concrete has been assumed to be 30MPa (1:2:4), in the absence of information on concrete types for the different structural elements – to be refined if more information on concrete types can be made available*

Road use

To assess the Indirect Scope 3 GHG emissions from traffic use of the project post construction, road use in two scenarios was considered:

1. Do nothing - No upgrade of the Princes Highway between Gerringong and Bomaderry. This represents the consequence of no action environmental assessment measure.
2. Do minimum - Construction of only the Gerringong upgrade and Foxground and Berry bypass. This represents the operational impacts environmental assessment measure.

The analysis is based on the Vehicle Kilometres Travelled (VKT) and average speed values in the opening year 2017 and the design year 2037, for the traffic impact footprint and involved the following steps:

1. Average speed by road type

   For both scenarios, for the opening year (2017) and the design year (2037), the average speed by road type was sourced from the Traffic *and Transport Assessment Technical Paper* (AECOM, 2012), for the traffic impact footprint. **Table O-12** gives the projected average speeds for the different road sections within the traffic impact footprint, including respective road section lengths.

Table O-12 Average speeds and section length estimates

Route	Section start	Section end	Length (km) 'Do nothing'	Length (km) 'Do something'	Average speed (km/h) 'Do nothing'	Average speed (km/h) 'Do something'
Princes Highway	Rose Valley Road	Belinda Street	3.8	3.8	77.8	97.5
	Belinda Street	Toolijooa Road	3.2	3.0	77.8	97.5
	Toolijooa Road	East of Berry	9.5	8.1	51.9	98.5
	East of Berry	Kangaroo Valley Road	2.0	1.9	51.9	98.5
	Kangaroo Valley Road	Schofields Lane	1.1	1.2	51.9	98.5
	Schofields Lane	Bolong Road	13.6	13.6	64.0	68.9
The 'Sandtrack'	Princes Highway | Rose Valley Road	Crooked River Road | Dooley's Road	8.7	8.7	50.3	50.5
	Crooked River Road | Dooley's Road	Bolong Road | Shoalhaven Heads Road	9.9	9.9	78.2	79.0
	Bolong Road | Shoalhaven Heads Road	Princes Highway | Bolong Road	13.8	13.8	71.2	72.4

2. Vehicle kilometres travelled

   For both scenarios, for the opening year (2017) and the design year (2037), the Average Annual Daily Traffic (AADT) and vehicle kilometres travelled (VKT), for light and heavy vehicles, were sourced from the Traffic *and Transport Assessment Technical Paper* (AECOM, 2012) , for the traffic impact footprint, as given in **Table O-13** below.

Table O-13: AADT Estimates (LV = Light Vehicles, HV = Heavy Vehicles)

			'Do Nothing'				'Do Something'			
			2017 Opening Year AADT		2037 Design Year AADT		2017 Opening Year AADT		2037 Design Year AADT	
Route	Section Start	Section End	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way
Princes Highway	Rose Valley Road	Belinda Street	13,057	1,680	19,710	2,537	15,229	1,707	31,631	2,774
	Belinda Street	Toolijooa Road	11,528	1,605	17,420	2,425	13,373	1,605	30,088	2,650
	Toolijooa Road	East of Berry	11,150	1,552	16,850	2,345	12,862	1,543	28,938	2,549
	East of Berry	Kangaroo Valley Road	12,563	1,680	18,933	2,532	11,895	1,436	25,632	2,552
	Kangaroo Valley Road	Schofields Lane	13,976	1,808	21,015	2,719	14,981	1,808	29,781	2,965
	Schofields Lane	Bolong Road	13,976	1,808	21,015	2,719	14,981	1,808	29,781	2,965
The 'Sandtrack'	Princes Highway | Rose Valley Road	Crooked River Road | Dooley's Road	10,401	346	15,371	511	8,451	346	5,463	553
	Crooked River Road | Dooley's Road	Bolong Road | Shoalhaven Heads Road	10,078	384	14,845	565	7,823	384	4,759	610
	Bolong Road | Shoalhaven Heads Road	Princes Highway | Bolong Road	9,754	421	14,319	618	7,195	421	4,055	667

Table O-14: VKT Estimates (LV = Light Vehicles, HV = Heavy Vehicles)

			'Do Nothing'			'Do Something'				
			2017 Opening Year VKT	2037 Design Year VKT		2017 Opening Year VKT		2037 Design Year VKT		
Route	Section Start	Section End	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way	LV, 2-way	HV, 2-way
Princes Highway	Rose Valley Road	Belinda Street	18,110,059	2,330,160	27,337,770	3,518,819	21,122,623	2,367,609	43,872,197	3,847,538
	Belinda Street	Toolijooa Road	13,464,704	1,874,640	20,346,560	2,832,400	14,643,435	1,757,475	32,946,360	2,901,750
	Toolijooa Road	East of Berry	38,662,625	5,381,560	58,427,375	8,131,288	38,026,503	4,561,880	85,555,197	7,536,119
	East of Berry	Kangaroo Valley Road	9,170,990	1,226,400	13,820,725	1,848,360	8,249,183	995,866	17,775,792	1,769,812
	Kangaroo Valley Road	Schofields Lane	5,611,364	725,912	8,437,523	1,091,679	6,561,678	791,904	13,044,078	1,298,670
	Schofields Lane	Bolong Road	69,376,864	8,974,912	104,318,460	13,497,116	74,365,684	8,974,912	147,832,884	14,718,260
The 'Sandtrack'	Princes Highway | Rose Valley Road	Crooked River Road | Dooley's Road	33,028,376	1,098,723	48,810,611	1,622,681	26,836,151	1,098,723	17,347,757	1,756,052
	Crooked River Road | Dooley's Road	Bolong Road | Shoalhaven Heads Road	36,415,046	1,385,777	53,642,408	2,039,821	28,268,411	1,385,777	17,196,647	2,204,235
	Bolong Road | Shoalhaven Heads Road	Princes Highway | Bolong Road	49,130,898	2,120,577	72,124,803	3,112,866	36,241,215	2,120,577	20,425,035	3,359,679

3. Rate of fuel consumption

The rate of fuel consumption was calculated for each road type within the traffic impact footprint, using the basic fuel-speed formula given below (Equation 1 in Austroads Guide to Project Evaluation Part 4: Project Evaluation Data part 6):

$$Fuel\ Consumption\ (L/100km) = A + (B/V) + (CxV) + (DxV^2)$$

Where: A, B, C and D are the Fuel consumption parameter values given in **Table O-15**.
V is the all day average link speed in km/h

Table O-15: Fuel consumption parameter values on freeways - litres/100 km (Austroads Guide to Project Evaluation Part 4: Project Evaluation Data Table 6.3)

Vehicle type	A	B	C	D
Cars	-18.433	1306.02	0.15477	0.0003203
Light commercial vehicle (LCV)	-27.456	2060.5	0.1911	0.000851
Rigid trucks	-65.056	4156.75	0.49681	0.0006798
Articulated vehicles	-80	6342.8	0.48496	0.0020895
Buses	-80	5131.63	0.60539	0.0015775

As the GHG emissions from road use were assessed for two vehicle categories, light vehicles and heavy vehicles, weighted average fuel consumption parameters were applied for each vehicle category, according to the likely proportional makeup of vehicle types within each category, based on Australian Bureau of Statistics NSW Registration vehicle type data for the year 2011 (given in **Table O-16**). The likely proportional makeup of cars and LCV's within the category of 'light vehicles' and the likely proportional makeup of rigid trucks, articulated vehicles and buses within the category 'heavy vehicles' are given in **Table O-17**. The weighted average fuel consumption parameters applied for calculation of the fuel consumption rate of light and heavy vehicles are given in **Table O-18**.

Table O-16: Australian Bureau of Statistics NSW Registration vehicle type data for calculating weighted average fuel consumption parameters for light and heavy vehicles

Category	2011 NSW registrations	Proportion total	Heavy/ Light	Sub-classification according to fuel consumption parameters	Proportion heavy/light
Articulated trucks	18578	0.39%	H	Articulated vehicles	0.11
Buses	23390	0.49%	H	Buses	0.14
Heavy rigid trucks	84401	1.77%	H	Rigid trucks	0.50
Light rigid trucks	39460	0.83%	H	Rigid trucks	0.23
Non-freight carrying trucks	3320	0.07%	H	Rigid trucks	0.02
Total	**169149**				1.00
Campervans	10537	0.22%	L	Cars	0.00
Light commercial vehicles	675152	14.13%	L	LCV	0.15
Motor cycles	181107	3.79%	L	Cars	0.04
Passenger vehicles	3742476	78.32%	L	Cars	0.81
Total	**4609272**				1.00

Table O-17: Estimated proportional makeup of light and heavy vehicles according to vehicle type

Category	Cars	LCV	Rigid Trucks	Articulated vehicles	Buses
Light Vehicles	0.85	0.15	0	0	0
Heavy Vehicles	0	0	0.75	0.11	0.14

Table O-18: Fuel consumption parameter values on freeways for light and heavy vehicles - litres/100 km (adapted from Austroads Guide to Project Evaluation Part 4: Project Evaluation Data Table 6.3)

Vehicle category	A	B	C	D
Light	-19.7546613	1416.5339122	0.1600915	0.0003980
Heavy	-68.7637949	4531.6554390	0.5105230	0.0009588

Rates of fuel consumption calculated according to Equation 1 are applicable at the year of 2008 (year of publication of Austroads Guide to Project Evaluation). Annual rates of fuel efficiency improvement were applied to calculate rates of fuel consumption, for light and heavy vehicles, in the years 2017 and 2037, according to road transport fuel intensity projections by vehicle type, given by SKM (2011) in Australian Transport Emissions Projections to 2050 (**Table O-19**), as follows:

- Rates of fuel consumption for the years 2017 and 2020 were calculated by applying the annual percentage change in fuel intensity for 2008-2020, given in **Table O-19**, to the rate of fuel consumption in the year 2008.
- Rates of fuel consumption in the year 2037 were calculated by applying the annual percentage change in fuel intensity for 2020-2030, given in **Table O-19**, to the rate of fuel consumption in the year 2020.

Table O-19: Estimated fuel intensity projections by road type

Vehicle Type	Annual % Fuel Intensity Change (2008-2020)[1]	Annual % Fuel Intensity Change (2020-2030)[1]	Heavy/Light	Annual % Fuel Intensity Change (2008-2020) (based on vehicle proportions)	Annual % Fuel Intensity Change (2020-2030) (based on vehicle proportions)
Passenger	-1.1	-1.4	Light	-0.97	-1.37
Motorcycles	1	-0.8			
LCV	0.2	-1.2			
Buses	0.4	0.3	Heavy	-0.40	-0.53
Rigid	-0.5	-0.6			
Articulated	-0.7	-1.1			

SKM (2011) Australian transport emissions projections to 2050

4. Total fuel quantity combusted

   For both scenarios, for the opening year (2017) and the design year (2037), VKT was factored by the rate of fuel consumption, for each road type to determine the total quantity of fuel consumed in each scenario.

5. Fuel quantity combusted by fuel type

   The analysis considered three fuels, petrol, diesel and LPG. The total quantity of fuel combusted in each scenario, for the opening year (2017) and the design year (2037), was apportioned according to fuel type, based on Australian Bureau of Statistics Survey of Motor Vehicle Use for 12 Months to 31 October 2010. Estimates of the proportional makeup of light and heavy vehicles, by fuel type, are given in **Table O-20** below.

Table O-20: Fuel type proportions for light and heavy vehicles (calculated from data in ABS Survey of Motor Vehicle Use 9208.0 for the 12 months ending 31 October 2010)

Vehicle category	Fuel type	Estimated proportion
Light Vehicles	Petrol	84.1
	Diesel	8.4
	LPG/CNG/dual fuel/hybrid (assume LPG)	7.5
Heavy Vehicles	Petrol	0.8
	Diesel	97.3
	LPG/CNG/dual fuel/hybrid (assume LPG)	1.9

The estimated total quantities of each fuel type used in each scenario, for the opening year (2017) and the design year (2037) are given in **Table O-21** below.

Table O-21: Fuel quantity estimates by fuel type

Route	Section Start	Section End	'Do Nothing'						'Do Something'					
			2017 – Fuel Quantities (kL)			2037 – Fuel Quantities (kL)			2017 – Fuel Quantities (kL)			2037 – Fuel Quantities (kL)		
			Petrol	Diesel	LPG	Petrol	Diesel	LPG	Petrol	Diesel	LPG	Petrol	Diesel	LPG
Princes Highway	Rose Valley Road	Belinda Street	1864.2	951.3	181.2	2162.8	1259.0	213.2	2311.8	1043.7	222.1	3687.4	1560.6	352.3
	Belinda Street	Toolijooa Road	1386.4	754.0	135.6	1610.2	1000.4	159.9	1603.0	763.4	154.8	2769.2	1175.8	264.6
	Toolijooa Road	East of Berry	5058.9	2909.3	498.0	5876.2	3865.8	587.7	4189.4	1994.2	404.5	7236.9	3072.6	691.6
	East of Berry	Kangaroo Valley Road	1199.8	667.7	117.7	1389.8	884.1	138.4	908.8	434.8	87.8	1504.1	702.1	145.0
	Kangaroo Valley Road	Schofields Lane	734.0	397.6	71.8	848.3	524.9	84.2	722.9	345.7	69.8	1103.7	515.2	106.4
	Schofields Lane	Bolong Road	7645.0	4016.3	745.3	8835.1	5298.2	873.8	7887.7	3879.8	763.9	12,043.0	5780.1	1163.6
The 'Sandtrack'	Princes Highway / Rose Valley Road	Crooked River Road / Dooley Road	4453.1	954.7	407.7	5055.7	1184.8	464.8	3600.5	866.5	331.4	1791.6	910.4	174.1
	Crooked River Road / Dooley Road	Bolong Road / Shoalhaven Heads Road	3738.6	827.9	342.8	4230.9	1026.5	389.6	2901.8	743.6	268.0	1359.4	787.4	133.9
	Bolong Road / Shoalhaven Heads Road	Princes / Bolong Road	5137.1	1230.8	472.8	5793.7	1529.7	535.9	3771.5	1088.9	350.6	1638.4	1182.4	165.9

6. The GHG emission calculation

The Scope 3 GHG emissions associated with the use of petrol, diesel and LPG, in both scenarios, for the opening year (2017) and the design year (2037) were calculated according to the formula below, as given by the *NGA Factors 2011*:

GHG emissions (t CO_2-e) = (Q x $EF_{full\ fuel\ cycle}$) / 1000

Where: Q is the quantity of fuel (in kL).
$EF_{full\ fuel\ cycle}$ is the relevant emission factor (in kg $CO_{2\text{-}e}$/kL).

The emission factor applied represents the full fuel cycle, which is the sum of Scope 1 and Scope 3 emissions. The emission factors for petrol, diesel and LPG are given in **Table O-22**.

Table O-22: Scope 1, Scope 3 and full fuel cycle emission factors for (post 2004 vehicles) (Source: NGA Factors 2011 Tables 4 and 38)

Fuel	Energy content factor (GJ per kL)	Scope 1 emission factor (kg CO_2-e/GJ)			Scope 3 emission factor (kg CO_2-e/GJ)	Emissions per unit quantity (t CO_2-e per kL)			Full fuel cycle (t CO_2-e per kL)
		CO_2	CH_4	N_2O		Scope 1	Scope 2	Scope 3	
Petrol - gasoline	34.2	66.7	0.6	2.3	5.3	2.38032	-	0.18126	2.56158
Diesel oil	38.6	69.2	0.2	0.5	5.3	2.69814	-	0.20458	2.90272
Liquid petroleum gas (LPG)	26.2	59.6	0.6	0.6	5	1.59296	-	0.131	1.72396

The estimated GHG emissions from the use of fuel in each scenario, for the opening year (2017) and the design year (2037) are given in **Table O-23** below.

Table O-23: GHG emission estimates

Route	Section Start	Section End	'Do Nothing'		'Do Something'		Difference 'Do Something' – 'Do Nothing'	
			GHG Emissions (t CO2-e)- opening year 2017	GHG Emissions (t CO2-e)- design year 2037	GHG Emissions (t CO2-e)- opening year 2017	GHG Emissions (t CO2-e)- design year 2037	GHG Emissions (t CO2-e)- opening year 2017	GHG Emissions (t CO2-e)- design year 2037
Princes Highway	Rose Valley Road	Belinda Street	7849.1	9562.2	9334.4	14,583.0	1485.4	5020.8
	Belinda Street	Toolijooa Road	5973.9	7304.1	6589.2	10,962.7	615.2	3658.6
	Toolijooa Road	East of Berry	22,262.1	27,287.0	17,217.4	28,649.3	-5044.8	1362.3
	East of Berry	Kangaroo Valley Road	5214.4	6365.0	3741.4	6140.8	-1473.0	-224.3
	Kangaroo Valley Road	Schofields Lane	3158.1	3842.0	2975.8	4506.1	-182.4	664.2
	Schofields Lane	Bolong Road	32,526.4	39,517.4	32,783.9	49,632.9	257.5	10,115.5
The 'Sandtrack'	Princes Highway/ Rose Valley Road	Crooked River Road/| Dooley Road	14,880.9	17,190.9	12,309.4	7531.9	-2571.5	-9659.0
	Crooked River Road/| Dooley Road	Bolong Road/ Shoalhaven Heads Road	12,570.7	14,489.1	10,053.5	5998.7	-2517.2	-8490.3
	Bolong Road/ Shoalhaven Heads Road	Princes Highway/ Bolong Road	17,546.6	20,205.2	13,426.4	7914.9	-4120.3	-12,290.3
		Totals	121,982.2	145,763.0	108,431.3	135,920.4	**-13,550.9**	**-9,842.6**