Appendix 15A

GHG Assessment

Global Centre of Rail Excellence (GCRE)

Summary

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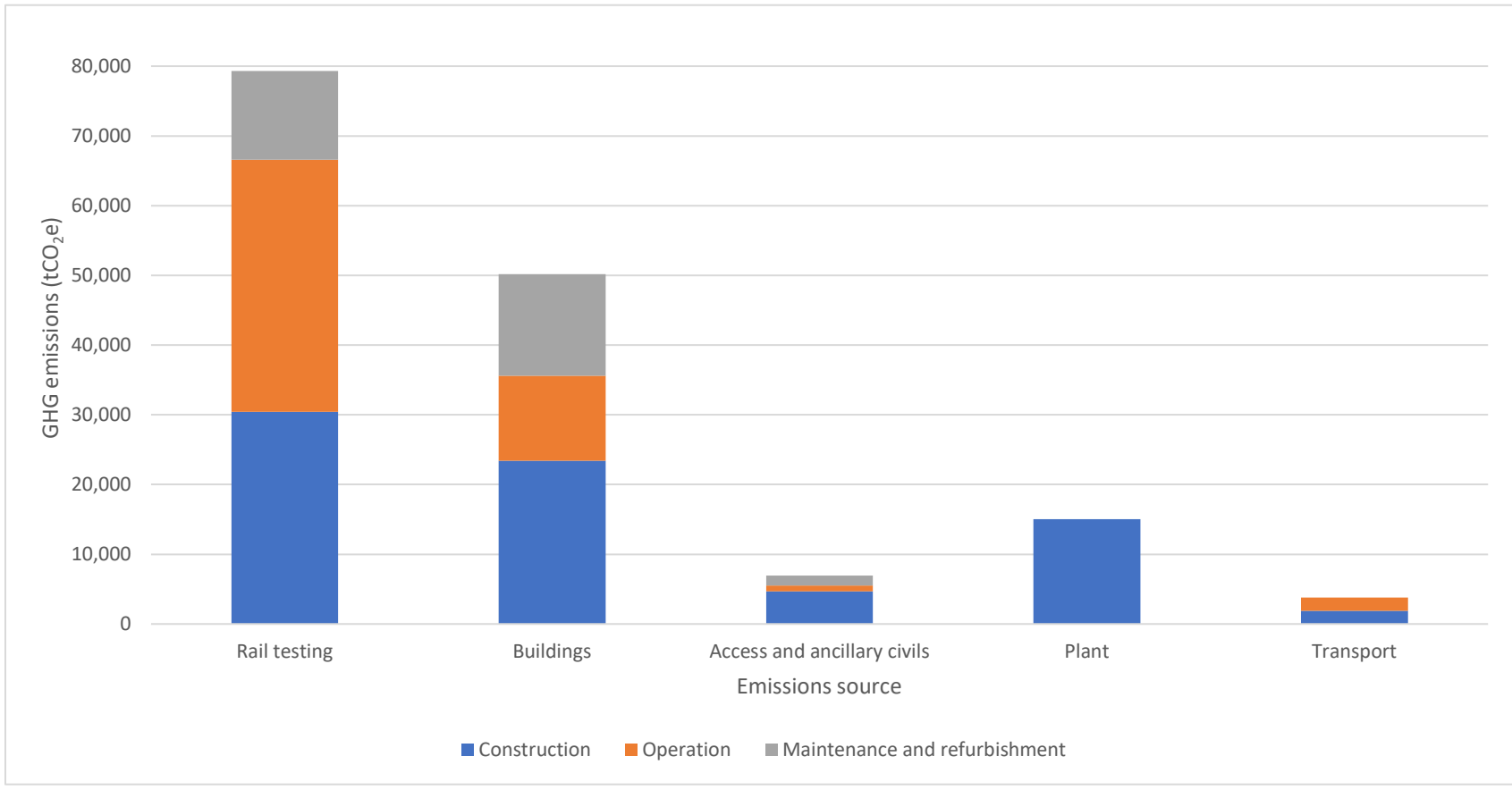
Emissions source	Emissions over appraisal period (kgCO2e)	Emissions over appraisal period (tCO2e)	Annual emissions in opening year (kgCO2e)	Annual emissions in opening year, 2023 (tCO2e)	% Emissions over appraisal period
Stage A - Construction					
Rail testing infrastructure	30,429,695	30,430			20%
Buildings	23,422,230	23,422			15%
Access and ancillary civils	4,694,518	4,695			3%
Plant	15,030,447	15,030			10%
Transport	1,917,458	1,917			1%
Stage B - Operation					
Buildings	12,191,199	12,191			8%
Access and ancillary civils	801,512	802	137,336	137	1%
Transport	1,886,316	1,886	13,228	13	1%
Rolling Stock Testing (operational 2024)	13,192,827	13,193	0	0	8%
Infrastructure Testing (operational 2023)	22,978,703	22,979	1,075,376	1,075	15%
Stage B - Maintenance and refurbishment					
Rail testing infrastructure	12,712,383	12,712			8%
Buildings	14,559,697	14,560			9%
Access and ancillary civils	1,463,676	1,464			1%
Total	155,280,661	155,281	1,225,940	1,226	
Construction total	75,494,347	75,494			49%
Operation total	51,050,557	51,051			33%
Maintenance total	28,735,757	28,736			19%
		36,172			
		79,786			

Global Centre of Rail Excellence (GCRE)

Summary chart

ARUP

	Rail testing	Buildings	Access and ancillary civils	Plant	Transport
Construction	30,430	23,422	4,695	15,030	1,917
Operation	36,172	12,191	802	0	1,886
Maintenance and refurbishment	12,712	14,560	1,464	0	0



Global Centre of Rail Excellence (GCRE)

Buildings A1-B7

Phase	Asset	Benchmark name	Source	Units	Area (m2)	Quantity (nr)	Total area	Benchmark ($kgCO2e/m^2$)	A1-A5 kgCO2e	WLC kgCO2e	B1-B5 kgCO2e	B6-B7 kgCO2e	Proxy	Source
Phase I	Modular buildings (Shunters cabin)	Small medium light industrial	RICS 2012	kgCO2e	30	13	390	435	169,650	360,957	104,678	86,630	Warehouse	RICS 2017
	Substation	Utilities compond	RICS 2012	kgCO2e	88	2	176	395	69,520	147,915	42,895	35,500	Warehouse	RICS 2017
	Staff facilities (replaced in Phase 2)	Small medium light industrial	RICS 2012	kgCO2e	120	1	120	435	52,200	111,064	32,209	26,655	Warehouse	RICS 2017
	Infrastructure Testing R&D Centre (relocated in Ph	Low-rise offices	RICS 2012	kgCO2e	240	1	240	925	222,000	634,286	202,971	209,314	Office	RICS 2017
Phase II	Carriagewash equipment and associated plantroom	Other industrial/utilities/specialist uses	RICS 2012	kgCO2e	430	1	430	545	234,350	498,617	144,599	119,668	Warehouse	RICS 2017
	Rolling stock maintenance shed 1	Other industrial/utilities/specialist uses	RICS 2012	kgCO2e	14398	1	14398	545	7,846,910	16,695,553	4,841,710	4,006,933	Warehouse	RICS 2017
	Rolling stock maintenance shed 2	Other industrial/utilities/specialist uses	RICS 2012	kgCO2e	25040	1	25040	545	13,646,800	29,035,745	8,420,366	6,968,579	Warehouse	RICS 2017
	Signalling control centre	Low-rise offices	RICS 2012	kgCO2e	300	1	300	925	277,500	792,857	253,714	261,643	Office	RICS 2017
	Staff accommodation	Live work unit	RICS 2012	kgCO2e	300	1	300	515	154,500	302,941	54,529	93,912	Residential	RICS 2017
Phase III	Decommissioning shed	Other industrial/utilities/specialist uses	RICS 2012	kgCO2e	350	1	350	545	190,750	405,851	117,697	97,404	Warehouse	RICS 2017
	Static testing structures	Other industrial/utilities/specialist uses	RICS 2012	kgCO2e	500	1	500	545	272,500	579,787	168,138	139,149	Warehouse	RICS 2017
	Modular building (Shunters cabin)	Small medium light industrial	RICS 2012	kgCO2e	30	1	30	435	13,050	27,766	8,052	6,664	Warehouse	RICS 2017
	Research and Development Centre	Other industrial/utilities/specialist uses	RICS 2012	kgCO2e	500	1	500	545	272,500	579,787	168,138	139,149	Warehouse	RICS 2017
Total					**42326**				**23,422,230**	**50,173,127**	**14,559,697**	**12,191,199**		RICS 2017
							42774							

Stage(s)	Office	Warehouse	Residential
A1-A5	0.35	0.47	0.51
B1-B5	0.32	0.29	0.18
B6-B7	0.33	0.24	0.31
RICS 2017 Figure 1 data			

Ancillary civil works*					
A1-A3		A4			
Floor area (m2)	42774	Mass (tonnes)	1026.576		
10% (m2)	4277.4	Source location	Swansea/F		
Thickness (m)**	0.1	Distance travelled (k	25		
Volume (m3)	427.74	tonne.km	25664.4		
Concrete density	2400	Freight mode	Rail/road	90%	10%
Mass (kg)	1026576	Conversion factors	Rail/road	0.03333	0.129087
Concrete EF (kgCO2e/kg)	0.103	Freight kgCO2e	Rail/road	769.855	331.2937
Emissions kgCO2e	105737.328	Total A4 kgCO2e	1101.149		

*Ancillary civil works calculated as 10% of main hardstanding area as advised by Chris Justice (approved by Phill Harris)
**0.1 m thick concrete used as fair assumption for buildings ancillary hardstanding, e.g. walkways etc.

ARUP

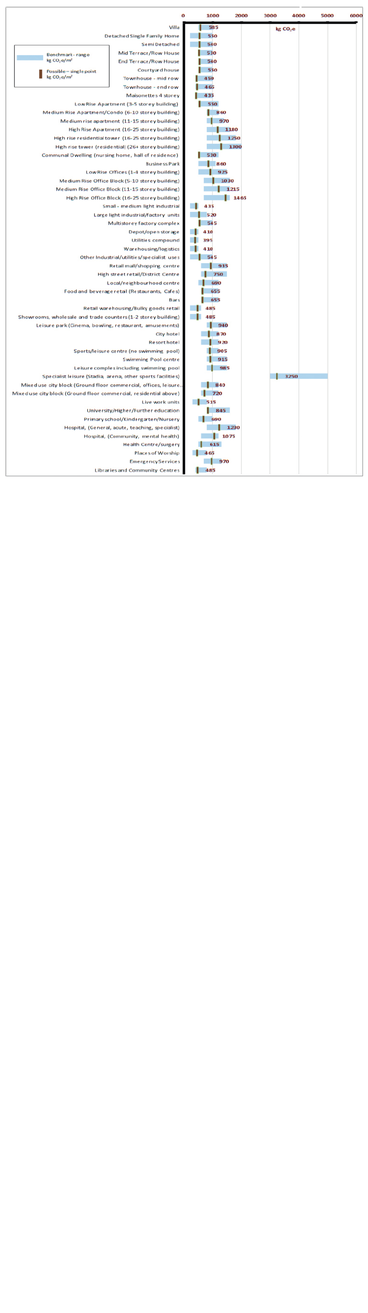
Source: Chris Justice (Chris.Justice@arup.com)

Source: ..\..\Transport\2020_07_03 Traffic Flows.xlsx
Source: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

Buildings info source: Chris Justice (Chris.Justice@arup.com)

Buildings carbon benchmarks source: https://www.igbc.ie/wp-content/uploads/2015/02/ Figure 6: Embodied carbon benchmark values (sourced from Atkins Carbon Critical Masterplanning Tool. Reproduced with permission from Atkins))

WLC breakdown source: https://www.rics.org/globalassets/rics-website/me Figure 1: Total whole life carbon emissions breakdown for different building types



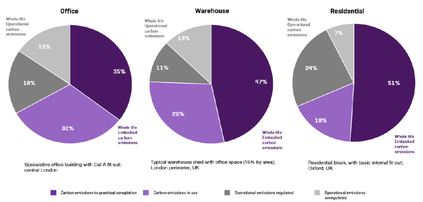


Figure 1: Total whole life carbon emissions breakdown for different building types © Sturgis Carbon Profiling

Global Centre of Rail Excellence (GCRE)

Substations A1-A4

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A1-A3

Asset	Area (m2)	Quantity (nr)
Substation	88	3

By cost (pg. 14): https://www.nation *'We are on track to meet our 2017/18 carbon intensity target by reducing capital carbon intensity from a baseline of 188tCO2/£m to 138tCO2/£m, exceeding our target of a 10 per cent reduction'*

Cost of electrical equipment from: Eòghann macLachlainn (Eoghann.MacLachlainn@arup.com) and Carl Thomas (carl.thomas@se.com)

Electrical Equipment Descritpion			Cost, £
Phase 1 - Equipment	MV SS	MV Panel (4ways)	50,000
		MV Ring Main Unit (Site)	10,000
		MV Ring Main Unit (Test L	10,000
	SS1	MV Ring Main Unit	10,000
		MV Panel (4ways)	50,000
		SS1-Tx1 (250kVA)	10,000
		SS1-Tx2 (3MVA)	25,000
		LV Panel Board	10,000
	SS5	MV Ring Main Unit	10,000
		MV Panel (4ways)	50,000
		SS5-Tx1 (500kVA)	13,000
		SS5-Tx2 (2.5MVA)	22,000
		LV Panel Board	12,000
Phase 2 - Equipment	SS2	MV Ring Main Unit	10,000
		MV Panel (4ways)	50,000
		SS2-Tx1 (500kVA)	13,000
		SS2-Tx2 (2.5MVA)	22,000
		LV Panel Board	12,000
	SS3	MV Ring Main Unit	10,000
		MV Panel (4ways)	50,000
		SS3-Tx1 (800kVA)	16,000
		SS3-Tx2 (2MVA)	20,000
		LV Panel Board	15,000
	SS4	SS4-Tx1 (1MVA)	20,000
		LV Panel Board	20,000
Total			540,000

tCO2/£m	kgCO2/£
138	0.138

kgCO2 = 74,520

Material quantity of structure (based on drawing on RHS)

Reinforced concrete (assumed 75kg rebar per m3 concrete)

Component	CS Area (mm2	CS Area m2
2 x large walls	9650000	9.65
1 x short ceiling	3325000	3.325
1 x floor	10900000	10.9
4 x small walls	5390000	5.39
1 x small outer wall	1925000	1.925
1 x long ceiling	7575000	7.575
Total	38765000	38.765

Depth (m) 4

Volume (m3) 155.06

Mass concrete

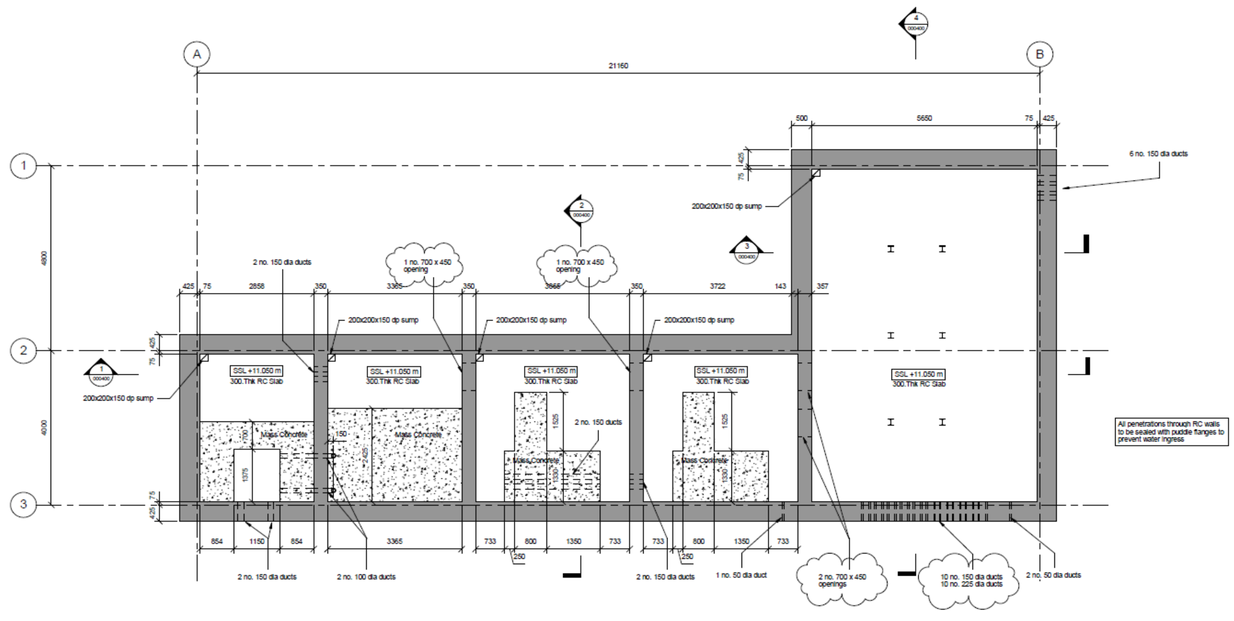
Component	CS area (mm2	CS area (m2)
1	4349100	4.3491
2	8160125	8.160125
3	4412000	4.412
4	4412000	4.412
Total	21333225	21.333225

Depth (m) 4

Volume (m3) 85.3329

Material	Volume (m3)	Density (kg m3)	Weight (kg)	Emission factor (kgCO2e/kg)	Emissions (kgCO2e)	Source
Concrete - General (with 75kg rebar per m3 concrete)	155.06	2300	356,638	0.16075	57,330	ICE v2.0
Concrete - General	85.3329	2400	204,799	0.103	21,094	ICE v2.0
Total					**78,424**	

A1-A3 substation emissions (kgCO2e): 309,792



REINFORCED CONCRETE - Modification Factors			
For reinforcement add this value to the appropriate concrete coefficient for each 100 kg of rebar per m3 of concrete	**1.04**	**0.077**	Add for each 100 kg steel rebar per m3 concrete. Use multiple of this value, i.e. for 150 kg steel use a factor of 1.5 times these values.
EXAMPLE: Reinforced RC 25/30 MPa (with 110 kg per m^3 concrete)	**1.92 MJ/kg (0.78 + 1.04 * 1.1)**	**0.198 kgCO2/kg (0.113 + 0.077 * 1.1)**	with 110 kg rebar per m3 concrete

A4

Material	Weight (kg)	Weight (tonnes)	Source location	Distance (km)	tonne.km	Freight mode 1	Freight mode 2	Percentage split		Conversion factor 1	Conversion factor 2	Freight mode 1 kgCO2e	Freight mode 2 kgCO2e	Total A4 kgCO2e
Concrete - General	204,799	204.79896	Swansea/Pe	25	5119.974	Rail	Road	90%	10%	0.03333	0.129087	153.5839	66.09213	219.676
Reinforced concrete	356,638	356.638	Swansea/M	40	14265.52	Road	N/A	100%	0%	0.129087	0	1841.491	0	1841.491
Total														2061.167

Freight mode: ..\..\Transport\2020_07_03 Traffic Flows.xlsx

Conversion factors (I https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

Material source local Chris Justice (Chris.Justice@arup.com)

A1-A4 substation emissions (kgCO2e): 311,853

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Misc. Assets A1-A3

ARUP

Quantities from: Chris Justice (Chris.Justice@arup.com)

Assumptions:
Duel-loop track assumed over single-loop track for rolling stock testing as a worst-case scenario for emissions.

Summaries of RSSB export by construction phase

Phase I-III

	Steel - General	Nylon 66	Rubber - General	Soil - General (Rammed Soil)	Concrete - General	Steel - Plate	Granite - General - Lower	Concrete - Reinforced - For each 25kg rebar	Aggregates and Sand - Typical UK Mix	HDPE - Pipe	Steel - Bar and Rod - Virgin	Steel - Section - Virgin	Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	Concrete - 32/40 MPa - Average UK Additions	Aluminium - Cast Products	Concrete - Precast Concrete Paving	Insulation - Mineral Wool	Total kg CO2e
Track	6,643,345	180,655	198,019	3,992,841	7,011,538	2,180	1,185,735	19,731	346,099	4,201,611	0	0	0	0	0	0	0	23,781,755
OLE	0	0	0	0	138,432	0	0	0	0	0	32,708	547,232	0	0	0	0	0	718,372
Rail cable trough	0	0	0	0	0	0	0	0	4,819	0	62,225	0	83,529	0	0	0	0	150,573
Fencing	4,490,356	0	0	0	0	0	0	0	0	0	0	0	0	238,998	0	0	0	4,729,354
Lighting bollards	0	0	0	0	768	0	0	0	0	0	0	0	0	0	60,720	0	0	61,488
Platform	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	379,500	0	379,500
Acoustic barrier	259,147	0	0	0	0	0	0	0	0	0	0	0	0	1,698	0	0	38,016	298,861
																		30,119,903
Total kgCO2e	11,392,848	180,655	198,019	3,992,841	7,150,737	2,180	1,185,735	19,731	350,918	4,201,611	94,933	547,232	83,529	240,696	60,720	379,500	38,016	30,119,903
Emissions factor (kgCO2e/kg)	1.46	6.5	2.85	0.024	0.103	2.46	0.006	0.018	0.00747	2.52	2.77	3.03	0.115	0.138	13.2	0.132	1.28	
Density (kg/m3)		7800	1140	1500	1460	2400	7800	2880	2400	2240	970	7800	7800	2400	2400	2700	2500	140
Volume (m3)		1,000	24	46	113,951	28,927	0	68,619	457	20,972	1,719	4	23	303	727	2	1,150	212
Mass (kg)		7,803,321	27,793	69,480	166,368,384	69,424,636	886	########	1,096,176	46,976,988	1,667,306	34,272	180,605	726,336	1,744,177	4,600	2,875,000	29,700

	Mass (kg)				
	Steel - General	Concrete - 32/40 MPa - Average UK Additions	Concrete - General	Aluminium - Cast Products	Insulation - Mineral Wool
Fencing	3075586.27	1731873.15			
Lighting bollards			7452	4600	
Acoustic barrier	177498.0269	12303.9			29700

Phase I

	Steel - General	Nylon 66	Rubber - General	Soil - General (Rammed Soil)	Concrete - General	Steel - Plate	Granite - General - Lower	Concrete - Reinforced - For each 25kg rebar	Aggregates and Sand - Typical UK Mix	HDPE - Pipe	Steel - Bar and Rod - Virgin	Steel - Section - Virgin	Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	Concrete - 32/40 MPa - Average UK Additions	Aluminium - Cast Products
Track	1,773,727	44,425	48,634	1,161,938	457,195	620	415,440	6,617	116,070	1,409,077	0	0	0	0	0
OLE	0	0	0	0	59,328	0	0	0	0	0	14,018	234,528	0	0	0
Rail cable trough	0	0	0	0	0	0	0	0	1,673	0	21,606	0	29,003	0	0
Fencing	1,347,055	0	0	0	0	0	0	0	0	0	0	0	0	71,697	0
Lighting bollards	0	0	0	0	267	0	0	0	0	0	0	0	0	0	21,120
Total kgCO2e	3,120,782	44,425	48,634	1,161,938	516,790	620	415,440	6,617	117,743	1,409,077	35,624	234,528	29,003	71,697	21,120
Emissions factor (kgCO2e/kg)	1.46	6.5	2.85	0.024	0.103	2.46	0.006	0.018	0.00747	2.52	2.77	3.03	0.115	0.138	13.2
Density (kg/m3)	7800	1140	1500	1460	2400	7800	2880	2400	2240	970	7800	7800	2400	2400	2700
Volume (m3)	274	6	11	33,160	2,091	0	24,042	153	7,037	576	2	10	105	216	1
Mass (kg)	2,137,522	6,835	17,064	48,414,080	5,017,376	252	########	367,620	15,762,126	559,157	12,861	77,402	252,200	519,542	1,600

Phase II

	Soil - General (Rammed Soil)	Steel - General	Nylon 66	Steel - Plate	Granite - General - Lower	Concrete - General	Rubber - General	Concrete - Reinforced - For each 25kg rebar	Aggregates and Sand - Typical UK Mix	HDPE - Pipe	Concrete - Precast Concrete Paving	Steel - Bar and Rod - Virgin	Steel - Section - Virgin	Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	Concrete - 32/40 MPa - Average UK Additions	Aluminium - Cast Products	Insulation - Mineral Wool
Track	2,302,750	4,172,615	95,931	1,560	649,125	4,848,241	104,857	13,114	230,029	2,792,534	0	0	0	0	0	0	0
OLE	0	0	0	0	0	79,104	0	0	0	0	0	18,690	312,704	0	0	0	0
Rail cable trough	0	0	0	0	0	0	0	0	1,472	0	0	19,013	0	25,523	0	0	0
Fencing	0	3,143,301	0	0	0	0	0	0	0	0	0	0	0	0	167,302	0	0
Lighting bollards	0	0	0	0	0	234	0	0	0	0	0	0	0	0	0	18,480	0
Platform	0	0	0	0	0	0	0	0	0	0	379,500	0	0	0	0	0	0
Acoustic barrier	0	259,147	0	0	0	0	0	0	0	0	0	0	0	1,698	0	0	38,016
Total kgCO2e	2,302,750	7,575,062	95,931	1,560	649,125	4,927,579	104,857	13,114	231,502	2,792,534	379,500	37,704	312,704	25,523	169,000	18,480	38,016
Emissions factor (kgCO2e/kg)	0.024	1.46	6.5	2.46	0.006	0.103	2.85	0.018	0.00747	2.52	0.132	2.77	3.03	0.115	0.138	13.2	1.28
Density (kg/m3)		7800	1140	1500	1460	2400	7800	2880	2400	2240	970	7800	7800	2400	2400	2700	2500	140
Volume (m3)		12,301	4,551	10	0	45,078	6,133	13	304	13,835	1,142	369	2	43	92	454	1	212
Mass (kg)		95,947,904	5,188,399	14,759	634	108,187,500	########	36,792	728,556	30,990,862	1,108,148	2,875,000	13,611	103,203	221,936	1,224,635	1,400	29,700

Phase III

	Soil - General (Rammed Soil)	Granite - General - Lower	Concrete - General	Steel - General	Nylon 66	Rubber - General	Steel - Bar and Rod - Virgin	Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	Aggregates and Sand - Typical UK Mix	Aluminium - Cast Products
Track	528,154	121,170	1,706,102	697,004	40,300	44,528	0	0	0	0
Rail cable trough	0	0	0	0	0	0	21,606	29,003	1,673	0
Lighting bollards	0	0	267	0	0	0	0	0	0	21,120
Total kgCO2e	528,154	121,170	1,706,369	697,004	40,300	44,528	21,606	29,003	1,673	21,120
Emissions factor (kgCO2e/kg)	0.024	0.006	0.103	1.46	6.5	2.85	2.77	0.115	0.00747	13.2
Density (kg/m3)	7800	2400	7800	1140	1500	2880	7800	2400	2240	2500
Volume (m3)	2821.333333	8414.58333	2123.93487	418.7719298	4.13333333	5.425	1	105.08333	100	0.64
Mass (kg)	22006400	20195000	16566692	477400	6200	15624	7800	252200	224000	1600

Global Centre of Rail Excellence (GCRE)

Misc. Assets A4

ARUP

Basis of calculations:

Material source locati Chris Justice (Chris.Justice@arup.com)

Freight mode: _\Transport\2020_07_03 Traffic Flows.xlsx

Conversion factors (R: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

Phase	Material(s)	Volume (m3)	Mass (kg)	Mass (tonnes)	Source location	Distance travelled (km)	tonne.km	Freight mode 1	Freight mode 2	Percentage split		Conversion factor 1	Conversion factor 2	Freight mode 1 kgCO2e	Freight mode 2 kgCO2e	Total A4 kgCO2e	
Phase I	Steel - General	274.04	2,137,521.84	2,137.52	Swansea/Neath	25	53,438.05	Rail	Road	80%	20%	0.03333	0.129086853	1,425	1,380	2,805	
	Nylon 66	6.00	6,834.60	6.83	Addlestone/London/Plymouth	320	2,187.07	Rail	Road	80%	20%	0.03333	0.129086853	58	56	115	
	Rubber - General	11.38	17,064.43	17.06	Addlestone/London/Plymouth	320	5,460.62	Rail	Road	80%	20%	0.03333	0.129086853	146	141	287	
	Soil - General (Rammed Soil)	33,160.33	48,414,080.00	48,414.08	Pre-existing on site	0	0.00	N/A	N/A	0%	0%	0	0	0	0	0	
	Concrete - General	2,090.57	5,017,375.80	5,017.38	Swansea/Penderyn	25	125,434.40	Rail	Road	80%	20%	0.03333	0.129086853	3,345	3,238	6,583	
	Steel - Plate	0.03	252.00	0.25	Swansea/Neath	25	6.30	Rail	Road	80%	20%	0.03333	0.129086853	0	0	0	
	Granite - General - Lower	24,041.67	69,240,000.00	69,240.00	Local (max 50 miles by road)	50	3,462,000.00	Road	N/A	100%	0%	0.129086853	0	446,899	0	446,899	
	Concrete - Reinforced - For each 25kg rebar	153.18	367,620.00	367.62	Swansea/Merthyr/Abergwili (max 40 miles by road)	40	14,704.80	Road	N/A	100%	0%	0.129086853	0	1,898	0	1,898	
	Aggregates and Sand - Typical UK Mix	7,036.66	15,762,126.45	15,762.13	Swansea, Portadawe and Penderyn	25	394,053.16	Rail	Road	80%	20%	0.03333	0.129086853	10,507	10,173	20,680	
	HDPE - Pipe	576.45	559,157.47	559.16	Maesteg/Portadawe	30	16,774.72	Road	N/A	100%	0%	0.129086853	0	2,165	0	2,165	
	Steel - Bar and Rod - Virgin	1.65	12,860.55	12.86	Swansea/Neath	25	321.51	Rail	Road	70%	30%	0.03333	0.129086853	8	12	20	
	Steel - Section - Virgin	9.92	77,401.97	77.40	Swansea/Neath	25	1,935.05	Rail	Road	70%	30%	0.03333	0.129086853	45	75	120	
	Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	105.08	252,200.00	252.20	Swansea/Penderyn	25	6,305.00	Rail	Road	80%	20%	0.03333	0.129086853	168	163	331	
	Concrete - 32/40 MPa - Average UK Additions	216.48	519,542.10	519.54	Swansea/Penderyn	25	12,988.55	Rail	Road	80%	20%	0.03333	0.129086853	346	335	682	
	Aluminium - Cast Products	0.59	1,600.00	1.60	Swansea/Neath	25	40.00	Road	N/A	100%	0%	0.129086853	0	5	0	5	482,590 Total Phase I
Phase II	Soil - General (Rammed Soil)	12,301.01	95,947,904.00	95,947.90	Pre-existing on site	0	0.00	N/A	N/A	0%	0%	0	0	0	0	0	
	Steel - General	4,551.23	5,188,398.96	5,188.40	Swansea/Neath	25	129,709.97	Rail	Road	90%	10%	0.03333	0.129086853	3,891	1,674	5,565	
	Nylon 66	9.84	14,758.55	14.76	Addlestone/London/Plymouth	320	4,722.74	Rail	Road	90%	10%	0.03333	0.129086853	142	61	203	
	Steel - Plate	0.43	634.20	0.63	Swansea/Neath	25	15.86	Rail	Road	90%	10%	0.03333	0.129086853	0	0	1	
	Granite - General - Lower	45,078.13	108,187,500.00	108,187.50	Local (max 50 miles by road)	50	5,409,375.00	Road	N/A	100%	0%	0.129086853	0	698,279	0	698,279	
	Concrete - General	6,133.41	47,840,568.00	47,840.57	Swansea/Penderyn	25	1,196,014.20	Rail	Road	90%	10%	0.03333	0.129086853	35,877	15,439	51,316	
	Rubber - General	12.78	36,792.00	36.79	Addlestone/London/Plymouth	320	11,773.44	Rail	Road	90%	10%	0.03333	0.129086853	353	152	505	
	Concrete - Reinforced - For each 25kg rebar	303.57	728,556.00	728.56	Swansea/Merthyr/Abergwili (max 40 miles by road)	40	29,142.24	Road	N/A	100%	0%	0.129086853	0	3,762	0	3,762	
	Aggregates and Sand - Typical UK Mix	13,835.21	30,990,861.51	30,990.86	Swansea, Portadawe and Penderyn	25	774,771.54	Rail	Road	90%	10%	0.03333	0.129086853	23,241	10,001	33,242	
	HDPE - Pipe	1,142.42	1,108,148.43	1,108.15	Maesteg/Portadawe	30	33,244.45	Road	N/A	100%	0%	0.129086853	0	4,291	0	4,291	
	Concrete - Precast Concrete Paving	368.59	2,875,000.00	2,875.00	Swansea/Merthyr/Abergwili (max 40 miles by road)	40	115,000.00	Road	N/A	100%	0%	0.129086853	0	14,845	0	14,845	
	Steel - Bar and Rod - Virgin	1.75	13,611.40	13.61	Swansea/Neath	25	340.29	Rail	Road	70%	30%	0.03333	0.129086853	8	13	21	
	Steel - Section - Virgin	43.00	103,202.63	103.20	Swansea/Neath	25	2,580.07	Rail	Road	70%	30%	0.03333	0.129086853	60	100	160	
	Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	92.47	221,936.00	221.94	Swansea/Penderyn	25	5,548.40	Rail	Road	90%	10%	0.03333	0.129086853	166	72	238	
	Concrete - 32/40 MPa - Average UK Additions	453.57	1,224,634.95	1,224.63	Swansea/Penderyn	25	30,615.87	Rail	Road	90%	10%	0.03333	0.129086853	918	395	1,314	
	Aluminium - Cast Products	0.56	1,400.00	1.40	Swansea/Neath	25	35.00	Road	N/A	100%	0%	0.129086853	0	5	0	5	
	Insulation - Mineral Wool	212.14	29,700.00	29.70	Cardiff	50	1,485.00	Rail	Road	90%	10%	0.03333	0.129086853	45	19	64	813,810 Total Phase II
Phase III	Soil - General (Rammed Soil)	2,821.33	22,006,400.00	22,006.40	Pre-existing on site	0	0.00	N/A	N/A	0%	0%	0	0	0	0	0	
	Granite - General - Lower	8,414.58	20,195,000.00	20,195.00	Local (max 50 miles by road)	50	1,009,750.00	Road	N/A	100%	0%	0.129086853	0	130,345	0	130,345	
	Concrete - General	2,123.93	16,566,692.00	16,566.69	Swansea/Penderyn	25	414,167.30	Rail	Road	80%	20%	0.03333	0.129086853	11,043	10,693	21,736	
	Steel - General	418.77	477,400.00	477.40	Swansea/Neath	25	11,935.00	Rail	Road	80%	20%	0.03333	0.129086853	318	308	626	
	Nylon 66	4.13	6,200.00	6.20	Addlestone/London/Plymouth	320	1,984.00	Rail	Road	80%	20%	0.03333	0.129086853	53	51	104	
	Rubber - General	5.43	15,624.00	15.62	Addlestone/London/Plymouth	320	4,999.68	Rail	Road	80%	20%	0.03333	0.129086853	133	129	262	
	Steel - Bar and Rod - Virgin	1.00	7,800.00	7.80	Swansea/Neath	25	195.00	Rail	Road	80%	20%	0.03333	0.129086853	5	5	10	
	Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	105.08	252,200.00	252.20	Swansea/Penderyn	25	6,305.00	Rail	Road	80%	20%	0.03333	0.129086853	168	163	331	
	Aggregates and Sand - Typical UK Mix	100.00	224,000.00	224.00	Swansea, Portadawe and Penderyn	25	5,600.00	Rail	Road	70%	30%	0.03333	0.129086853	131	217	348	
	Aluminium - Cast Products	0.64	1,600.00	1.60	Swansea/Neath	25	40.00	Road	N/A	100%	0%	0.129086853	0	5	0	5	153,768 Total Phase III
													Total			1,450,168	

Material	Source	Distance to GCRE
Steel - General	Swansea/Neath	25
Nylon 66	Addlestone/London/Plymouth	320
Rubber - General	Addlestone/London/Plymouth	320
Soil - General (Rammed Soil)	Pre-existing on site	0
Concrete - General	Swansea/Penderyn	25
Steel - Plate	Swansea/Neath	25
Granite - General - Lower	Local (max 50 miles by road)	50
Concrete - Reinforced - For each 25kg rebar	Swansea/Merthyr/Abergwili (max 40 miles by road)	40
Aggregates and Sand - Typical UK Mix	Swansea, Portadawe and Penderyn	25
HDPE - Pipe	Maesteg/Portadawe	30
Steel - Bar and Rod - Virgin	Swansea/Neath	25
Steel - Section - Virgin	Swansea/Neath	25
Concrete - 1:2:4 Cement:Sand:Aggregate - Average UK Additions	Swansea/Penderyn	25
Concrete - 32/40 MPa - Average UK Additions	Swansea/Penderyn	25
Aluminium - Cast Products	Swansea/Neath	25
Concrete - Precast Concrete Paving	Swansea/Merthyr/Abergwili (max 40 miles by road)	40
Insulation - Mineral Wool	Cardiff	50
Asphalt, 5% binder content	Penderyn	22

Freight mode	kgCO2e
Rail	0.03333
Road (All HGVs, average laden)	0.129087
Source: Freighting goods, DEFRA 2019	

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Civils A1-A4

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Basis and assumptions:
Fully flexible pavement structure based on A40 Low Carbon side roads
Access road chainage from drainage designs: ..\..\..\4-30 ..\..\..\4-30 Drawings\4-31 Issue drawings\Drainage Submission\PDFs\CG3053.pdf

Maintenance road and track dimensions from BoQ: Chris Justice (Chris.Justice@arup.com)
Road resurfacing, cess, retaining walls & crossings from: John Smith (John.Smith@arup.com)
RC: kg rebar per m3 concrete from: Peter Richardson (Peter.Richardson@arup.com)

A1-A3

Access

Phase	Asset	Length (m)	Width (m)	Area (m2)	Pavement type	Pavement layer	Material (ICEv3 Reference)	Density (kg m^3)	Thickness (mm)	Thickness (m)	Volume (m^3)	Weight (kg)	Emission factor (kgCO2-e/kg)	Emissions (kgCO2-e)
Phase II	Access road	2852	7.3	20819.6	Fully flexible	TSCS	Asphalt, 5% binder content	2100	200	0.2	4,164	8,744,232	0.05420	473,937
						Binder course								
						Base								
						Subbase	Aggregates and Sand - Typical UK Mix	2,240	320	0.32	6,662	14,923,489	0.00747	111,478
						Total			520	0.52				585,416
	Rolling stock maintenance road 1	115	10	1150	Fully flexible	TSCS	Asphalt, 5% binder content	2100	200	0.2	230	483,000	0.05420	26,179
						Binder course								
						Base								
						Subbase	Aggregates and Sand - Typical UK Mix	2,240	320	0.32	368	824,320	0.00747	6,158
						Total			520	0.52				32,336
	Rolling stock maintenance road 2	115	10	1150	Fully flexible	TSCS	Asphalt, 5% binder content	2100	200	0.2	230	483,000	0.05420	26,179
						Binder course								
						Base								
						Subbase	Aggregates and Sand - Typical UK Mix	2,240	320	0.32	368	824,320	0.00747	6,158
						Total			520	0.52				32,336
	Rolling stock maintenance road 3	200	10	2000	Fully flexible	TSCS	Asphalt, 5% binder content	2100	200	0.2	400	840,000	0.05420	45,528
						Binder course								
						Base								
						Subbase	Aggregates and Sand - Typical UK Mix	2,240	320	0.32	640	1,433,600	0.00747	10,709
						Total			520	0.52				56,237
	Rolling stock maintenance road 4	200	10	2000	Fully flexible	TSCS	Asphalt, 5% binder content	2100	200	0.2	400	840,000	0.05420	45,528
						Binder course								
						Base								
						Subbase	Aggregates and Sand - Typical UK Mix	2,240	320	0.32	640	1,433,600	0.00747	10,709
						Total			520	0.52				56,237
	Resurface existing road	900	7.3	6570	Fully flexible	TSCS	Asphalt, 5% binder content	2100	40	0.04	263	551,880	0.05420	29,912
	Cess access track	24600	3	73800	N/A	Subbase	Aggregates and Sand - Typical UK Mix	2,240	300	0.3	22,140	49,593,600	0.00747	370,464
	Total	**3482**	**47.3**											**1,162,938**

Ancillary civil works	
Pavement area (m2)	164,699
10% (m2)	16,470
Thickness (m)	0.15
Volume (m3)	2470.479
Asphalt, 5% binder content	2100
Mass (kg)	5,188,006
Asphalt EF (kgCO2e/kg)	0.05420
Emissions kgCO2e	**281,190**

*Ancillary civil works calculated as 10% of main hardstanding area as advised by Chris Justice (approved by Phill Harris)

**0.15 m depth assumed

Concrete - general emissions factor	0.103

Carbon factors	
ICE v.3	Asphalt, 5% binder content
ICE v.3	Aggregates and Sand - Typical UK Mix
ICE v.2	Concrete - General (with 200kg rebar per m3 concrete)

Retaining walls & rail crossings

Phase	Asset					Volume (m3)	Material	Density (kg m3)	Weight (kg)	Emission factor (kgCO2e/kg)	Emissions (kgCO2e)	Source
Phase II	Retaining wall 1					500	Concrete - General (with 200kg rebar per m	2300	1,150,000	0.257	295,550	ICE v2.0
	Retaining wall 2					360	Concrete - General (with 200kg rebar per m	2300	828,000	0.257	212,796	ICE v2.0
	Retaining wall 3					360	Concrete - General (with 200kg rebar per m	2300	828,000	0.257	212,796	ICE v2.0
	Total								2,806,000		721,142	
	Rail crossing 1					1300	Concrete - General (with 200kg rebar per m	2300	2,990,000	0.257	768,430	ICE v2.0
	Rail crossing 2					1300	Concrete - General (with 200kg rebar per m	2300	2,990,000	0.257	768,430	ICE v2.0
	Rail crossing 3					1500	Concrete - General (with 200kg rebar per m	2300	3,450,000	0.257	886,650	ICE v2.0
	Total								9,430,000		2,423,510	
	Grand total								12,236,000		**3,144,652**	

REINFORCED CONCRETE - Modification Factors			
For reinforcement add this value to the appropriate concrete coefficient for each 100 kg of rebar per m3 of concrete	**1.04**	**0.077**	Add for each 100 kg steel rebar per m3 concrete. Use multiple of this value, i.e. for 150 kg steel use a factor of 1.5 times these values.
EXAMPLE: Reinforced RC 25/30 MPa (with 110 kg per m^3 concrete)	**1.92 MJ/kg (0.78 + 1.04 * 1.1)**	**0.198 kgCO2/kg (0.113 + 0.077 * 1.1)**	with 110 kg rebar per m3 concrete

A4

Phase	Material	Weight (kg)	Weight (tonnes)		Source location	Distance (km)	tonne.km	Freight mode 1	Freight mode 2	Percentage split		Conversion factor 1	Conversion factor 2	Freight mode 1 kgCO2e	Freight mode 2 kgCO2e	Total A4 kgCO2e
Phase II	Asphalt, 5% binder content	17,130,118	17130.118		Penderyn	22	376862.5938	Road	N/A	100%	0%	0.129086853	0	48648.006	0	48,648
	Aggregates and Sand - Typical UK Mix	69,032,929	69032.929		Swansea, Porta	25	1725823.232	Rail	Road	90%	10%	0.03333	0.12908685	51769.519	22278.1089	74,048
	Concrete - General (with 200kg rebar per m3 concrete)	12236000	12236		Swansea/Mert	40	489440	Road	N/A	1	0	0.129086853	0	63180.269	0	63,180
	Total															**185,876**

Freight mode: ..\..\Transport\2020_07_03 Traffic Flows.xlsx

Conversion factors (R https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

Material source locati Chris Justice (Chris.Justice@arup.com)

Total emissions from civil works (kgCO2e) 4,774,656

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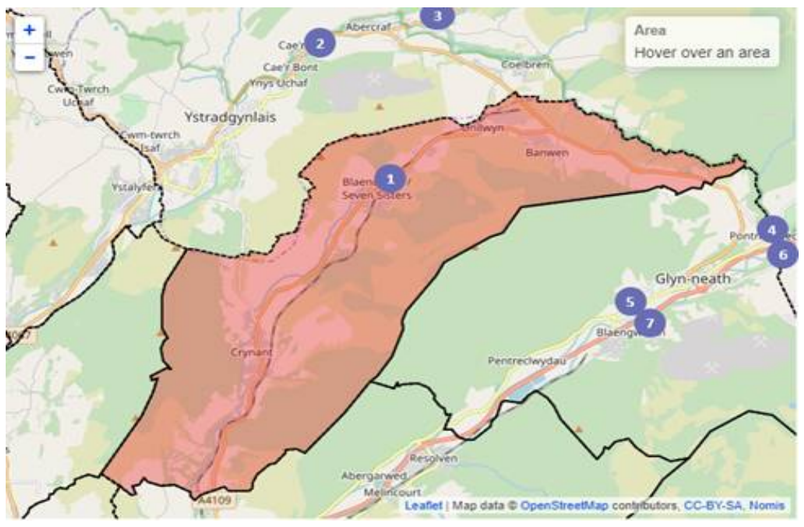
Basis of calculation

Source: Socio-economics chapter (workforce numbers) and Transport Assessment
Based on construction duration estimates provided by Chris Justice (Chris.Justice@arup.com)
Assume multiple construction activities can be undertaken simultaneously

Assumptions (based on those used in Transport Assessment)

Assume each commuting construction worker drives to work in a light goods vehicle (small diesel engine car)
2 people per vehicle
Distances based on method used in Transport Assessment (distribution as below)

Worker start location	Distribution of workers	Distance (km) to and from site
1	62%	12
2	5%	10.4
3	20%	10
4	1%	24.4
5	5%	22.6
6	7%	24.4
7	0%	22.6



Phases	Construction period (months)	Construction period (days)	No of workers	Distance travelled (km)
Phase I	18	548	80	285,623
Phase II	24	730	244	1,161,533
Phase III	12	365	244	580,767
			Total distance	2,027,923 km

	Km	kgCO2e
Small diesel car	1	0.13721

Source: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

Total emissions **278,251** kgCO2e

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Plant A5

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Power rating sources: https://shop.bsigroup.com/ProductDetail?pid=000000000030258086
ICES (1998) The Reference Manual for Construction Plant

Plant type	Power rating, kW (SB 5228-1:2009)	Proxy value where actual plant not available
Excavator with breaker	121	
Excavator with pulveriser	147	
Wheeled mobile crane	275	
Articulated dump truck	194	
Tracked crusher	172	
Tracked excavator	250	
Dozer	200	
Telehandler	90	Wheeled excavator
Vibratory roller	98	
Handheld angle grinder	2.3	
Tamper	1.1	
Hydraulic vibratory compactor	250	
Concrete mixer truck & pump	167	
Mobile telescopic crane (rail-mo	610	
Mobile telescopic crane	610	
Road planer	185	
Asphalt paver	112	
Concrete pump and mixer truck	171	
Tracked drilling / piling rig	104	
MEWP RRV	35	Lifting platform
Road rail excavator crane	610	
Wheeled excavator	90	
Lorry with lifting boom	50	
Concrete pump and mixer truck	171	
Poker vibrator	2.2	
Rotary bored piling rig	164	Oscillatory bored piling rig (ICES 1998)

Activity	Country	Unit	Year	kg CO2e
Electricity g	Electricity:	kWh	2019	0.2556
DEFRA 2019:				

Plant hours per week: 85 As per project description
Small and handheld plant excluded

Source: Based on construction duration estimates provided by Chris Justice (Chris.Justice@arup.com)

Construction Phase	Construction Activities	Estimated Construction Time	Estimated Construction Time (weeks, assume worst case)	Plant Type	No. plant	% on-time	% on time	Total use (hours)	kWhr	kgCO2e
Phase 1	Demolition of existing washery site and site establishment.	4 – 6 months	24	Excavator with breaker	1	50	50%	1020	123420	31546.152
			24	Excavator with pulveriser	1	50	50%	1020	149940	38324.664
			24	Wheeled mobile crane	1	50	50%	1020	280500	71695.8
			24	Articulated dump truck	2	20	20%	816	158304	40462.5024
			24	Tracked crusher	1	50	50%	1020	175440	44842.464
			24	Tracked excavator	2	50	50%	2040	510000	130356
			24	Dozer	1	30	30%	612	122400	31285.44
			24	Telehandler	2	80	80%	3264	293760	75085.056
			24	Vibratory roller	1	30	30%	612	59976	15329.8656
			40	Handheld angle grinder	2	20	20%	1360	3128	799.5168
			40	Tamper	1	20	20%	680	748	191.1888
			40	Hydraulic vibratory compactor	1	20	20%	680	170000	43452
			40	Articulated dump truck	2	50	50%	3400	659600	168593.76
			40	Tracked excavator	2	50	50%	3400	850000	217260
			40	Concrete mixer truck & pump	1	20	20%	680	113560	29025.936
			40	Telehandler	2	80	80%	5440	489600	125141.76
			40	Mobile telescopic crane (rail-m	1	50	50%	1700	1037000	265057.2
	Construction of electrical infrastructure – Primary DNO MV	6 – 8 months	32	Telehandler	2	50	50%	2720	244800	62570.88
			32	Mobile telescopic crane	1	20	20%	544	331840	84818.304
			32	Concrete mixer truck & pump	1	20	20%	544	90848	23220.7488
			32	Tracked excavator	2	70	70%	3808	952000	243331.2
	Internal highways and hardstanding work	2 – 4 months	16	Dozer	1	50	50%	680	136000	34761.6
			16	Articulated dump truck	2	20	20%	544	105536	26975.0016
			16	Vibratory roller	1	50	50%	680	66640	17033.184
			16	Road planer	1	20	20%	272	50320	12861.792
			16	Asphalt paver	1	40	40%	544	60928	15573.1968
			16	Tracked excavator	2	70	70%	1904	476000	121665.6
			16	Telehandler	2	80	80%	2176	195840	50056.704
			24	Handheld angle grinder	2	20	20%	816	1876.8	479.71008
			24	Tamper	1	20	20%	408	448.8	114.71328
			24	Hydraulic vibratory compactor	1	20	20%	408	102000	26071.2
			24	Articulated dump truck	2	50	50%	2040	395760	101156.256
			24	Tracked excavator	2	50	50%	2040	510000	130356
			24	Concrete mixer truck & pump	1	20	20%	408	68136	17415.5616
			24	Telehandler	2	80	80%	3264	293760	75085.056
			24	Mobile telescopic crane (rail-m	1	50	50%	1020	622200	159034.32
			8	Handheld angle grinder	2	20	20%	272	625.6	159.90336
			8	Tamper	1	20	20%	136	149.6	38.23776
			8	Hydraulic vibratory compactor	1	20	20%	136	34000	8690.4
			8	Articulated dump truck	2	50	50%	680	131920	33718.752
			8	Tracked excavator	2	50	50%	680	170000	43452
			8	Concrete mixer truck & pump	1	20	20%	136	22712	5805.1872
			8	Telehandler	2	80	80%	1088	97920	25028.352
			8	Mobile telescopic crane (rail-m	1	50	50%	340	207400	53011.44
	OLE installation on test track and onto selected sidings. Discrete activities (foundation	4 – 6 months	24	Concrete pump and mixer truc	1	20	20%	408	69768	17832.7008
			24	Tracked drilling / piling rig	2	50	50%	2040	212160	54228.096
			24	Wheeled mobile crane	2	50	50%	2040	561000	143391.6
			24	Tracked excavator	2	50	50%	2040	510000	130356
			24	MEWP RRV	2	50	50%	2040	71400	18249.84
			24	Road rail excavator crane	2	50	50%	2040	1244400	318068.64
	Construction of rail crossings; 2 no. bridge crossings	9 – 12 months	48	Mobile telescopic crane	4	70	70%	11424	6968640	1781184.384
			48	Tracked excavator	2	30	30%	2448	612000	156427.2
			48	Concrete pump and mixer truc	2	30	30%	2448	418608	106996.2048
			48	Articulated dump truck	2	30	30%	2448	479912	121387.5072
			48	Poker vibrator	2	30	30%	2448	5385.6	1376.55936
			48	Rotary bored piling rig	1	20	20%	816	133824	34205.4144
Phase 2	Additional electrical infrastructure. 3no. substations.	2 – 4 months	16	Telehandler	2	50	50%	1360	122400	31285.44
			16	Mobile telescopic crane	1	20	20%	272	165920	42409.152
			16	Concrete mixer truck & pump	1	20	20%	272	45424	11610.3744
			16	Tracked excavator	2	70	70%	1904	476000	121665.6
	Rolling Stock Maintenance Shed construction, including full-internal fit-out	12 – 18 months	72	Wheeled excavator	2	50	50%	6120	550800	140784.48
			72	Lorry with lifting boom	1	10	10%	612	30600	7821.36
			72	Wheeled mobile crane	2	50	50%	6120	1683000	430174.8
			72	Articulated dump truck	2	50	50%	6120	1187280	303468.768
			72	Concrete pump and mixer truc	2	40	40%	4896	837216	213992.4096
			72	Mobile telescopic crane	2	50	50%	6120	3733200	954205.92
			72	Poker vibrator	2	20	20%	2448	5385.6	1376.55936
			72	Rotary bored piling rig	1	20	20%	1224	200736	51308.1216
			72	Telehandler	2	80	80%	9792	881280	225255.168
			32	Handheld angle grinder	2	20	20%	1088	2502.4	639.61344
			32	Tamper	1	20	20%	544	598.4	152.95104
			32	Hydraulic vibratory compactor	1	20	20%	544	136000	34761.6
			32	Articulated dump truck	2	50	50%	2720	527680	134875.008
			32	Tracked excavator	2	50	50%	2720	680000	173808
			32	Concrete mixer truck & pump	1	20	20%	544	90848	23220.7488
			32	Telehandler	2	80	80%	4352	391680	100113.408
			32	Mobile telescopic crane (rail-m	1	50	50%	1360	829600	212045.76
	OLE installation on test track and on roads connecting to maintenance shed. Discrete	9 – 12 months	48	Concrete pump and mixer truc	1	20	20%	816	139536	35665.4016
			48	Tracked drilling / piling rig	2	50	50%	4080	424320	108456.192
			48	Wheeled mobile crane	2	50	50%	4080	1122000	286783.2
			48	Tracked excavator	2	50	50%	4080	1020000	260712
			48	MEWP RRV	2	50	50%	4080	142800	36499.68
			48	Road rail excavator crane	2	50	50%	4080	2488800	636137.28
	Construction of carriagewash	4 – 6 months	24	Articulated dump truck	1	50	50%	1020	197880	50578.128
			24	Concrete pump and mixer truc	1	40	40%	816	139536	35665.4016
			24	Mobile telescopic crane	1	50	50%	1020	622200	159034.32
			24	Poker vibrator	1	20	20%	408	897.6	229.42656
			24	Rotary bored piling rig	1	20	20%	408	66912	17102.7072
			24	Telehandler	1	80	80%	1632	146880	37542.528
			24	Tracked excavator	1	80	80%	1632	408000	104284.8
			40	Handheld angle grinder	2	20	20%	1360	3128	799.5168
			40	Tamper	1	20	20%	680	748	191.1888
			40	Hydraulic vibratory compactor	1	20	20%	680	170000	43452
			40	Articulated dump truck	2	50	50%	3400	659600	168593.76
			40	Tracked excavator	2	50	50%	3400	850000	217260
			40	Concrete mixer truck & pump	1	20	20%	680	113560	29025.936
			40	Telehandler	2	80	80%	5440	489600	125141.76
			40	Mobile telescopic crane (rail-m	1	50	50%	1700	1037000	265057.2
	Acoustic Barrier Construction*									
	Internal highways and hardstanding works	8 – 10 months	40	Dozer	1	50	50%	1700	340000	86904
			40	Articulated dump truck	2	20	20%	1360	263840	67437.504
			40	Vibratory roller	1	50	50%	1700	166600	42582.96
			40	Road planer	1	20	20%	680	125800	32154.48
			40	Asphalt paver	1	40	40%	1360	152320	38932.992
			40	Tracked excavator	2	70	70%	4760	1190000	304164
			40	Telehandler	2	80	80%	5440	489600	125141.76
	Construction of rail crossings; 1no. bridge crossings	6 – 9 months	36	Mobile telescopic crane	2	70	70%	4284	2613240	667944.144
			36	Tracked excavator	1	30	30%	918	229500	58660.2
			36	Concrete pump and mixer truc	1	30	30%	918	156978	40123.5768
			36	Articulated dump truck	1	30	30%	918	178092	45520.3152
			36	Poker vibrator	1	30	30%	918	2019.6	516.20976
			36	Rotary bored piling rig	1	20	20%	612	100368	25654.0608
Phase 3	Research & Development Centre construction	2 – 4 months	16	Wheeled excavator	1	50	50%	680	61200	15642.72
			16	Lorry with lifting boom	1	10	10%	136	6800	1738.08
			16	Articulated dump truck	1	50	50%	680	131920	33718.752
			16	Concrete pump and mixer truc	1	40	40%	544	93024	23776.9344
			16	Mobile telescopic crane	1	50	50%	680	414800	106022.88
			16	Poker vibrator	1	20	20%	272	598.4	152.95104
			16	Rotary bored piling rig	1	20	20%	272	44608	11401.8048
			16	Telehandler	1	80	80%	1088	97920	25028.352
	Station Testing facilities and laboratories	6 – 8 months	32	Wheeled excavator	1	50	50%	1360	122400	31285.44
			32	Lorry with lifting boom	1	10	10%	272	13600	3476.16
			32	Articulated dump truck	1	50	50%	1360	263840	67437.504
			32	Concrete pump and mixer truc	1	40	40%	1088	186048	47553.8688
			32	Mobile telescopic crane	1	50	50%	1360	829600	212045.76
			32	Poker vibrator	1	20	20%	544	1196.8	305.90208
			32	Rotary bored piling rig	1	20	20%	544	89216	22803.6096
			32	Telehandler	1	80	80%	2176	195840	50056.704
	Rolling stock decommissioning facility	6 – 8 months	32	Articulated dump truck	1	50	50%	1360	263840	67437.504
			32	Concrete pump and mixer truc	1	70	70%	1904	325584	83219.2704
			32	Mobile telescopic crane	1	50	50%	1360	829600	212045.76
			32	Poker vibrator	1	20	20%	544	1196.8	305.90208
			32	Rotary bored piling rig	1	20	20%	544	89216	22803.6096
			32	Telehandler	1	80	80%	2176	195840	50056.704
			32	Tracked excavator	1	80	80%	2176	544000	139046.4
			40	Handheld angle grinder	2	20	20%	1360	3128	799.5168
			40	Tamper	1	20	20%	680	748	191.1888
			40	Hydraulic vibratory compactor	1	20	20%	680	170000	43452
			40	Articulated dump truck	2	50	50%	3400	659600	168593.76
			40	Tracked excavator	2	50	50%	3400	850000	217260
			40	Concrete mixer truck & pump	1	20	20%	680	113560	29025.936
			40	Telehandler	2	80	80%	5440	489600	125141.76
			40	Mobile telescopic crane (rail-m	1	50	50%	1700	1037000	265057.2

Total	15,030,447

*No available information on acoustic barrier construction at time of assessment therefore excluded from the calculation
Exclusion justified under Section 5.5.2 Cut off rules of IEMA guidance 'Assessing Greenhouse Gas Emissions and Evaluating their Significance.' Available at https://www.iaia.org/pdf/wab/EIA%20Guide_GHG%20Assessment%20and%20Significance_IEMA_16May17.pdf

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Source: \\Global\Europe\Bristol\Jobs\264xxx\264904-11\4.40_Calculations\Costing\2020-04-21 GCRE Updated Phased Costing.xlsx

Design life 60

Assets requiring replacement within the 60-year lifecycle:

No construction programme available for maintenance and refurbishments at the time of the assessment so A5 emissions are excluded from the calculation

Exclusion of A5 justified under Section 5.5.2 Cut off rules of IEMA guidance 'Assessing Greenhouse Gas Emissions and Evaluating their Significance.' Available at https://www.iaia.org/pdf/wab/EIA%20Guide_GHG%20Assessment%20and%20Significance_IEMA_16May17.pdf

Asset	Life (years)	A1-A3	A4	No. of replacements	B2-B5 kgCO2e
Substations	25	309,792	2,061	2.4	748,447
Palisade fencing	25	4,729,354	6,308	2.4	11,365,589
Lighting bollards	25	61,488	25	2.4	147,629
Acoustic barriers	30	298,861	313	2	598,348
Access roads	20	94,787	4,967	3	299,262
Cess access track	25	370,464	53,196	2.4	1,016,785
Total					**14,176,059**

A4

	Material	Mass (kg)	Mass (tonnes)	Distance (km)	tonne.km	Freight mode 1	Freight mode 2	Percentage split		Conversion factor 1	Conversion factor 2	A4 kgCO2e
	Steel - General	3075586.3	3075.586	25	76889.65676	Rail	Road	80%	20%	0.03333	0.129086853	4,035
Fencing	Concrete - 32/40 MPa	1731873.2	1731.873	25	43296.82875	Rail	Road	80%	20%	0.03333	0.129086853	2,272
	Concrete - General	7452	7.452	25	186.3	Rail	Road	80%	20%	0.03333	0.129086853	10
Lighting bollards	Aluminium - Cast Prod	4600	4.6	25	115	Road	N/A	100%	0%	0.129086853	0	15
	Steel - General	177498.03	177.498	25	4437.450672	Rail	Road	80%	20%	0.03333	0.129086853	233
	Concrete - 32/40 MPa	12303.9	12.3039	25	307.5975	Rail	Road	80%	20%	0.03333	0.129086853	16
Acoustic barrier	Insulation - Mineral W	29700	29.7	50	1485	Rail	Road	90%	10%	0.03333	0.129086853	64
Access road	Asphalt, 5% binder con	1748846.4	1748.846	22	38474.6208	Road	N/A	100%	0%	0.129086853	0	4,967
Cess access track	Aggregates and Sand -	49593600	49593.6	25	1239840	Rail	Road	90%	10%	0.03333	0.129086853	53,196

Civils A1-A3 (Assume replace top 40mm of access track, replace whole cess track)

Asset	Length (m)	Width (m)	Area (m2)	Material (ICEv3 Reference)	Density (kg m3)	Thickness (mm)	Thickness (m)	Volume (m3)	Weight (kg)	Emission factor (kgCO2-e/kg)	Emissions (kgCO2-e)
Access road	2852	7.3	20819.6	Asphalt, 5% binder c	2100	40	0.04	832.784	1748846.4	0.0542	94,787
Cess access track	24600	3	73800	Aggregates and San	2240	300	0.3	22140	49593600	0.00747	370,464

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Operational hours per day: 12 https://catalogues.rssb.co.uk/rgs/standards/GIGN7621%20Iss%201.pdf
Sidings area taken from: ..\..\..\4-80 GIS\4-84 Map Documents\ENV_Environment\Environmental Statement\Intro\GCRE_264904_ES_1_1_SiteLayout_P01_2.mxd

Operational hours per day: 12

Lighting areas	Measure	Units	Light intensity (W/m2)	kWh/unit	kWh
Sidings	71,600	m2	3	13.1	941,468
Hardstanding associated with access (car parks)	16,470	m2	2	8.8	144,375
Hardstanding associated with buildings (walkways)	4,277	m2	3	13.1	56,244
Access roads	3,752	m	8	35.1	131,560

Reference: Energy benchmarks based on Arup experience, adopted as per Llanelli Wellness Centre Carbon Assessment

	kgCO2e:			
Operational year	Sidings	Car parks	Walkways	Access roads
1	101,518	15,568	6,065	14,186
2	94,604	14,508	5,652	13,220
3	95,543	14,652	5,708	13,351
4	89,528	13,729	5,348	12,511
5	95,478	14,642	5,704	13,342
6	90,413	13,865	5,401	12,634
7	83,279	12,771	4,975	11,637
8	75,083	11,514	4,485	10,492
9	66,065	10,131	3,947	9,232
10	55,584	8,524	3,321	7,767
11	51,531	7,902	3,078	7,201
12	44,791	6,869	2,676	6,259
13	37,093	5,688	2,216	5,183
14	37,093	5,688	2,216	5,183
15	37,093	5,688	2,216	5,183
16	37,093	5,688	2,216	5,183
17	37,093	5,688	2,216	5,183
18	37,093	5,688	2,216	5,183
19	35,887	5,503	2,144	5,015
20	34,681	5,318	2,072	4,846
21	33,475	5,133	2,000	4,678
22	32,269	4,949	1,928	4,509
23	31,063	4,764	1,856	4,341
24	29,858	4,579	1,784	4,172
25	28,652	4,394	1,712	4,004
26	27,446	4,209	1,640	3,835
27	26,240	4,024	1,568	3,667
28	25,034	3,839	1,496	3,498
29	25,034	3,839	1,496	3,498
30	25,034	3,839	1,496	3,498
31	25,034	3,839	1,496	3,498
32	25,034	3,839	1,496	3,498
33	25,034	3,839	1,496	3,498
34	25,034	3,839	1,496	3,498
35	25,034	3,839	1,496	3,498
36	25,034	3,839	1,496	3,498
37	25,034	3,839	1,496	3,498
38	25,034	3,839	1,496	3,498
39	25,034	3,839	1,496	3,498
40	25,034	3,839	1,496	3,498
41	25,034	3,839	1,496	3,498
42	25,034	3,839	1,496	3,498
43	25,034	3,839	1,496	3,498
44	25,034	3,839	1,496	3,498
45	25,034	3,839	1,496	3,498
46	25,034	3,839	1,496	3,498
47	25,034	3,839	1,496	3,498
48	25,034	3,839	1,496	3,498
49	25,034	3,839	1,496	3,498
50	25,034	3,839	1,496	3,498
51	25,034	3,839	1,496	3,498
52	25,034	3,839	1,496	3,498
53	25,034	3,839	1,496	3,498
54	25,034	3,839	1,496	3,498
55	25,034	3,839	1,496	3,498
56	25,034	3,839	1,496	3,498
57	25,034	3,839	1,496	3,498
58	25,034	3,839	1,496	3,498
59	25,034	3,839	1,496	3,498
60	25,034	3,839	1,496	3,498
Total:	**########**	**348,362**	**135,710**	**317,441**

Emissions from lighting over design life (kgCO2e): ########

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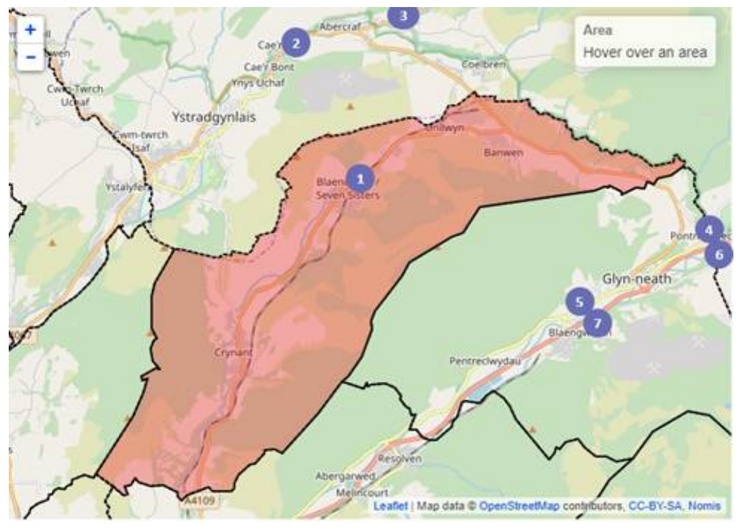
Basis of calculation
Source: OBC (workforce numbers) and Transport Assessment
Local traffic (that unrelated to GCRE) is not affected by the operation of GCRE
OBC - 'In respect of the Core Activities, it is considered that the site could support in the region of 50 to 90 permanent jobs'

Assumptions (based on those used in Transport Assessment)
Assume each commuting employee drives to work in a small diesel engine car/van
1 person per vehicle
Distances based on method used in Transport Assessment (distribution as below, construction and operation split assumed the same)

Further assumptions
Workers travelling to site as a result of indirect employment excluded from assessment (as visits to site are variable and difficult to anticipate)
Rolling Stock testing operational 252 days per year (see Rolling stock testing B6 tab)
Infrastructure testing operational 105 days (see Infrastructure testing B6 tab)
Each shift lasts 12 hrs
90 employees used as worse-case scenario

Worker start location	Distribution of workers	Distance (km) to and from site
1	62%	12
2	5%	10.4
3	20%	10
4	1%	24.4
5	5%	22.6
6	7%	24.4
7	0%	22.6



Phase	Year	Operational year	No. of permanent employees	No. of working days	Distance travelled	Gallons of fuel	Litres of fuel	kgCO2e
Phase I	2023	1	90	105	123,247	1,202	5,466	13,228
Phase II	2024	2	90	252	295,793	2,886	13,119	31,747
Phase III	2025	3	90	252	295,793	2,886	13,119	31,747
Phase III	2026	4	90	252	295,793	2,886	13,119	31,747
Phase III	2027	5	90	252	295,793	2,886	13,119	31,747
Phase III	2028	6	90	252	295,793	2,886	13,119	31,747
Phase III	2029	7	90	252	295,793	2,886	13,119	31,747
Phase III	2030	8	90	252	295,793	2,886	13,119	31,747
Phase III	2031	9	90	252	295,793	2,886	13,119	31,747
Phase III	2032	10	90	252	295,793	2,886	13,119	31,747
Phase III	2033	11	90	252	295,793	2,886	13,119	31,747
Phase III	2034	12	90	252	295,793	2,886	13,119	31,747
Phase III	2035	13	90	252	295,793	2,886	13,119	31,747
Phase III	2036	14	90	252	295,793	2,886	13,119	31,747
Phase III	2037	15	90	252	295,793	2,886	13,119	31,747
Phase III	2038	16	90	252	295,793	2,886	13,119	31,747
Phase III	2039	17	90	252	295,793	2,886	13,119	31,747
Phase III	2040	18	90	252	295,793	2,886	13,119	31,747
Phase III	2041	19	90	252	295,793	2,886	13,119	31,747
Phase III	2042	20	90	252	295,793	2,886	13,119	31,747
Phase III	2043	21	90	252	295,793	2,886	13,119	31,747
Phase III	2044	22	90	252	295,793	2,886	13,119	31,747
Phase III	2045	23	90	252	295,793	2,886	13,119	31,747
Phase III	2046	24	90	252	295,793	2,886	13,119	31,747
Phase III	2047	25	90	252	295,793	2,886	13,119	31,747
Phase III	2048	26	90	252	295,793	2,886	13,119	31,747
Phase III	2049	27	90	252	295,793	2,886	13,119	31,747
Phase III	2050	28	90	252	295,793	2,886	13,119	31,747
Phase III	2051	29	90	252	295,793	2,886	13,119	31,747
Phase III	2052	30	90	252	295,793	2,886	13,119	31,747
Phase III	2053	31	90	252	295,793	2,886	13,119	31,747
Phase III	2054	32	90	252	295,793	2,886	13,119	31,747
Phase III	2055	33	90	252	295,793	2,886	13,119	31,747
Phase III	2056	34	90	252	295,793	2,886	13,119	31,747
Phase III	2057	35	90	252	295,793	2,886	13,119	31,747
Phase III	2058	36	90	252	295,793	2,886	13,119	31,747
Phase III	2059	37	90	252	295,793	2,886	13,119	31,747
Phase III	2060	38	90	252	295,793	2,886	13,119	31,747
Phase III	2061	39	90	252	295,793	2,886	13,119	31,747
Phase III	2062	40	90	252	295,793	2,886	13,119	31,747
Phase III	2063	41	90	252	295,793	2,886	13,119	31,747
Phase III	2064	42	90	252	295,793	2,886	13,119	31,747
Phase III	2065	43	90	252	295,793	2,886	13,119	31,747
Phase III	2066	44	90	252	295,793	2,886	13,119	31,747
Phase III	2067	45	90	252	295,793	2,886	13,119	31,747
Phase III	2068	46	90	252	295,793	2,886	13,119	31,747
Phase III	2069	47	90	252	295,793	2,886	13,119	31,747
Phase III	2070	48	90	252	295,793	2,886	13,119	31,747
Phase III	2071	49	90	252	295,793	2,886	13,119	31,747
Phase III	2072	50	90	252	295,793	2,886	13,119	31,747
Phase III	2073	51	90	252	295,793	2,886	13,119	31,747
Phase III	2074	52	90	252	295,793	2,886	13,119	31,747
Phase III	2075	53	90	252	295,793	2,886	13,119	31,747
Phase III	2076	54	90	252	295,793	2,886	13,119	31,747
Phase III	2077	55	90	252	295,793	2,886	13,119	31,747
Phase III	2078	56	90	252	295,793	2,886	13,119	31,747
Phase III	2079	57	90	252	295,793	2,886	13,119	31,747
Phase III	2080	58	90	252	295,793	2,886	13,119	31,747
Phase III	2081	59	90	252	295,793	2,886	13,119	31,747
Phase III	2082	60	90	252	295,793	2,886	13,119	31,747

Total CO2e 1,886,316

Small diesel vans average 63.7 MPG = 102.5 KMPG
https://vanfueldata.vehicle-certification-agency.gov.uk/download.aspx

1 gallon = 4.546 litres

Global Centre of Rail Excellence (GCRE)

Rolling Stock Testing B6

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Assumptions (as per project description)

Fuel proportions for first two years stated as 70% e-, 20% H, 10% diesel

Have assumed 10% diesel over first 5 years of design life. Diesel usage is de-scoped after 5 operational years, with equal electic and hydrogen take-up

60 year design life

Rolling Stock testing operational during the daytime for seven days per week, for four evenings each week and for two nights per week = 116 hours a week = 6,048 hours a year (252 days)

Daytime (defined as 0700-1900), evening (1900-2300) and night-time (2300-0700)

Further assumptions

'Over 80% of journeys per km use electrified rail' (https://www.rssb.co.uk/en/Research-and-Technology/Sustainability/Decarbonisation/Decarbonisation-our-final-report-to-the-Rail-Minister)

Conversions:

kWh to kgCO2e https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Electricity/diesel power usage, train kms: https://dataportal.orr.gov.uk/

Electric train

Passenger train	Traction electricity usage (million kWh)	Train kms (million kms)	Electrified train kms (million km)	Electric kms (%)
2018-19	3,976.0	530.3	424.2	80%

kWh/train-km	9.4

Diesel train

Passenger train	Diesel usage (million litres)	Train kms (million kms)	Diesel train kms (million kms)	Diesel kms (%)
2018-19	469.3	530.3	106.1	20%

litre/train-km	4.4

H2 consumption (k 0.48 From Figure 6 of: References\Study on the use of fuel cells and hydrogen in the railway environment_final.pdf

kg H2 to kgCO2e: https://www.industry.gov.au/sites/default/files/2019-11/australias-national-hydrogen-strategy.pdf

kgCO2e / kgH2: 0

Assume 'green' / 100% recycled hydrogen. Assumed that hydrogen fuel would also be zero carbon at the point of use.

Rolling stock testing

Year operation 2024 Average speed (112.654 Average speed (mp 70

Appraisal perio 60 Vehicle-km per 567776.16 Operational hours 5040

Year	Operational year	Operational hours	Vehicle/fuel proportion			Energy consumption			Emissions (kgCO2e)		
			Electric	Hydrogen	Diesel	Electric (kWh)	Hydrogen (kg)	Diesel (litres)	Electric	Hydrogen	Diesel
2023	1	0	70%	20%	10%	0	0	0	0	0	0
2024	2	5040	70%	20%	10%	3,724,949	54,507	251,221	374,304	0	607,952
2025	3	5040	70%	20%	10%	3,724,949	54,507	251,221	378,021	0	607,952
2026	4	5040	70%	20%	10%	3,724,949	54,507	251,221	354,222	0	607,952
2027	5	5040	70%	20%	10%	3,724,949	54,507	251,221	377,761	0	607,952
2028	6	5040	70%	20%	10%	3,724,949	54,507	251,221	357,724	0	607,952
2029	7	5040	75%	25%	0%	3,991,017	68,133	0	353,031	0	0
2030	8	5040	75%	25%	0%	3,991,017	68,133	0	318,288	0	0
2031	9	5040	75%	25%	0%	3,991,017	68,133	0	280,059	0	0
2032	10	5040	75%	25%	0%	3,991,017	68,133	0	235,627	0	0
2033	11	5040	75%	25%	0%	3,991,017	68,133	0	218,445	0	0
2034	12	5040	75%	25%	0%	3,991,017	68,133	0	189,877	0	0
2035	13	5040	75%	25%	0%	3,991,017	68,133	0	157,242	0	0
2036	14	5040	75%	25%	0%	3,991,017	68,133	0	157,242	0	0
2037	15	5040	75%	25%	0%	3,991,017	68,133	0	157,242	0	0
2038	16	5040	75%	25%	0%	3,991,017	68,133	0	157,242	0	0
2039	17	5040	75%	25%	0%	3,991,017	68,133	0	157,242	0	0
2040	18	5040	75%	25%	0%	3,991,017	68,133	0	157,242	0	0
2041	19	5040	75%	25%	0%	3,991,017	68,133	0	152,130	0	0
2042	20	5040	75%	25%	0%	3,991,017	68,133	0	147,018	0	0
2043	21	5040	75%	25%	0%	3,991,017	68,133	0	141,906	0	0
2044	22	5040	75%	25%	0%	3,991,017	68,133	0	136,794	0	0
2045	23	5040	75%	25%	0%	3,991,017	68,133	0	131,682	0	0
2046	24	5040	75%	25%	0%	3,991,017	68,133	0	126,570	0	0
2047	25	5040	75%	25%	0%	3,991,017	68,133	0	121,458	0	0
2048	26	5040	75%	25%	0%	3,991,017	68,133	0	116,346	0	0
2049	27	5040	75%	25%	0%	3,991,017	68,133	0	111,234	0	0
2050	28	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2051	29	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2052	30	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2053	31	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2054	32	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2055	33	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2056	34	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2057	35	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2058	36	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2059	37	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2060	38	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2061	39	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2062	40	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2063	41	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2064	42	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2065	43	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2066	44	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2067	45	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2068	46	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2069	47	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2070	48	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2071	49	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2072	50	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2073	51	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2074	52	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2075	53	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2076	54	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2077	55	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2078	56	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2079	57	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2080	58	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2081	59	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
2082	60	5040	75%	25%	0%	3,991,017	68,133	0	106,123	0	0
								Total:	**9,067,993**	**0**	**3,039,759**

Combined total: 12,107,752

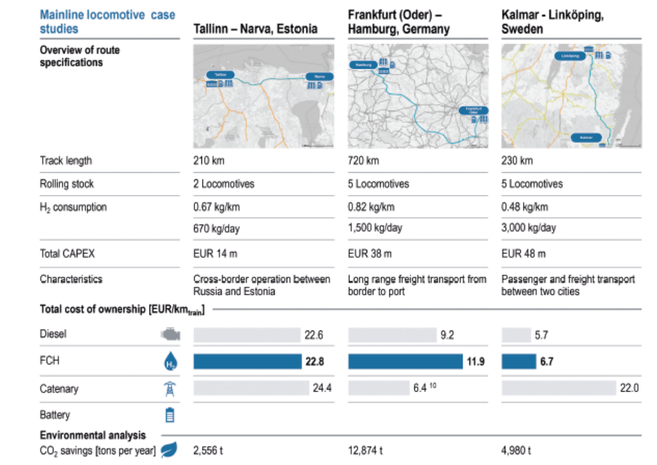

Figure 6: Overview of the Mainline Locomotives case studies including economic and environmental results(10).

Emissions intensity of production

Production technology	Emissions (kg CO_{2-e}/kg hydrogen)[vi]
Electrolysis – Australian grid electricity[vii]	40.5
Electrolysis – 100% renewable electricity	0
Coal gasification, no CCS[viii]	12.7 – 16.8
Coal gasification + CCS – best case[ix]	0.71
Steam methane reforming (SMR), no CCS[x]	8.5
SMR + CCS – best case[xi]	0.76

ARUP

Assumptions (based on project description)
Infrastructure testing operational 105 days / 2520 hours per year
60 year design life
Likely to mostly be powered electrically (25kV OLE) but potentially could be some diesel / bi-mode stock and potentially some hydrogen trains in the future.

Further assumptions
Electric freight vehicles are 4% of the total fleet (based on the fact that diesel freight trains produce 96% of total rail freight carbon emissions - see para. 6.23 of https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/901692/conversion-factors-2020-methodology.pdf). Expected to be within 5% margin of error.
'Only a small percentage of rail freight (around 5 per cent) is currently powered by electric traction' - Rail Freight Strategy 2016 (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/552492/rail-freight-strategy.pdf)

Electricity usage, train kms: https://dataportal.orr.gov.uk/

	Traction electricity usage (million kWh)	Freight train kms (million kms)	Electrified frieght train kms (million km)	Electric kms (%)
2018-19	74.9	33.6	1.3	4%

kWh/train-km	55.7

Infrastructure testing

Year operational:	2023	Average speed (	40
Appraisal period:	60	Average speed (	64.3738

Year	Operational	Operational	Distance (km)	kWh	kgCO2e
2023	1	2520	162,222	9,031,513	973,859
2024	2	2520	162,222	9,031,513	907,537
2025	3	2520	162,222	9,031,513	916,549
2026	4	2520	162,222	9,031,513	858,847
2027	5	2520	162,222	9,031,513	915,920
2028	6	2520	162,222	9,031,513	867,337
2029	7	2520	162,222	9,031,513	798,896
2030	8	2520	162,222	9,031,513	720,272
2031	9	2520	162,222	9,031,513	633,763
2032	10	2520	162,222	9,031,513	533,215
2033	11	2520	162,222	9,031,513	494,333
2034	12	2520	162,222	9,031,513	429,684
2035	13	2520	162,222	9,031,513	355,832
2036	14	2520	162,222	9,031,513	355,832
2037	15	2520	162,222	9,031,513	355,832
2038	16	2520	162,222	9,031,513	355,832
2039	17	2520	162,222	9,031,513	355,832
2040	18	2520	162,222	9,031,513	355,832
2041	19	2520	162,222	9,031,513	344,264
2042	20	2520	162,222	9,031,513	332,696
2043	21	2520	162,222	9,031,513	321,128
2044	22	2520	162,222	9,031,513	309,560
2045	23	2520	162,222	9,031,513	297,991
2046	24	2520	162,222	9,031,513	286,423
2047	25	2520	162,222	9,031,513	274,855
2048	26	2520	162,222	9,031,513	263,287
2049	27	2520	162,222	9,031,513	251,719
2050	28	2520	162,222	9,031,513	240,151
2051	29	2520	162,222	9,031,513	240,151
2052	30	2520	162,222	9,031,513	240,151
2053	31	2520	162,222	9,031,513	240,151
2054	32	2520	162,222	9,031,513	240,151
2055	33	2520	162,222	9,031,513	240,151
2056	34	2520	162,222	9,031,513	240,151
2057	35	2520	162,222	9,031,513	240,151
2058	36	2520	162,222	9,031,513	240,151
2059	37	2520	162,222	9,031,513	240,151
2060	38	2520	162,222	9,031,513	240,151
2061	39	2520	162,222	9,031,513	240,151
2062	40	2520	162,222	9,031,513	240,151
2063	41	2520	162,222	9,031,513	240,151
2064	42	2520	162,222	9,031,513	240,151
2065	43	2520	162,222	9,031,513	240,151
2066	44	2520	162,222	9,031,513	240,151
2067	45	2520	162,222	9,031,513	240,151
2068	46	2520	162,222	9,031,513	240,151
2069	47	2520	162,222	9,031,513	240,151
2070	48	2520	162,222	9,031,513	240,151
2071	49	2520	162,222	9,031,513	240,151
2072	50	2520	162,222	9,031,513	240,151
2073	51	2520	162,222	9,031,513	240,151
2074	52	2520	162,222	9,031,513	240,151
2075	53	2520	162,222	9,031,513	240,151
2076	54	2520	162,222	9,031,513	240,151
2077	55	2520	162,222	9,031,513	240,151
2078	56	2520	162,222	9,031,513	240,151
2079	57	2520	162,222	9,031,513	240,151
2080	58	2520	162,222	9,031,513	240,151
2081	59	2520	162,222	9,031,513	240,151
2082	60	2520	162,222	9,031,513	240,151

Total:	21,792,111

Habitat loss and creatoion for GCRE
Construction will result in some habitat loss, although this will be limited to areas of development including temporary works which require clearance within the washery area only
Areas within the Nant Helen site will have been cleared as part of the Nant Helen Complementary Earthworks project
The areas within the washery area which would require clearance to facilitate development, largely comprise buildings or other man made habitats associated with the current operations of the washery.
The operation of the Site as a rail testing, maintenance, research, development and storage facility will result in no further habitat loss
Opportunities exist within the washery for small-scale habitat creation, to mitigate for habitat loss, in addition to enhancements of the retained marshy grassland and acid grassland - heathland within the washery.
Embankments created around the tracks, will provide additional area for the establishment of grassland, and lichen / heathland communities.
Management and monitoring of any created / enhanced habitats will be crucial to ensure that the intended mitigation for this Project is implemented.
Source: Ecology chapter

Notes on the chapter
The ecology chapter states that opportunities exist for habitat creation as above, however, no indication of scale is given

Cut off
It is anticipated that the impact of habitat loss/creation as part of the GCRE project will be negligible and most habitat loss/creation will form part of future baseline (i.e. be included within the Nant Helen scope)
These activities are not expected to significantly change the result of the quantification and are excluded at this time
Guidance c https://www.iaia.org/pdf/wab/EIA%20Guide_GHG%20Assessment%20and%20Significance_IEMA_16May17.pdf

The emissions intensity of electricity will (and assumed to) decrease over time as per the table below

Table 1: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Year	Grid average		
	Consumption-based		
	Domestic	Commercial/ Public sector	Industrial
2010	0.501	0.492	0.483
2011	0.485	0.476	0.467
2012	0.532	0.523	0.513
2013	0.495	0.486	0.477
2014	0.441	0.433	0.425
2015	0.369	0.363	0.356
2016	0.291	0.285	0.280
2017	0.247	0.243	0.238
2018	0.180	0.177	0.174
2019	0.146	0.143	0.141
2020	0.141	0.138	0.135
2021	0.115	0.113	0.111
2022	0.107	0.105	0.103
2023	0.112	0.110	0.108
2024	0.104	0.102	0.100
2025	0.105	0.103	0.101
2026	0.099	0.097	0.095
2027	0.105	0.103	0.101
2028	0.100	0.098	0.096
2029	0.092	0.090	0.088
2030	0.083	0.081	0.080
2031	0.073	0.072	0.070
2032	0.061	0.060	0.059
2033	0.057	0.056	0.055
2034	0.049	0.048	0.048
2035	0.041	0.040	0.039
2036	0.041	0.040	0.039
2037	0.041	0.040	0.039
2038	0.041	0.040	0.039
2039	0.041	0.040	0.039
2040	0.041	0.040	0.039
2041	0.040	0.039	0.038
2042	0.038	0.038	0.037
2043	0.037	0.036	0.036
2044	0.036	0.035	0.034
2045	0.034	0.034	0.033
2046	0.033	0.032	0.032
2047	0.032	0.031	0.030
2048	0.030	0.030	0.029
2049	0.029	0.028	0.028
2050	0.028	0.027	0.027
2051	0.028	0.027	0.027
2052	0.028	0.027	0.027
2053	0.028	0.027	0.027
2054	0.028	0.027	0.027
2055	0.028	0.027	0.027
2056	0.028	0.027	0.027
2057	0.028	0.027	0.027
2058	0.028	0.027	0.027
2059	0.028	0.027	0.027
2060	0.028	0.027	0.027
2061	0.028	0.027	0.027
2062	0.028	0.027	0.027
2063	0.028	0.027	0.027
2064	0.028	0.027	0.027
2065	0.028	0.027	0.027
2066	0.028	0.027	0.027
2067	0.028	0.027	0.027
2068	0.028	0.027	0.027

2069	0.028	0.027	0.027
2070	0.028	0.027	0.027
2071	0.028	0.027	0.027
2072	0.028	0.027	0.027
2073	0.028	0.027	0.027
2074	0.028	0.027	0.027
2075	0.028	0.027	0.027
2076	0.028	0.027	0.027
2077	0.028	0.027	0.027
2078	0.028	0.027	0.027
2079	0.028	0.027	0.027
2080	0.028	0.027	0.027
2081	0.028	0.027	0.027
2082	0.028	0.027	0.027
2083	0.028	0.027	0.027
2084	0.028	0.027	0.027
2085	0.028	0.027	0.027
2086	0.028	0.027	0.027
2087	0.028	0.027	0.027
2088	0.028	0.027	0.027
2089	0.028	0.027	0.027
2090	0.028	0.027	0.027
2091	0.028	0.027	0.027
2092	0.028	0.027	0.027
2093	0.028	0.027	0.027
2094	0.028	0.027	0.027
2095	0.028	0.027	0.027
2096	0.028	0.027	0.027
2097	0.028	0.027	0.027
2098	0.028	0.027	0.027
2099	0.028	0.027	0.027
2100	0.028	0.027	0.027

Source: Department for Transport
https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
Table 2b: Converting road and rail fuels to CO2e (emissions factors), kgCO2e/litre

Year	Diesel
2010	2.562
2011	2.567
2012	2.609
2013	2.597
2014	2.601
2015	2.601
2016	2.602
2017	2.556
2018	2.511
2019	2.465
2020	2.420
2021	2.420
2022	2.420
2023	2.420
2024	2.420
2025	2.420
2026	2.420
2027	2.420
2028	2.420
2029	2.420
2030	2.420
2031	2.420
2032	2.420
2033	2.420
2034	2.420
2035	2.420
2036	2.420
2037	2.420
2038	2.420
2039	2.420
2040	2.420
2041	2.420
2042	2.420
2043	2.420
2044	2.420
2045	2.420
2046	2.420
2047	2.420
2048	2.420
2049	2.420
2050	2.420
2051	2.420
2052	2.420
2053	2.420
2054	2.420
2055	2.420
2056	2.420
2057	2.420
2058	2.420
2059	2.420
2060	2.420
2061	2.420
2062	2.420
2063	2.420
2064	2.420
2065	2.420
2066	2.420
2067	2.420

2068	2.420
2069	2.420
2070	2.420
2071	2.420
2072	2.420
2073	2.420
2074	2.420
2075	2.420
2076	2.420
2077	2.420
2078	2.420
2079	2.420
2080	2.420
2081	2.420
2082	2.420
2083	2.420
2084	2.420
2085	2.420
2086	2.420
2087	2.420
2088	2.420
2089	2.420
2090	2.420
2091	2.420
2092	2.420
2093	2.420
2094	2.420
2095	2.420
2096	2.420
2097	2.420
2098	2.420
2099	2.420
2100	2.420

Phase 1 – Infrastructure Testing (operational 2023):

- Infrastructure test track with 25kV overhead line electrification. Bi-directional rail access from N&B branch line.
- 12 full-length stabling roads.
- 1 shunters cabin (probably a portacabin with basic amenities) from which the shunter will move around the facility opening / closing hand points to enable train movements.
- Staff facilities – modular site cabin buildings with mess facilities, changing rooms, storage, IT.
- Infrastructure testing R&D facility – modular site cabin buildings with advanced IT for monitoring of infrastructure tests.
- External storage space – concrete hardstanding area with vehicle access for storage of materials & equipment for testing.

Phase 2 – Rolling Stock Testing (operational 2024):

- Rolling stock test track with 25kV overhead line (and potential 3rd rail DC) electrification. Bi-directional rail access from N&B branch line.
- 12 full-length stabling roads.
- Rolling stock maintenance shed. 2 roads at 400m length, 2 roads at 250m length. Internal and external storage spaces.
- Carriagewash.
- Improved (permanent) staff facilities. Those introduced in phase 1 will be removed. Provision of overnight accommodation, in addition to all previous functions.
- Upgrade of all points to electric points.
- Central control centre – panel from which all train movements are controlled. Points are changed electronically.
- Infrastructure testing R&D facility – relocated to location shown on final plan. [3] on phasing sketches.

Phase 3 – Aspirational inclusions (operational 2025):

- Rolling stock R&D / education facility.
- Stationary testing facilities and associated laboratories.
- Rolling stock maintenance & decommissioning facility.
- 10 'through' sidings, south of the N&B branch line (the phasing of this conflicts with what is shown in the email you sent across. It was later re-shuffled for the through sidings to be the last constructed).

Source: ..\..\..\4-70 Technical Notes\Rail\EIA Rail Information.docx