CORY

DECARBONISATION

ENVIRONMENTAL STATEMENT: 6.3 APPENDIX 5-1: CONSTRUCTION PHASE ASSESSMENT

Cory Decarbonisation Project

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Revision A

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations (2009) - Regulation 5(2)(a)

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1. CONSTRUCTION DUST ASSESSMENT METHODOLOGY

1.1. STEP 1 – SCREENING THE NEED FOR A DETAILED ASSESSMENT

1.1.1. An assessment will normally be required where there are:

- 'Human receptors' within approximately 350m of the Site Boundary; or within approximately 50m of the route(s) used by construction vehicles on the public highway, up to approximately 500m from the Site entrance(s); and/or
- 'Ecological receptors' within approximately 50m of the Site Boundary; or within approximately 50m of the route(s) used by construction vehicles on the public highway, up to approximately 500m from the Site entrance(s).

1.1.2. Where the need for a more detailed assessment is screened out, it can be concluded that the level of risk is 'negligible'.

1.2. STEP 2A – DEFINE THE POTENTIAL DUST EMISSIONS MAGNITUDE

1.2.1. The following are examples of how the potential dust emission magnitude for different activities can be defined (note that not all the criteria need to be met for a particular class). Other criteria may be used if justified in the assessment.

Table 1-1: Magnitude Examples (Dust Emissions)

Dust Emission Magnitude	Activity
Large	Demolition: >50,000m^3 building demolished, dusty material (e.g. concrete), onsite crushing/screening, demolition >20m above ground level.
	Earthworks: >10,000m^2 site area, dusty soil type (e.g. clay). >10 earth moving vehicles active simultaneously. >8m high bunds formed, >100,000 tonnes material moved.
	Construction: >100,000m^3 building volume, onsite concrete batching, sandblasting.
	Trackout: >50 Heavy Duty Vehicles (HDV) out/day, dusty surface material (e.g. clay), >100m unpaved roads.
Medium	Demolition: 20,000 - 50,000m^3 building demolished, dusty material (e.g. concrete).

Dust Emission Magnitude	Activity
	10-20m above ground level.
	Earthworks: 2,500 - 10,000m^2 site area, moderately dusty soil (e.g. silt), 5-10 earth moving vehicles active simultaneously, 4m - 8m high bunds, 20,000 - 100,000 tonnes material moved.
	Construction: 25,000 - 100,000m^3 building volume, dusty material e.g. concrete, onsite concrete batching.
	Trackout: 10 - 50 HDV out/day, moderately dusty surface material (e.g. clay), 50 - 100m unpaved roads.
Small	Demolition: <20,000m^3 building demolished, non-dusty material (e.g. metal cladding), <10m above ground level, work during wetter months.
	Earthworks: <2,500m^2 site area, soil with large grain size (e.g. sand), <5 earth moving vehicles active simultaneously, <4m high bunds, <20,000 tonnes material moved, earthworks during wetter months.
	Construction: <25,000m^3, non-dusty material (e.g. metal cladding or timber).
	Trackout: <10 HDV out/day, non-dusty soil, < 50m unpaved roads.
Note: HDV = Heavy Duty Vehicle(s).	

1.3. STEP 2B – DEFINE THE SENSITIVITY OF THE AREA

1.3.1. **Tables 1-2** to **Table 1-4** below present the IAQM dust guidance[1] methodology to determine the sensitivity of the area to dust soiling, human health and ecological impacts respectively. The IAQM dust guidance[1] provides guidance for the sensitivity of individual receptors to dust soiling and health impacts to assist in the assessment of the overall sensitivity of the Study Area.

Table 1-2: Sensitivity of the Area to Dust Soiling Impacts

Receptor Sensitivity	Number of Receptors	Distance from the Source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

Table 1-3: Sensitivity of the Area to Human Health Impacts

Receptor Sensitivity	Annual Mean PM_{10} Concentration (µg/m^3)	Number of Receptors	Distance from the Source (m)				
			<20	<50	<100	<200	<350
High	>32	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	28-32	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	24-28	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<24	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>32	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	28-32	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	24-28	>10	Low	Low	Low	Low	Low

Receptor Sensitivity	Annual Mean PM_{10} Concentration ($\mu g/m^3$)	Number of Receptors	Distance from the Source (m)				
			<20	<50	<100	<200	<350
		1-10	Low	Low	Low	Low	Low
	<24	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Table 1-4: Sensitivity of the Area to Ecological Impacts

Receptor Sensitivity*	Distance from the Sources (m)	
	<20	<50
High	High	Medium
Medium	Medium	Low
Low	Low	Low

Notes:

*Receptor sensitivity judged using the following metrics:

High sensitivity receptor:

- locations with an international or national designation and the designated features may be affected by dust soiling; or
- locations where there is a community of a particularly dust sensitive species such as vascular species included in the Red Data List For Great Britain.

Medium sensitivity receptor:

- locations where there is a particularly important plant species, where its dust sensitivity is uncertain or unknown; or
- locations with a national designation where the features may be affected by dust deposition.

Low sensitivity receptor:

- locations with a local designation where the features may be affected by dust deposition.

1.4. STEP 2C – DEFINE THE RISK OF IMPACT

1.4.1. The dust emissions magnitude determined at Step 2A should be combined with the sensitivity of the area determined at Step 2B to determine the risk of impacts without mitigation applied. For those cases where the risk category is 'negligible' no mitigation measures beyond those required by legislation will be required.

Table 1-5: Risk of Dust Impacts

Sensitivity of surrounding Area	Dust Emission Magnitude		
	Large	Medium	Small
Demolition			
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible
Earthworks and Construction			
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible
Trackout			
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

1.5. STEP 3 – SITE SPECIFIC MITIGATION

1.5.1. Having determined the risk categories for each of the four activities it is possible to determine the site-specific mitigation measures to be adopted. These measures will be related to whether the Site is considered to be a low, medium or high risk site. The IAQM dust guidance[1] details the mitigation measures required for high, medium and low risk sites as determined in Step 2C. For the Proposed Scheme these are set out in **Section 5.9** of **Chapter 5: Air Quality (Volume 1)**.

2. KEY MODEL INPUTS

2.1.1. The general model inputs used in the air quality assessment are summarised in **Table 2-1** below.

Table 2-1: Key Model Inputs

Variable	Input	Commentary
Meteorological Data	5 years of hourly sequential data from London City Airport, 2018 to 2022.	London City Airport is approximately 7.5km west of the Site Boundary and representative of conditions to the east of central London. Wind roses are shown in **Figure 2-1** of this appendix. The prevailing wind is from the southwest in all years.
Surface Roughness at Site	1.0m	1.0m is the recommended value for 'cities' in ADMS. Sensitivity testing was undertaken for surface roughness between 0.3m to 1.0m. The selected value is conservative in that it gives the highest ground level impacts.
Surface Roughness of Met Site (London City Airport)	0.5m	London City Airport itself has an open aspect hence the roughness length was reduced to ADMS recommendation for 'open suburbia' for the meteorological site.
Minimum Monin-Obukhov Length at Site	100m	Selected value is the ADMS recommended values for large conurbations >1million population. Both Met Site (London City Airport) and process Site are located within the overall London conurbation.
Minimum Monin-Obukhov Length at Met Site	100m	
Building Downwash	Included in the Baseline: Riverside 1 and Riverside 2 housing units.	Downwash is the enhanced turbulent mixing of pollutants in the lee of buildings which can result in relatively elevated pollutant concentrations in the wake of the building. Buildings are included where they are within 5L of an emission point, where L is the lesser

Variable	Input	Commentary
		or the building height or crosswind width, and greater than 1/3rd of the exhaust stack height for Riverside 1 and Riverside 2. This follows best practice guidance[2]. Building parameters are provided in **Table 2-2** and visualised in **Figure 2-2**: Modelled **Building Layouts (Baseline)** of this appendix. The ADMS 'Main building' is source specific and set to be the housing unit for Riverside 1 and Riverside 2 in the Baseline, and to the Absorber Column(s) and Stack(s) with the Carbon Capture Facility.
Receptors	Gridded at variable resolution (100m within 5km, 250m to 15km).	Receptors set at height 0m. Resolution of fine grid is within the recommended minimum resolution of 1.5 x Stack(s) height (150m). Impacts on human health are assessed against the maximum impact in the Study Area, irrespective of the presence of properties at the point of maximum impact. Impacts on ecological receptors are assessed at grid points within each habitats site which were selected based on their presence within each ecological site.
Terrain Data	Not included.	No significant terrain gradients within the Study Area, so no requirement to model terrain.
Deposition	No plume depletion.	The Study Area is largely built up and there will be minimal plume depletion onto man-made surfaces. Deposition of pollutants to habitats sites is modelled using deposition velocity approach using the dry deposition velocities given by Environment Agency Guidance[2] (**Table 2-3**).
Amine Chemistry	ADMS amine chemistry module.	Details in **Section 2.2** below.

Table 2-2: Buildings Included in the Modelling for the Baseline

Building	Shape	Easting	Northing	Height	Length	Width	Angle
Existing Buildings							
Riverside 1	Rectangular	594438	180670	65	107	170	90.4
Riverside 2	Rectangular	549692	180657	50	126	148	90.4

Table 2-3: Dry Deposition Velocities used in Post-processing Model Outputs

Chemical Species	Vegetation Type	Deposition Velocity (mm/s)
NO_2	Short Vegetation	1.5
	Forest Vegetation	3
SO_2	Short Vegetation	12
	Forest Vegetation	24
NH_3	Short Vegetation	20
	Forest Vegetation	30

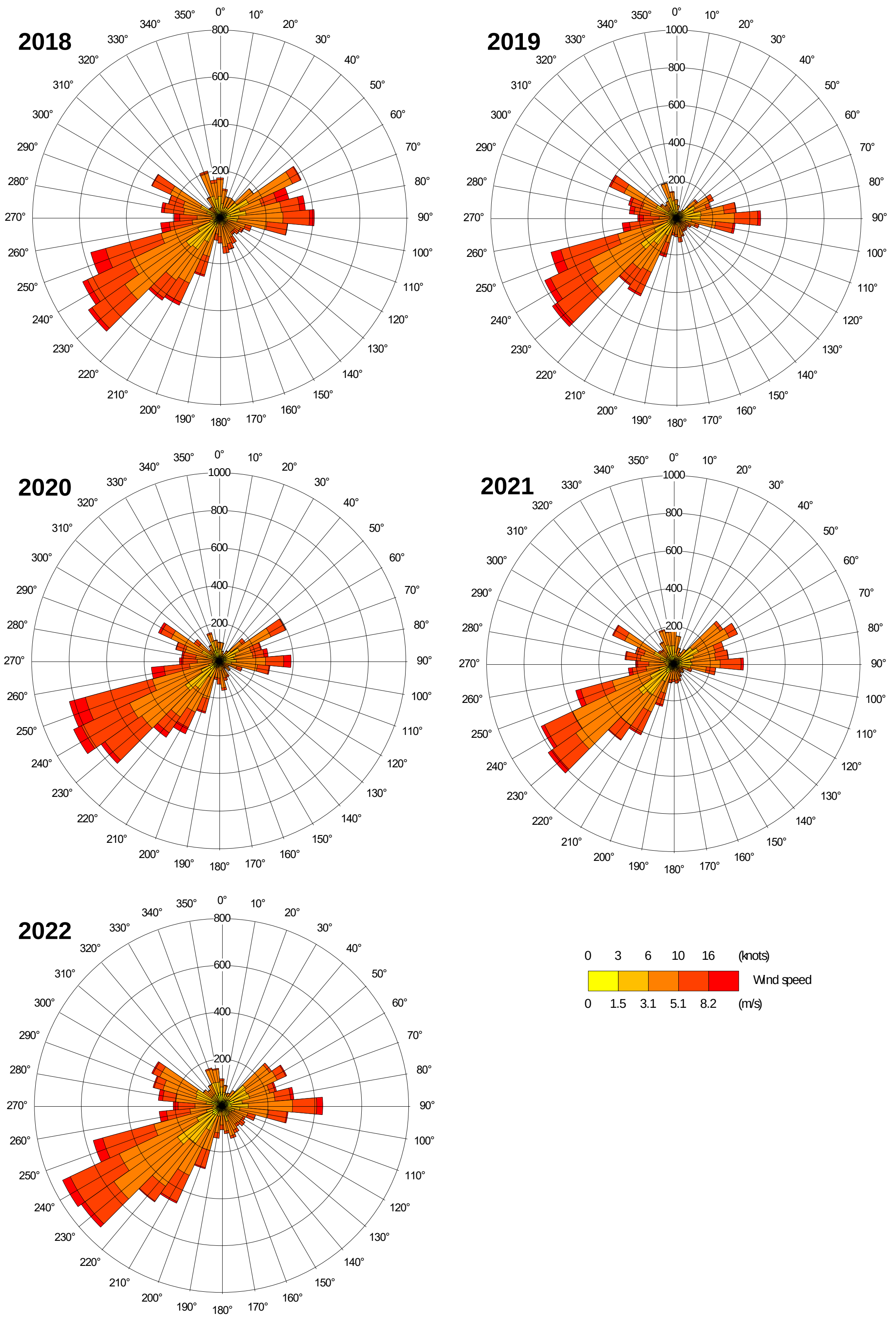

Figure 2-1: Wind Roses for London City Airport

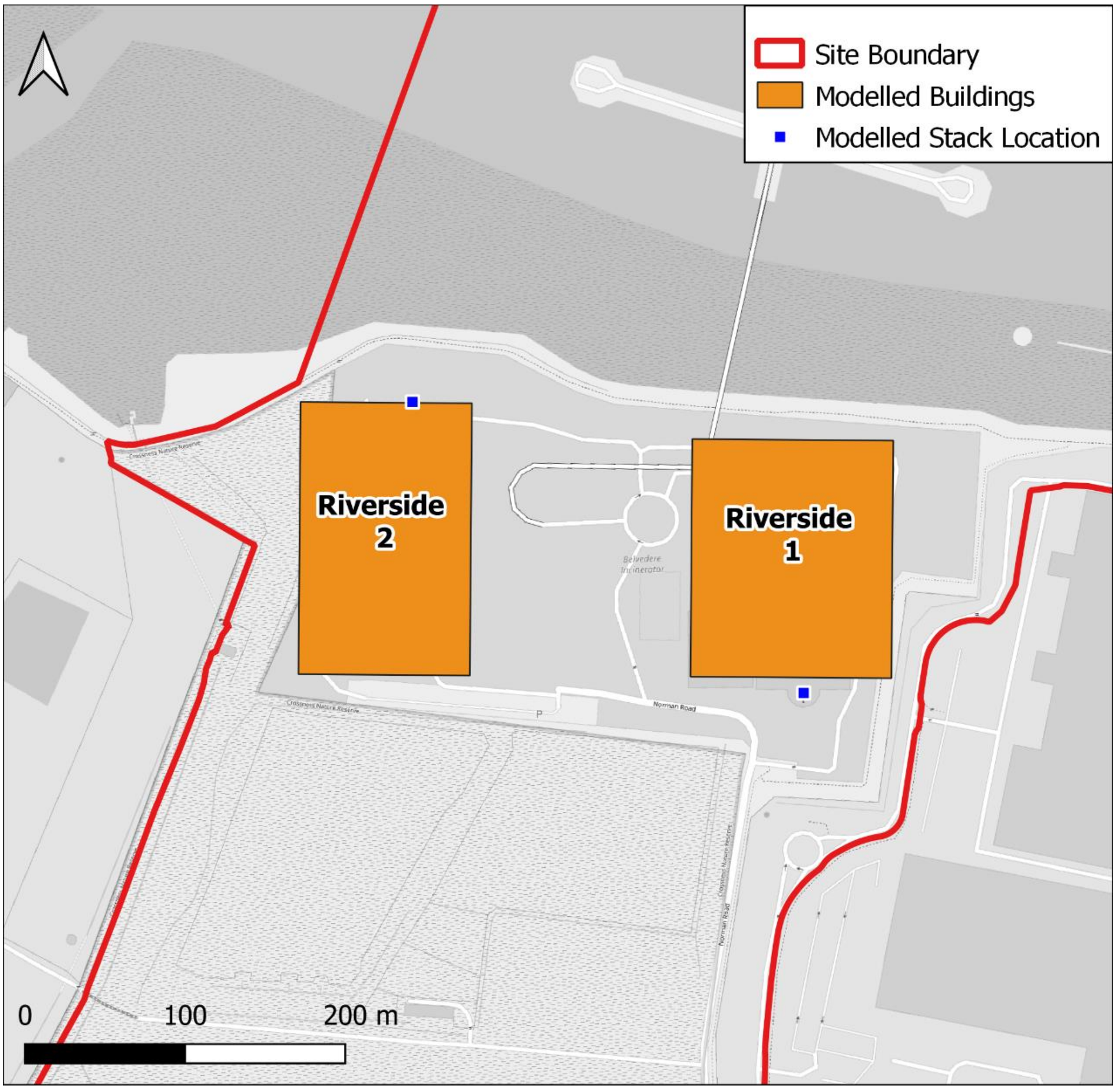

Figure 2-2: Indicative Modelled Building Layouts (Baseline) (Riverside 1 and Riverside 2 modelled stacks shown as blue squares)

2.2. POST PROCESSING

Sub-hourly Impacts

2.2.1. Meteorological data is input to the model as hourly mean data. It is not, therefore, possible to directly model 15 minute peak concentrations, required for sulphur dioxide (SO_2), since the variability of meteorological data on sub-hourly timescales is not represented in the model inputs. The Environment Agency provide scaling factors to adjust from hourly to sub-hourly peak concentrations. As such, the 99.9th percentile of 15 minute SO_2 concentrations for assessment against the 15 minute air quality objective is modelled by using the model to output the 99.9th percentile of hourly mean concentrations and using the Environment Agency's scaling factor of 1.34 to convert to a 15 minute averaging period. This approach results in higher, more conservative, modelled concentrations than directly outputting 15 minute average concentrations from the model itself.

Atmospheric Chemistry – NO_X to NO_2

2.2.2. Emissions of oxides of nitrogen (NO_X) from combustion sources include both nitrogen dioxide (NO_2) and nitric oxide (NO), with the majority being in the form of NO. In ambient air, NO is oxidised to form NO_2, and it is NO_2 which has the more significant health impacts. For this assessment, the conversion of NO to NO_2 has been estimated using the worst-case assumptions set out in Environment Agency Guidance[3], namely that:

- for the assessment of long term (annual mean) impacts, at receptors 70% of NO_X is NO_2; and
- for the assessment of short term (hourly mean) impacts, at receptors 35% of NO_X is NO_2.

2.2.3. The oxidation of NO to NO_2 is not, however, an instantaneous process, thus the Environment Agency worst case assumptions are very conservative for modelled impacts within a few hundred metres of any stack.

3. ASSESSMENT OF CONSTRUCTION PHASE TRAFFIC

3.1. TRAFFIC DATA

3.1.1. **Table 3-1** below presents the traffic data used in the assessment for Baseline, Do Minimum and Do Something. The speeds used were taken from speed limits for individual roads and vehicles were slowed to 20kph at approaches to junctions. As noted in **Chapter 5: Air Quality (Volume 1)** the data presented is a peak daily flow during the construction period and not representative of an annual average, further information is provided in **Chapter 18: Landside Transport (Volume 1)**. The annual average is likely to be much lower than what was assessed (due to the phasing of the construction activities), therefore, the assessment of annual mean impacts is worst case.

Table 3-1: Traffic Data used for the Assessment of Construction Vehicles

Road	Direction	Baseline 2022		Do Minimum 2028		Do Something 2028	
		AADT	HDV	AADT	HDV	AADT	HDV
Norman Road, 155m north of A2016 Eastern Way	NB	1,222	417	1,669	778	2,174	803
	SB	1,234	267	1,682	621	2,187	646
A2016 Eastern Way, 160m west of Clydesdale Way	EB	10,739	492	11,424	727	11,459	733
	WB	11,073	513	11,772	748	11,807	755
Yarnton Way, 140m south of Clydesdale Way	NB	5,112	200	5,334	213	5,334	213
	SB	4,837	96	5,047	104	5,095	104
A2016 Picardy Manorway, 55m north of Clydesdale Way	EB	15,394	958	16,426	1,341	16,931	1,366
	WB	15,083	1,114	16,102	1,505	16,607	1,530
A2016 Picardy Manorway, 85m east of Norman Road	EB	14,945	1,273	15,957	1,670	16,462	1,695
	WB	15,008	1,009	16,024	1,395	16,529	1,420
Little Brights Road, 30m south of B253 Picardy Manorway	NB	5,294	41	5,539	46	5,716	46
	SB	5,510	31	5,764	36	5,942	36
A2016 Bronze Age Way, 145m south of Horse Roundabout	NB	12,443	1,269	13,119	1,445	13,363	1,464
	SB	12,193	1,256	12,858	1,432	13,103	1,451
A206 Northend Road, 135m north of Bridge Road	NB	16,482	1,588	17,334	1,778	17,578	1,797
	SB	16,470	1,639	17,321	1,832	17,566	1,851
A2000 Perry Street, 75m south of Tanners Close	NB	7,719	268	8,072	280	8,072	280
	SB	8,625	382	9,020	399	9,020	399

Road	Direction	Baseline 2022		Do Minimum 2028		Do Something 2028	
		AADT	HDV	AADT	HDV	AADT	HDV
A206 Thames Road, 95m south of A206 Thames Road	NB	15,249	1,280	16,169	1,468	16,413	1,487
	SB	14,969	1,484	15,875	1,683	16,119	1,701
A206 Thames Road, 40m west of Screwfix Access	EB	20,403	998	21,587	1,171	21,831	1,190
	WB	20,592	982	21,786	1,154	22,030	1,173
A2026 Burnham Road, 95m north of Chatsworth Road	NB	8,951	116	9,555	123	9,555	123
	SB	9,315	263	9,943	281	9,943	281
A206 Bub Dunn Way, 190m east of A2026 Burnham Road	EB	12,770	1,396	13,760	1,612	14,004	1,630
	WB	14,448	1,620	15,550	1,851	15,794	1,870
A206 Bob Dunn Way, 300m south of Marsh St North	EB	15,665	1,717	16,943	1,965	17,187	1,984
	WB	12,809	1,684	13,878	1,929	14,122	1,948
A220 Bexley Road, 50m east of Park Crescent Road	EB	5,208	97	5,469	102	5,469	102
	WB	4,600	83	4,831	87	4,831	87
A2041 Harrow Manorway, 15m north of Godstow Road	NB	11,284	141	11,910	148	11,910	148
A2041 Harrow Manorway, 40m north of Thistlebrook	NB	9,762	77	10,304	82	10,304	82
	SB	9,715	60	10,254	64	10,254	64

Notes:
NB = Northbound
SB = Southbound
AADT = Annual Average Daily Traffic
HDV = Heavy Duty Vehicle

3.2. VERIFICATION

3.2.1. The comparison of modelled concentrations with local monitored concentrations is a process termed 'verification'. Model verification investigates the discrepancies between modelled and measured concentrations, which can arise due to the presence of inaccuracies and/or uncertainties in model input data, modelling and monitoring data assumptions. The following are examples of potential causes of such discrepancy:

- estimates of background pollutant concentrations;
- meteorological data uncertainties;
- traffic data uncertainties;
- model input parameters, such as 'roughness length'; and
- overall limitations of the dispersion model.

Nitrogen Dioxide

3.2.2. Most nitrogen dioxide is produced in the atmosphere by the reaction of NO with ozone. It is therefore most appropriate to verify the model in terms of the primary pollutant emissions of nitrogen oxides ($NO_X = NO + NO_2$), in line with the guidance provided within LAQM.TG(22)[4].

3.2.3. The model has been run to predict the 2022 annual mean road-NO_X contribution at eight roadside diffusion tubes within the modelled road network. The model outputs of road-NO_X have been compared with the 'measured' road-NO_X, which was determined from the NO_2 concentrations measured using diffusion tubes at the monitoring locations, utilising the NO_X from NO_2 calculator provided by Defra and the sector removed NO_X background concentration (from the DEFRA background mapping[5]). The most recent suitable data available for model verification purposes is 2022.

3.2.4. **Table 3-2** below presents a summary of the monitored and modelled inputs for the verification calculation. The table contains the full list of monitoring locations and the reason for their exclusion, if appropriate.

Table 3-2: Summary of Verification Undertaken

Company	ID	Monitored NO_2	Monitored Road NO_X	Unverified Modelled NO_X	Background NO_2	Include (Y/N)	Reason	Monitored NO_X / Modelled NO_X
WSP	DTS1	26.5	12.8	2.7	20.3	Y	N/A	4.79
WSP	DTS5	42.0	49.3	7.2	20.3	Y	N/A	6.85
WSP	DTS6	25.8	11.3	3.6	20.3	N	Excluded for conservatism	3.12
WSP	DTS7	27.7	15.4	2.8	20.3	Y	N/A	5.49
Dartford	DA36	27.4	14.7	5.1	20.3	N	Excluded for conservatism	2.89
Dartford	DA83	28.0	16.0	1.2	20.3	N	Missing nearby source	13.43
Dartford	DA96	32.0	25.0	6.8	20.3	N	Excluded for conservatism	3.70
Dartford	DA104	25.4	10.4	2.1	20.3	Y	N/A	5.01
Note: All concentrations are shown in $\mu g/m^3$.								

3.2.5. **Figure 3-1** below shows the comparison of monitored and modelled (unverified) NO_X for the monitoring points used in verification.

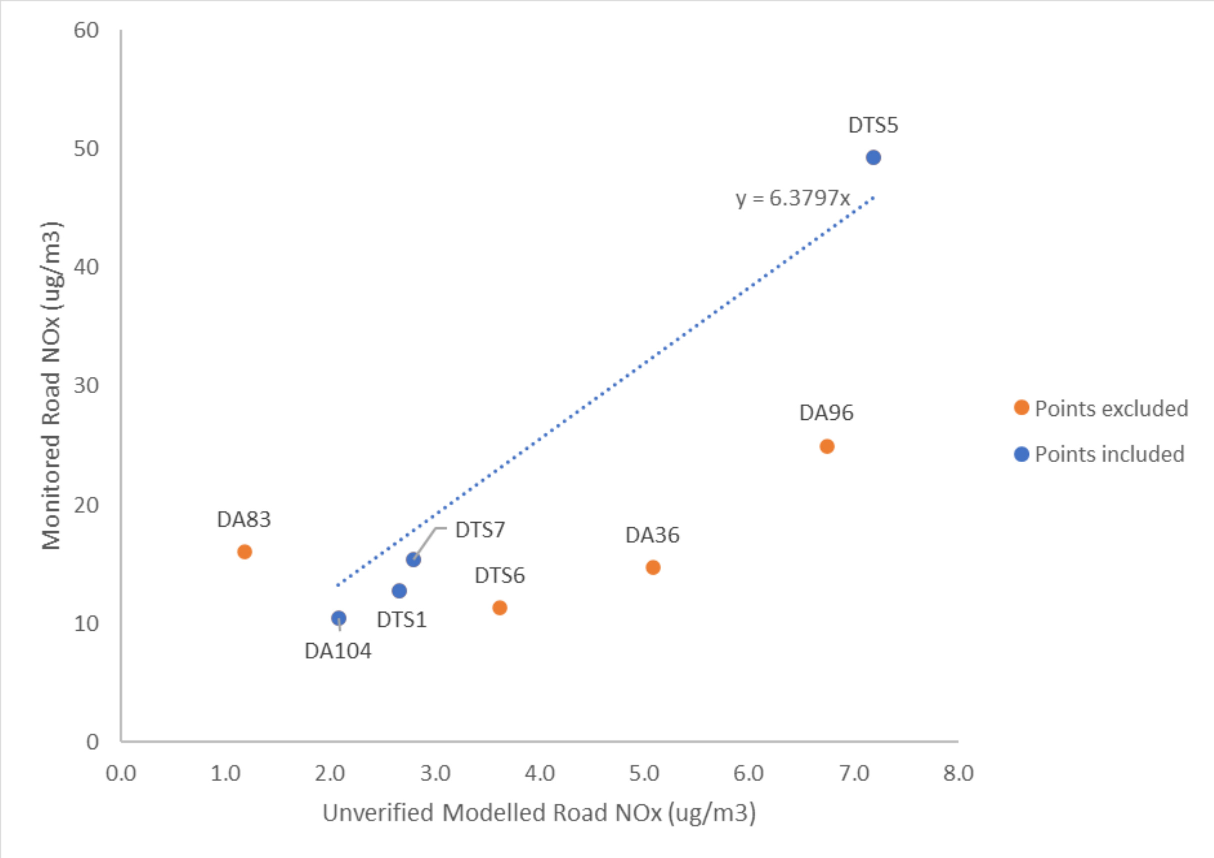

Figure 3-1: Spatial Distribution of Verification

3.2.6. From the graph a verification factor of 6.3797 was obtained and used for all receptors in the assessment of impacts from construction traffic.

3.3. RESULTS

3.3.1. The results of the modelling of construction traffic is presented in **Section 5.8** in **Chapter 5: Air Quality (Volume 1)**.

4. ASSESSMENT OF MARINE CONSTRUCTION VESSELS

4.1. MARINE EMISSIONS CALCULATIONS

4.1.1. The assessment of emissions uses the methodology proposed by European Environment Agency Guidance[6] in which detailed methodologies for calculating emissions, specifically from shipping are presented. The guidance adopts a tiered approach, with increasing sophistication, to inventory generation, as follows:

- Tier 1 – uses default emission rates based on fuel consumption;
- Tier 2 – emission rates based on fuel consumption and engine types in the fleet; and
- Tier 3 – emission rates for vessel movements stratified by engine technology either as mass/kWh or mass/hr.

4.1.2. For this assessment, taking into account data availability, a hybrid approach was used across the 3 tiers for each key emission sector, with emissions calculated for each of the following vessel/plant activities during construction:

- Hotelling (HOT) – the term used for when a ship is docked in port;
- Manoeuvring (MAN) – the movement of a ship casting off or docking up;
- Cruising (CRU) – the movement of a ship approaching or leaving the port; and
- Dredging (DRE) – the operation of a generator to power dredging equipment loaded onto the jack-up barge (not associated with vessel movements).

4.1.3. **Table 5-4** in **Chapter 5: Air Quality (Volume 1)** presents the vessel movement data for the construction phase that were used in the assessment.

4.1.4. A Tier 3 approach was used in which an emission factor is multiplied by an activity, e.g. energy used by vessel, to calculate the mass of emissions generated during the construction phase from marine vessels. The equation used to calculate the emissions from the marine vessels is set out below.

$$Emissions_{Marine} = \sum_{Vessels} EF_{Engine} \times P_{Engine} \times OL_{Mode} \times TM_{Vessel}$$

4.1.5. Where:

- $Emissions_{Marine}$ = Emissions (g) from all marine vessel movements;
- EF_{Engine} = Emission Factor (g/kWh) for each engine;
- P_{Engine} = Maximum Power of an engine (kW);
- OL_{Mode} = Operating Load (%) of each engine for each mode; and
- TM_{Vessel} = Time in Mode (hours) for each vessel.
  - N.B. this will change depending on the averaging period considered (e.g. annual mean, daily mean, etc.).

4.1.6. Further details of the data used within the calculation of each element is set out below:

- **Emission Factor (g/kWh)** – emission factors vary by engine size and type and are set out in **Table 4-1**, below:
  - for all modelled pollutants the emission factor data were taken from EEA standard values for engines run on Marine Diesel Oil for tugs, jack-up barges, jack-up generators, passenger boats and dredging boats.
- **Energy Used by Vessels (kW)** – a value for the energy used by each vessel was calculated for each of the relevant time periods (i.e. annual, daily, hourly, based on the averaging period for relevant pollutants):
  - ship engine power (with main engines and auxiliary engines taken into account, kW) – this is set out in **Table 5-4** of **Chapter 5: Air Quality (Volume 1)**;
  - operating load (%) – this was taken from EEA standard values, considered as a function of vessel activity for both the main and auxiliary engines. The values used within the assessment are set out in **Table 4-2**, below; and
  - time in mode (hrs) – the time in mode was chosen to represent peak activity within the relevant averaging period for each pollutant standard, based on the expected operating profile for construction vessels. The values used within the assessment are set out in **Table 4-3**, below.
    - ~ **Paragraph 5.4.50** in **Chapter 5: Air Quality (Volume 1)** of the ES sets out the key assumptions made with regards to ship types, engine size and length of time during each activity for the construction phase. Using this data, a reasonable worst case scenario for the time in mode for each vessel for each averaging period (i.e. daily, hourly - associated with a relevant air quality standards during the construction phase).
    - ~ as a worked example, the worst case hours of operation per day of dredging barges are considered. At their peak, they would have 2 visits per day (i.e. one in and one out). Therefore, the cruising time in mode would be 2 times the duration of cruising (2 x 0.82 = 1.64). Each of these vessels would be manoeuvring for 1 hour (2 hours in total). Typically, a dredging barge would be at site all day, until it is replaced by another – i.e. the equivalent hotelling for 24 hours per day.

Table 4-1: Marine Engine Emission Factors used within the Assessment

Ship Type	Engine Type	Fuel Type	Mode	NOx Emission Factor (g/kWh)	PM Emission Factor (g/kWh)	SO_2 Emission Factor (g/kWh)
Tug	High Speed	Marine Diesel Oil/Marine Fuel Oil	CRU	8.53	0.118	0.41
			MAN	11.7	0.367	0.608
			HOT	11.7	0.367	0.608
Jack-Up Barge	Low Speed	Marine Diesel Oil/Marine Fuel Oil	CRU	17.7	0.18	0.356
			MAN	24.3	0.361	0.53
			HOT	24.3	0.361	0.53
Jack-Up Generator	Low Speed	Marine Diesel Oil/Marine Fuel Oil	DRE	17.7	0.18	0.356
Passenger Boat	High Speed	Marine Diesel Oil/Marine Fuel Oil	CRU	8.53	0.118	0.41
			MAN	11.7	0.367	0.608
			HOT	11.7	0.367	0.608
Dredging Boat	Low Speed	Marine Diesel Oil/Marine Fuel Oil	CRU	17.7	0.18	0.356
			MAN	24.3	0.361	0.53
			HOT	24.3	0.361	0.53

Table 4-2: Engine Load Factors used within the Assessment

Phase	% Load of Maximum Continuous Rating Main Engine	% Time All Main Engine operating
CRU	80	100
MAN	20	100
HOT (CO_2 Vessels)	20	5
HOT (Tankers)	20	100
DRE	80	100

Table 4-3: Hours of Operation by Mode for a Worst Case Day and Worst Case Hour

Ship Type	Daily Operating Period (hours of operation in worst day)			Hourly Operating Period (hours of operation in worst hour)		
	CRU/DRE	MAN	HOT	CRU/DRE	MAN	HOT
Tug	3.28	4	0	0.55	0.45	0
Jack-up Barge	0	0	24	0	0	1
Jack-up Geni	11	0	0	1	0	0
Passenger Boat	2.46	1.50	1.50	0.55	0.45	0
Dredging Barge	1.64	2	24	0.55	0.45	0

4.2. MARINE VESSEL DISPERSION MODEL INPUTS

4.2.1. The sources used within the dispersion model to represent the construction phase contribution to pollutant concentrations from marine vessels are shown in **Figure 4-1** and **Figure 4-2**. Further model source input data are set out in **Table 4-4** below.

4.2.2. During construction, emissions from hotelling were added to a volume source (MAN-2), as it was not possible to spatially represent the location that the vessels would dock during construction activities.

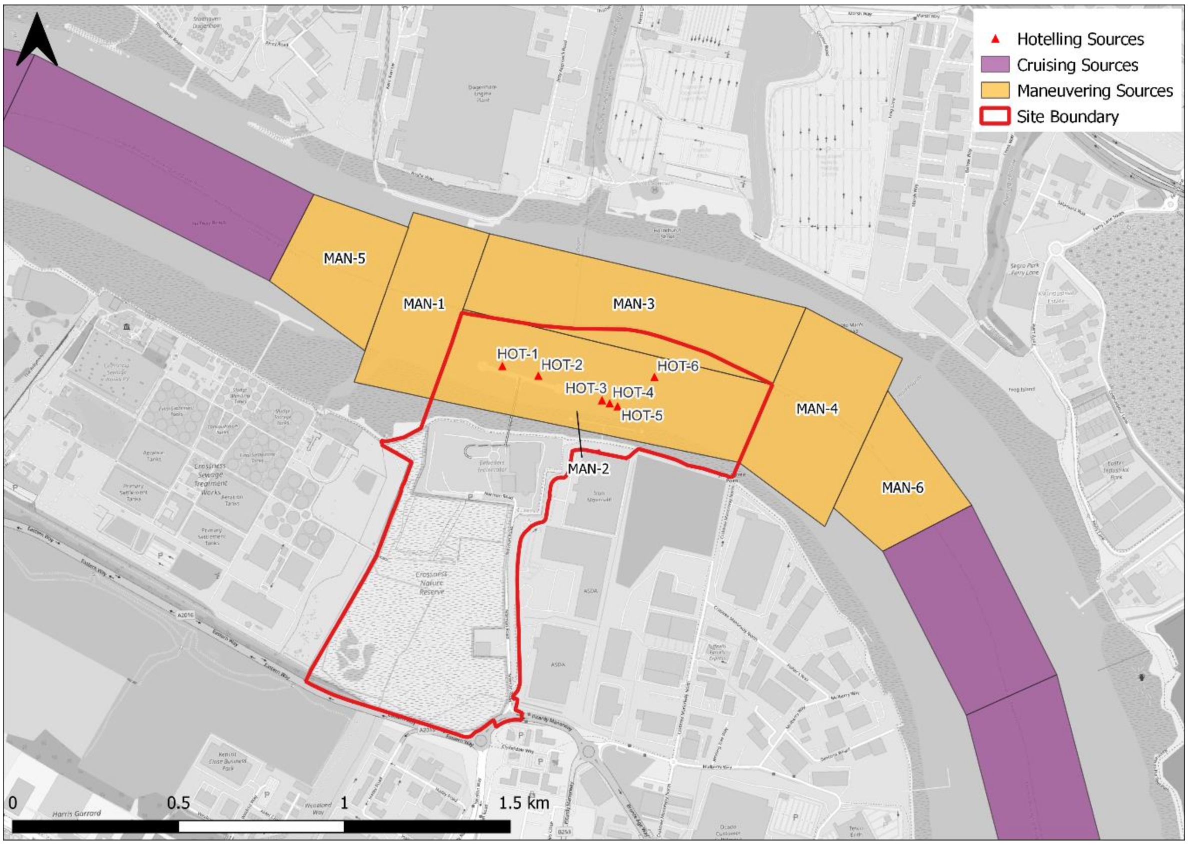

Figure 4-1: Manoeuvring (MAN) and Hotelling (HOT) sources used within the Dispersion Model for the Construction Phase

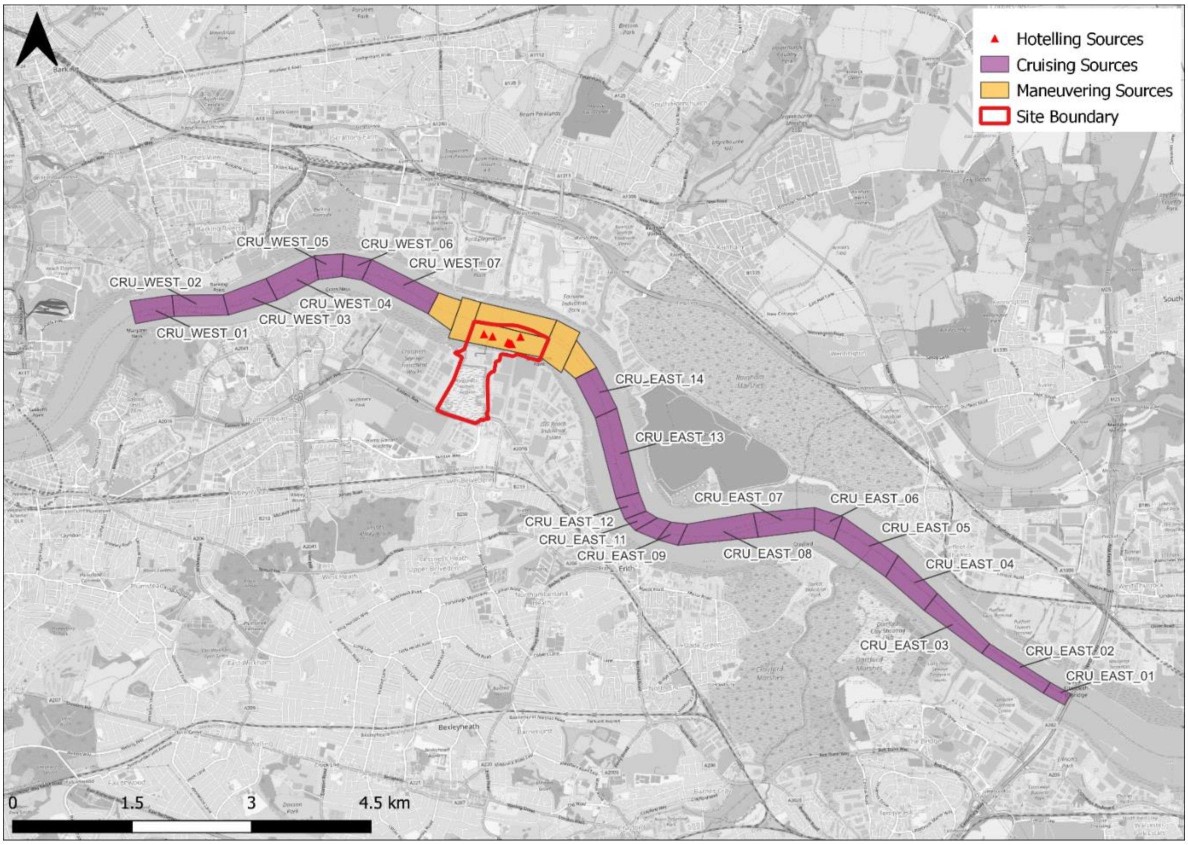

Figure 4-2: Cruising (CRU) sources used within the Dispersion Model for the Construction Phase

Table 4-4: Marine Dispersion Model Sources and Inputs

Source Name	Source Type	Height (m)	Cross-sectional Area (m^2)	Volume (m^3) / Diameter (m)	Temperature (°C)	NOx Emission Rate ($g/s/m^3$) Hourly	PM_{10} Emission Rate ($g/s/m^3$) Hourly	NOx Emission Rate ($g/s/m^3$) Daily	PM_{10} Emission Rate ($g/s/m^3$) Daily	SO_2 Emission Rate ($g/s/m^3$) Daily	SO_2 Emission Rate ($g/s/m^3$) Hourly
MAN-1	Volume	27	127123	3432314	Ambient	1.09E-07	2.89E-09	3.29E-08	9.33E-10	1.53E-09	4.70E-09
MAN-2	Volume	27	255094	6887549	Ambient	4.86E-07	6.84E-09	2.23E-07	2.99E-09	5.39E-09	1.23E-08
MAN-3	Volume	27	237289	6406816	Ambient	1.09E-07	2.89E-09	3.29E-08	9.33E-10	1.53E-09	4.70E-09
MAN-4	Volume	27	171659	4634793	Ambient	1.09E-07	2.89E-09	3.29E-08	9.33E-10	1.53E-09	4.70E-09
MAN-5	Volume	27	111361	3006750	Ambient	1.09E-07	2.89E-09	3.29E-08	9.33E-10	1.53E-09	4.70E-09
CRU_West_01	Volume	27	143990	3887732	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_West_02	Volume	27	173715	4690297	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_West_03	Volume	27	172756	4664423	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_West_04	Volume	27	187393	5059607	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_West_05	Volume	27	96975	2618327	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_West_06	Volume	27	86712	2341233	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_West_07	Volume	27	271964	7343016	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_01	Volume	27	48437	1307792	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_02	Volume	27	145569	3930369	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_03	Volume	27	193959	5236906	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_04	Volume	27	191253	5163830	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_05	Volume	27	252316	6812521	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_06	Volume	27	93441	2522912	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_07	Volume	27	220228	5946159	Ambient	6.14E-07	7.82E-09	1.27E-07	1.68E-09	5.48E-09	2.44E-08
CRU_East_08	Volume	27	259534	7007410	Ambient	5.68E-07	7.23E-09	1.18E-07	1.55E-09	5.07E-09	2.25E-08
CRU_East_09	Volume	27	64047	1729271	Ambient	5.68E-07	7.23E-09	1.18E-07	1.55E-09	5.07E-09	2.25E-08
CRU_East_10	Volume	27	61398	1657745	Ambient	5.68E-07	7.23E-09	1.18E-07	1.55E-09	5.07E-09	2.25E-08
CRU_East_11	Volume	27	48540	1310575	Ambient	5.68E-07	7.23E-09	1.18E-07	1.55E-09	5.07E-09	2.25E-08
CRU_East_12	Volume	27	77163	2083409	Ambient	5.68E-07	7.23E-09	1.18E-07	1.55E-09	5.07E-09	2.25E-08
CRU_East_13	Volume	27	318056	8587519	Ambient	5.68E-07	7.23E-09	1.18E-07	1.55E-09	5.07E-09	2.25E-08
CRU_East_14	Volume	27	169300	4571095	Ambient	5.68E-07	7.23E-09	1.18E-07	1.55E-09	5.07E-09	2.25E-08

4.3. MARINE VESSEL DISPERSION MODEL RESULTS

4.3.1. The modelled concentrations at human receptors for the construction phase from marine vessels are set out in **Table 4-5** (for all receptors, including those located within the River Thames) and **Table 4-6** (for impacts on land) below. A map of the impacts of construction emissions from marine vessels is provided in **Figure 4-3** by way of an indicative dispersion profile, showing hourly mean NO_2.

Table 4-5: Maximum Impacts (from marine vessels only) during Construction at all Modelled Receptors, including within the River Thames, on Human Health

Pollutant	Averaging Period	Air Quality Standard (µg/m³)	All Receptors (including within the River Thames)					
			Max Impact (µg/m³)	Impact as % of AQS	Total Concentration at Max Impact (µg/m³)	Location of Max Impact (X, Y)	Max Total Concentration (µg/m³)	Location of Max Total (X, Y)
NO_2	Hourly	200	10.20	5.1%	43.4	550500, 180700	60.2	550500, 180700
PM_{10}	Daily	50	0.12	0.2%	14.5	550500, 180700	19.7	550500, 180700
SO_2	15 minute	266	1.24	0.5%	3.8	550500, 180800	11.8	552000, 179900
	Hourly	350	0.81	0.2%	3.4	550500, 180700	11.7	552000, 179800
	Daily	125	0.16	0.1%	2.8	550000, 180700	11.4	552000, 179900

Table 4-6: Maximum Impacts (from marine vessels only) during Construction at Land Based Receptors on Human Health

Pollutant	Averaging Period	Air Quality Standard (µg/m³)	Land Receptors					Location of Max Total (X, Y)
			Max Impact (µg/m³)	Impact as % of AQS	Total Concentration at Max Impact (µg/m³)	Location of Max Impact (X, Y)	Max Total Concentration (µg/m³)	
NO_2	Hourly	200	8.96	14.9%	43.3	549500, 180800	59.6	549500, 180800
PM_{10}	Daily	50	0.11	0.6%	14.9	549800, 180700	19.7	549800, 180700
SO_2	15 minute	266	1.01	8.6%	3.6	550313, 180623	11.8	552000, 179900
	Hourly	350	0.70	6.0%	3.3	550313, 180623	11.7	552000, 179800
	Daily	125	0.16	1.4%	2.8	550000, 180700	11.4	552000, 179900

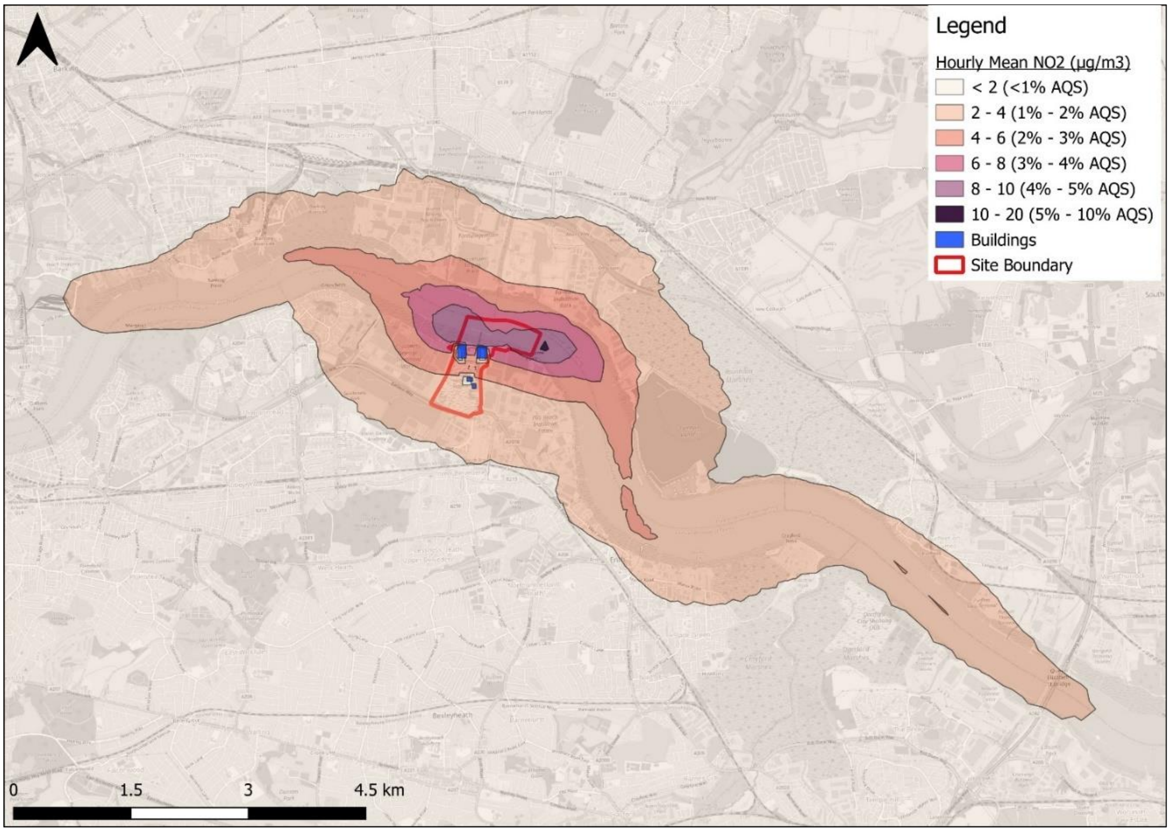

Figure 4-3: Hourly Mean NO_2 Concentrations from Marine Vessels during Construction

4.3.2. As can be seen in **Figure 4-3** (with reference to **Figure 4-1** and **Figure 4-2**) above, the bulk of the emissions during construction from marine vessels occur from the manoeuvring sources around the jetty. The greatest impacts occur in the middle of the River Thames, to the northeast of the Site.

4.3.3. The maximum modelled concentrations of daily NO_X (from marine emissions alone) at ecological receptors for the construction phase from marine vessels are set out in **Table 4-7** below. A map of the impacts of construction emissions from marine vessels is provided in **Figure 4-4** by way of an indicative dispersion profile, showing daily mean NOx. The impacts on daily NO_X are similar to the impacts on hourly NO_X, wherein the greatest source of emissions comes from marine vessels manoeuvring.

Table 4-7: Daily NOx Impacts from Marine Vessels during Construction on Ecological Sites

Habitat Site	2028 Maximum Background (µg/m^3)	Max Daily NOx Impact (µg/m^3)	Impact as % of Objective	Maximum Total Concentration (µg/m^3)
Epping Forest SAC, SSSI	28.15	0.14	0.07%	56.44
Ingrebourne Marshes SSSI	20.74	0.78	0.39%	42.26
Inner Thames Marshes SSSI	24.02	1.94	0.97%	49.97
Oxleas Woodlands SSSI	21.07	0.23	0.11%	42.37
West Thurrock Lagoon SSSI	48.41	0.64	0.32%	97.45
Crossness LNR	23.60	4.77	2.39%	51.97
Lesnes Abbey Wood LNR	19.78	0.61	0.30%	40.16
Rainham Marshes LNR	23.88	1.94	0.97%	49.69

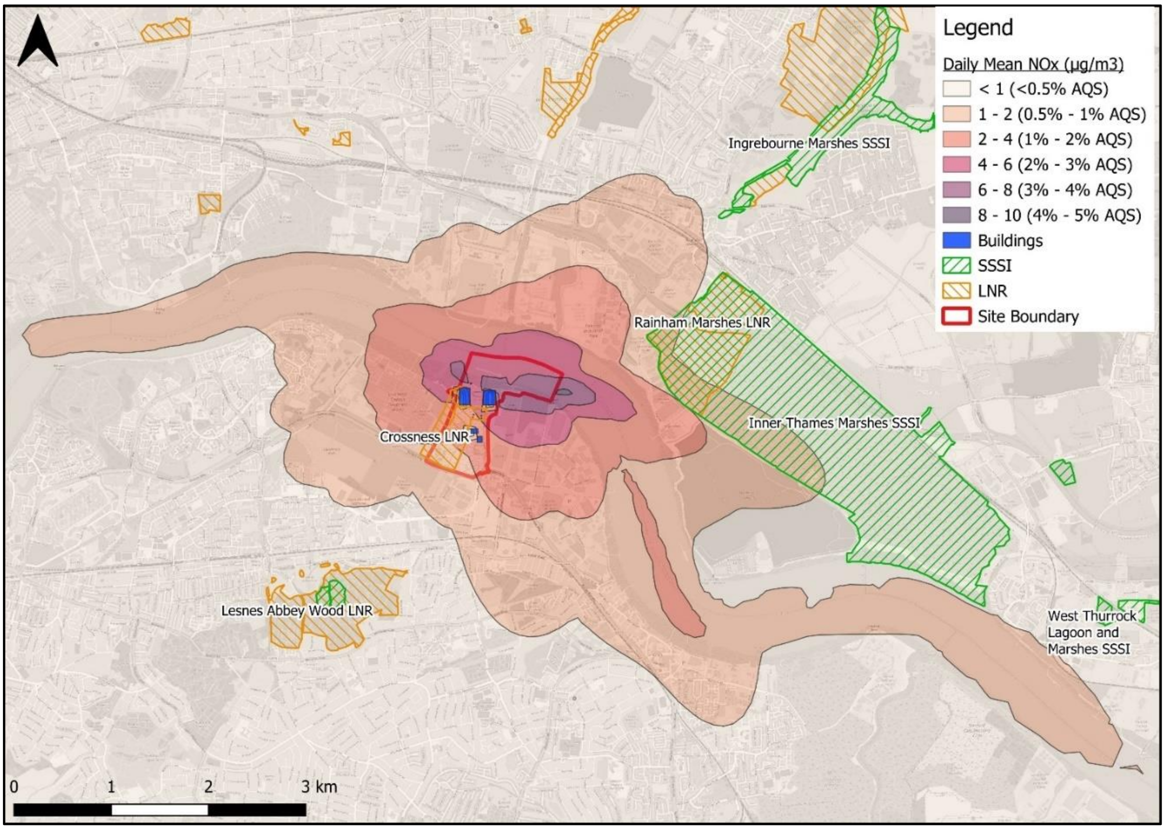

Figure 4-4: Daily Mean NOx Impacts from Marine Vessels during Construction

5. FULL PROPOSED SCHEME AQ IMPACT

5.1. METHODOLOGY

5.1.1. For each phase of the Proposed Scheme the impacts from the various modelled sources have been combined to produce a Full Proposed Scheme AQ Impact. Where appropriate, short term and long term impacts have been summed for the following sources of emissions:

- baseline during construction:
  - future Baseline traffic flows; and
  - operation of Riverside 1 and Riverside 2 (no Carbon Capture Facility);
- with Proposed Scheme during Construction:
  - construction-related marine vessel movements;
  - construction plus Future Baseline traffic movements; and
  - operation of Riverside 1 and Riverside 2 (no Carbon Capture Facility).

5.1.2. The 'impact' of the Full Proposed Scheme is defined as the difference between the Proposed Scheme and Baseline operation scenarios during the construction phase. This implies that for the construction phase, the impact is generally identical to the impact of marine vessel alone but that, for the assessment of significance, the total environmental concentration (i.e. modelled sources plus background concentrations) takes account of the Riverside Campus emissions. At the roadside, the construction impacts equate to the marine vessel impacts plus the construction traffic impact.

5.1.3. It should be noted that the maximum process contribution for a single pollutant from Riverside 1 and Riverside 2 may not occur at the same location as the maximum impact from the marine vessels. The results presented below, therefore, may not be identical to the marine vessel results presented above, noting that ground level concentrations are generally dominated by emissions from the stacks associated with Riverside 1 and Riverside 2.

5.1.4. The summation of short term impacts from the Riverside 1 and 2 exhaust stacks and marine vessels has been undertaken on a conservative basis, with the maximum short term impacts from each source added without consideration of whether maximum impacts would, in reality, occur under the same meteorological conditions or at the same time.

5.1.5. During construction, the risk of exceedance of short term objectives at the roadside with the Proposed Scheme is assessed with reference to the annual mean concentrations under the Full Proposed Scheme AQ Impact. This is because, as noted previously, short term impacts from road sources cannot be robustly modelled and cannot therefore be added to maximum hourly or daily concentrations from other sources.

5.2. MODEL RESULTS

5.2.1. The results of the Full Proposed Scheme AQ Impact during construction are presented in **Section 5.8** of **Chapter 5: Air Quality (Volume 1)**. The breakdown for each meteorological year (where appropriate) is presented in **Appendix 5-3: Detailed Model Pollutant Results (Volume 3)**.

5.2.2. The following sections present worked examples of the worst-case results showing the contribution from each source of emissions:

- Human Receptors:
  - Table 5-1: Example Source Contributions to Full Proposed Scheme AQ Impact, Annual Mean NO2 during Construction
  - Table 5-2: Example Source Contributions to Full Proposed Scheme AQ Impact, Process Contribution across the Modelled Study Area during Construction
- Ecological Receptors:
  - Table 5-3: Example Source Contributions to Full Proposed Scheme AQ Impact, Annual Mean NOX during Construction at Crossness LNR
  - Table 5-4: Example Source Contributions to Full Proposed Scheme AQ Impact, Nitrogen Deposition during Construction at Crossness LNR
  - Table 5-5: Example Source Contributions to Full Proposed Scheme AQ Impact, daily NOX during Construction at Ecological Sites

Human Receptors

5.2.3. **Table 5-1** below presents an example of the summation of the various sources that contribute to a Full Proposed Scheme AQ annual mean NO_2 impact from construction traffic, marine vessels and the operation of the Riverside 1 and Riverside 2 exhaust stacks. If the receptor is outside of the 200m road corridor, the road contribution will be zero.

Table 5-1: Example Source Contributions to Full Proposed Scheme AQ Impact, Annual Mean NO_2 during Construction

Receptor	Scenario	Road Contribution (inc. background) (µg/m³)	R1 & R2 Stack PC (Baseline Scenario) (µg/m³)	Marine PC (Construction only) (µg/m³)	Full Scheme PEC (µg/m³)
DTS5	Do Minimum	29.62	0.41	-	30.03
	Do Something	29.97	0.41	0.19	30.56

Note: Riverside 1 (R1) & Riverside 2 (R2) Stack PC is total emitted from Riverside 1 and Riverside 2 without Carbon Capture (when operational).

5.2.4. **Table 5-2** below presents an example of the summation of the various sources that contribute to a Full Proposed Scheme short term impact from marine vessels and the operation of the Riverside 1 and Riverside 2 exhaust stacks. As noted previously, this does not include emissions from construction traffic.

Table 5-2: Example Source Contributions to Full Proposed Scheme AQ Impact, Process Contribution across the Modelled Study Area during Construction

Pollutant	Averaging Time	Receptor (Easting, Northing)	Maximum Full Scheme PC (µg/m³)	R1 & R2 Stack PC at location of Max Full Scheme PC (Baseline Scenario) (µg/m³)	Marine PC at location of Max Full Scheme PC (Construction only) (µg/m³)
NO_2	1 hour	549200, 181100	59.46	50.40	9.06
PM_{10}	Daily	549800, 180900	0.8	0.70	0.07
SO_2	15 minutes	549200, 181100	104.6	103.70	0.95

Pollutant	Averaging Time	Receptor (Easting, Northing)	Maximum Full Scheme PC (µg/m^3)	R1 & R2 Stack PC at location of Max Full Scheme PC (Baseline Scenario) (µg/m^3)	Marine PC at location of Max Full Scheme PC (Construction only) (µg/m^3)
SO_2	1 hour	550200, 180300	71.6	71.27	0.37
SO_2	Daily	549700, 181000	7.0	6.91	0.10
Note: R1 & R2 Stack PC is total emitted from Riverside 1 and Riverside 2 without Carbon Capture (when operational).					

Ecological Receptors

5.2.5. **Table 5-3** below presents an example of the summation of the various sources that contribute to a Full Proposed Scheme annual mean NO_X impact from construction traffic, marine vessels and the operation of the Riverside 1 and Riverside 2 exhaust stacks.

Table 5-3: Example Source Contributions to Full Proposed Scheme AQ Impact, Annual Mean NO_X during Construction at Crossness LNR

Receptor	Scenario	Road Contribution (inc. background) (µg/m^3)	R1 & R2 Stack PC (Baseline Scenario) (µg/m^3)	Marine PC (Construction only) (µg/m^3)	Full Scheme PEC (µg/m^3)
T1_000	Do Minimum	59.34	0.44	-	59.77
T1_000	Do Something	59.96	0.44	0.21	60.61
Note: R1 & R2 Stack PC is total emitted from Riverside 1 and Riverside 2 without Carbon Capture (when operational).					

5.2.6. **Table 5-4** below presents an example of the summation of the various sources that contribute to a Full Proposed Scheme annual mean nitrogen deposition impact from construction traffic, marine vessels and the operation of the Riverside 1 and Riverside 2 exhaust stacks.

Table 5-4: Example Source Contributions to Full Proposed Scheme AQ Impact, Nitrogen Deposition during Construction at Crossness LNR

Receptor	Scenario	Road Contribution (inc. background) (kg/N/ha/yr)	R1 & R2 Stack PC (Baseline Scenario) (kg/N/ha/yr)	Marine PC (Construction only) (kg/N/ha/yr)	Full Scheme PEC (kg/N/ha/yr)
T1_000	Do Minimum	21.97	0.28	-	22.25
T1_000	Do Something	22.09	0.28	0.02	22.39
Note: R1 & R2 Stack PC is total emitted from Riverside 1 and Riverside 2 without Carbon Capture (when operational).					

5.2.7. **Table 5-5** below presents an example of the summation of the various sources that contribute to a Full Proposed Scheme daily mean NO_X impact from marine vessels and the operation of the Riverside 1 and Riverside 2 exhaust stacks.

Table 5-5: Example Source Contributions to Full Proposed Scheme AQ Impact, daily NO_X during Construction at Ecological Sites

Receptor	Maximum Full Scheme PC (µg/m³)	R1 & R2 Stack PC at Location of Max Full Proposed Scheme PC (Baseline Scenario) (µg/m³)	Marine PC at Location of Max Full Proposed Scheme PC (Construction only) (µg/m³)
Epping Forest – SAC, SSSI	1.4	1.3	0.1
Ingrebourne Marshes – SSSI	7.1	6.3	0.8
Inner Thames Marshes – SSSI	12.5	11.4	1.1
Oxleas Woodlands – SSSI	3.6	3.4	0.2
West Thurrock Lagoon and Marshes – SSSI	2.9	2.3	0.6
Crossness – LNR	29.7	27.2	2.4
Lesnes Abbey Woods – LNR (comprising Ancient Woodland)	7.2	6.7	0.5
Rainham Marshes – LNR	12.3	11.0	1.2
Note: R1 & R2 Stack PC is total emitted from Riverside 1 and Riverside 2 without Carbon Capture (when operational).			

5.3. REFERENCES

[1] Institute of Air Quality Management. (2016). 'Guidance on the assessment of dust from demolition and construction'. Available at: [redacted]

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