Cambridge Waste Water Treatment Plant Relocation Project
Anglian Water Services Limited

Appendix 7.1: Air Quality Assessment Method

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1 Introduction

1.1.1 This appendix sets out the quantitative approach that has been undertaken to assess the impact of Proposed Development on air quality during construction and operation. This includes an assessment of:

- The change in emissions of pollutants associated with traffic on the local road network during the construction and operational phases of the Proposed Development in isolation following best practice methods.
- Emissions of pollutants associated with the operation of the energy plant at the proposed WWTP in isolation following best practice methods.
- The combined impacts and effects of the operational phase emissions from traffic on the local road network and the energy plant following best practice methods.

1.1.2 The assessment within Chapter 7: Air Quality has been informed by the use of atmospheric dispersion modelling. Separate dispersion models were created to assess the construction traffic, operation traffic and the energy centre impacts. The approach for dispersion modelling of these aspects has been discussed in the following sections.

2 Parameters relevant to both Traffic using the public highways and operational energy plant

2.1 Modelled receptors

2.1.1 To allow the air quality impacts on sensitive receptors to be compared across different elements of the Proposed Development, the same sensitive receptors have been considered in both models (traffic and energy plant). The receptor points (referred to as 'discrete receptors') have been chosen as they are the human health or ecological receptors expected to experience the greatest change in concentrations due to their proximity to the energy plant and/or roads experiencing a change in flows from the proposed WWTP.

2.1.2 Gridded receptors and discrete human health receptors have been modelled at a height of 1.5m (1m for Fen Ditton Primary School) above ground level to best represent head/inhalation height. Ecological discrete receptors have been modelled at ground level (0m).

Gridded receptors

2.1.3 Pollutant concentrations were modelled across a Cartesian grid with 20m spacing up to 1km radius from the energy plant, 100m spacing up to 5km radius from the energy plant. The contours of the modelling results (Figure 4-2 to Figure 4-6 within this document and Appendix 7.2: Dispersion Model Results (App Doc Ref 5.4.7.2) show that the maximum impacts are located within 200m of the proposed WWTP and therefore the extent and resolution of the study area is appropriate.

2.1.4 This assessment has not considered concentrations within the proposed WWTP boundary in the judgement of significance as the air quality objectives do not apply at these locations as there is no relevant public exposure (see Chapter 7: Air quality; Table 1-4).

Sensitive human receptors

2.1.5 The air quality objectives only apply in locations of relevant exposure. Human receptors have therefore been chosen following the advice set out in Defra TG22. Modelled human health receptors selected for the assessment are presented in Table 2-1.

Table 2-1: Modelled human receptors

Receptor ID	Receptor name	National Grid reference		Height above ground (m)	Where included
		X	Y		
HH1	Poplar Hall Farm	548543	261390	1.5	Energy plant, Road and combined
HH2	Property on Flack End	545408	261909	1.5	Energy plant, Road and combined

Receptor ID	Receptor name	National Grid reference		Height above ground (m)	Where included
		X	Y		
HH3	Gatehouse	550452	260942	1.5	Energy plant and combined
HH4	Fen Ditton Community Primary School	548656	260466	1.0	Energy plant and combined
HH5	Property east of Horningsea Road, Fen Ditton	548870	260803	1.5	Energy plant and combined
HH6	Biggen Abbey	548782	261736	1.5	Energy plant and combined
HH7**	Quy Mill Hotel	550846	259899	1.5	Energy plant and combined
HH8	Fen Ditton Community Primary School	548714	260454	1.0	Energy plant and combined
HH9**	Low Fen Drove Way PROW 85/14	549921	261580	1.5	Energy plant and combined
HH10	Property to south of Horningsea	549278	262141	1.5	Energy plant and combined
HH11**	Bridleway	550451	260969	1.5	Energy plant and combined
HH12	Future Residential	549821	261567	1.5	Energy plant and combined
HH13	Property Horningsea Road, Fen Ditton	548768	260782	1.5	Energy plant and combined

*Note: **In accordance with LAQM TG22, only the short-term air quality objectives would apply at these locations*

Sensitive ecological receptors

2.1.6 Ecological designations with international status within 5km and statutory and non-statutory national designations within 2km of the proposed WWTP (Environment Agency, 2022) have been considered in this assessment to assess the effects associated with the operation of energy plant.

2.1.7 Ecological designations located within 200m of roads affected by construction or operational traffic have been considered in this assessment. (National Highways, 2019).

2.1.8 Modelled ecological receptors are presented in Table 2-2 along the element of the assessment they are included in, i.e. assessment of energy plant, roads or combined.

Table 2-2: Modelled ecological receptors

Receptor ID	Receptor name	Designation	Where included
E1	Milton Road Hedgerows	City Wildlife Site	Road and combined
E2	Kings Hedges Hedgerow	City Wildlife Site	Road and combined
E3	Low Fen Drove Way Grassland and Hedges	County Wildlife Site	Road and combined
E4	Wilbraham Fens	Site of Special Scientific Interest	Road and combined
E5	Allicky Farm Pond	County Wildlife Site	Energy Plant and combined
E6	Low Fen Drove Way Grassland and Hedges	County Wildlife Site	Energy Plant and combined
E7	Stow-cum-Quy Fen	Site of Special Scientific Interest	Energy Plant and combined
E8	Wilbraham Fens	Site of Special Scientific Interest	Energy Plant and combined
E9	Ditton Meadows	City Wildlife Site	Energy Plant and combined

2.1.9 The project ecologist has confirmed that the above ecological designations identified are sensitive to nitrogen and acid deposition, with the exception of Allicky Farm Pond County Wildlife Site (CWS) which is not sensitive to acid deposition.

2.1.10 The project ecologist confirmed that the River Cam CWS is not a sensitive habitat and has not been considered further.

2.1.11 The ecological designations were modelled using gridded receptor points using the same resolution as that specified in the gridded receptors section above. Where required, additional receptors points were added at the closest point to the affected road and/or to the energy plant as this represents the likely location of maximum impact.

2.2 Meteorological data

2.2.1 The most important meteorological parameters governing the atmospheric dispersion of emissions are wind direction, wind speed and atmospheric stability as described below:

- Wind direction determines the sector of the compass into which emissions are dispersed;

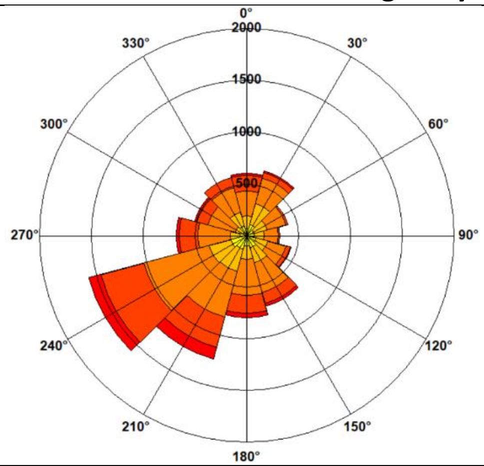
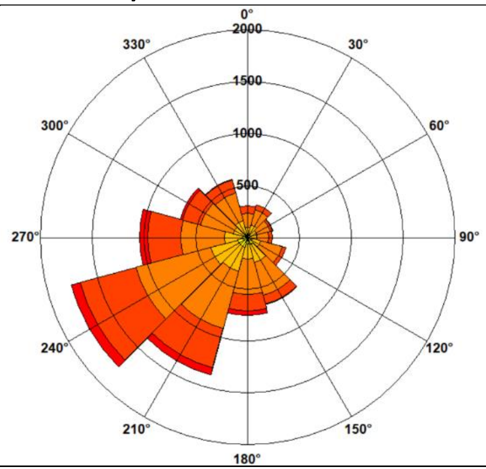
- Wind speed affects the distance which emissions travel over time and can affect dispersion by increasing the initial dilution of pollutants and, in the case of point sources, inhibiting plume rise; and
- Atmospheric stability is a measure of the turbulence of the air, and particularly of its vertical motion. It therefore affects the spread of the plume as it travels away from the source. ADMS uses a parameter known as the Monin-Obukhov length that, together with the wind speed, describes the stability of the atmosphere.

2.2.2 For meteorological data to be suitable for dispersion modelling purposes, parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. The year of meteorological data that is used for a modelling assessment can have a significant effect on source contribution concentrations therefore dispersion model simulations were performed for emissions from the site using five years of data.

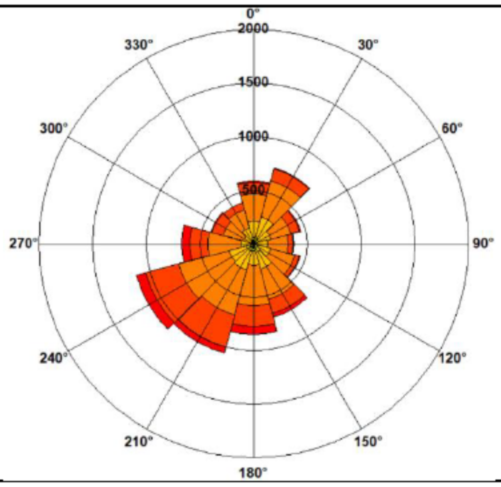
2.2.3 Following consideration of the meteorological data available, data from the Cambridge City Airport meteorological station (with missing data supplemented from RAF Mildenhall[1]) was used as this is the most representative data available for the study area. Detailed analysis of the meteorological inputs has been undertaken in Chapter 19: Odour.

2.2.4 The Cambridge City Airport meteorological station is located approximately 1.7 kilometres south of the proposed WWTP. Wind roses have been generated for each of the five years of meteorological data used in this assessment, as shown in Figure 2.1. The wind roses illustrate that in all meteorological years, there is a dominance of strong winds from the south west.

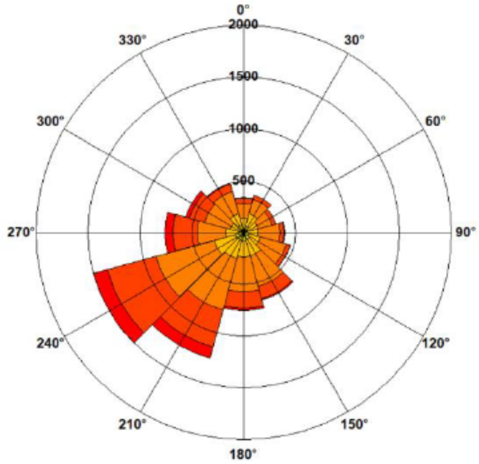
Figure 2.1: Wind roses for Cambridge City Airport (2016-2020)

	
2016	**2017**

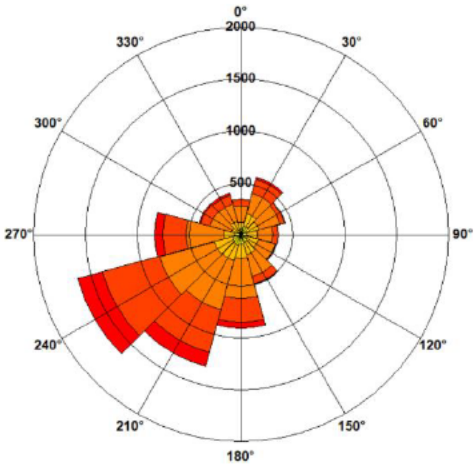
[1] No night-time data is available for Cambridge City Airport, so data for Mildenhall (the next closest meteorological site) has been patched into the data to provide night-time values.



2018



2019



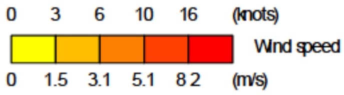
2020

Number around the outside of the wind rose shows direction in degrees.

Rose petals show direction in which wind is blowing from.

Numbers within chart (i.e. 500 to 2000) show number of hours per year.

Colours represent wind speed with below scale.



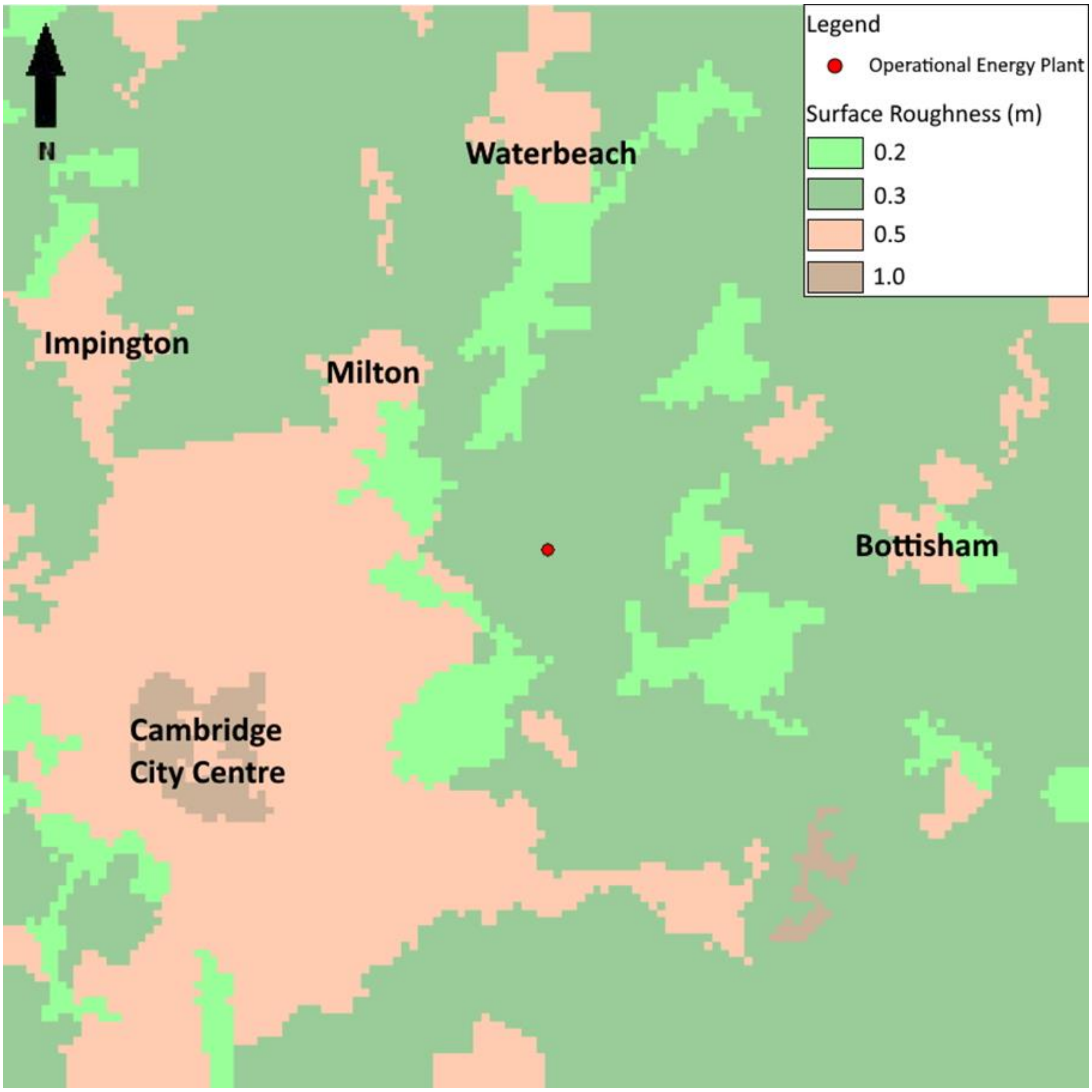
Notes on scale

Surface roughness

2.2.5 The roughness of the terrain over which a plume passes can have an effect on dispersion by altering the velocity profile with height and the degree of atmospheric turbulence. This is accounted for by a parameter called the surface roughness length. Surface roughness parameters surrounding the proposed WWTP have been split into a 100m by 100m grid and each grid square has been assigned a surface roughness based upon Corine Land Cover 2018 data (Copernicus Land Monitoring Service, 2018) as presented in Figure 2.2.

2.2.6 A surface roughness length of 0.2m has been assigned to the meteorological site.

Figure 2.2: Surface roughness included in dispersion model



Notes: The units applied are model specific and not representative of real-life heights

2.3 Background concentrations and deposition

Background concentrations

2.3.1 Total air pollutant concentrations comprise a background and local component. Background concentrations are determined by regional, national and international emissions, and often represents a significant proportion of the total pollutant concentration. The local component is determined by local pollutant sources such as roads, and in this case, has been determined using the ADMS and ADMS-Roads model.

2.3.2 Background concentrations are added to the pollutant contributions from the road and plant sources to determine the total pollutant concentrations at modelled receptors.

2.3.3 Background pollutant concentrations are spatially and temporally variable throughout the UK. Annual mean background concentrations of NO_2 were obtained from Defra's Air Information Resource (AIR) website (Defra, 2020) for comparison with SCDC urban background monitoring data at the Orchard Park Primary School (ORCH). This monitoring site was selected as it is approximately 160m from the nearest major road sources (A14 and B1049) and is therefore representative of background ambient concentrations. The urban background diffusion tube monitoring sites, DT9 and DT27, have also been considered for this purpose, however they are closer to and consequently more influenced by road sources including the A14 and the A10. On this basis, only the ORCH continuous monitor has been used for this comparison.

2.3.4 The comparison has been made using 2019 data as the effects associated with the coronavirus (Covid-19) pandemic during 2020 and 2021, when England was subject to periods of lockdown for periods, may have an influence on the 2020 and 2021 air quality monitoring data and therefore it may not be representative of normal conditions at the monitoring sites.

2.3.5 The comparison is presented below in Table 2-3. The data indicates that the monitored concentrations at ORCH and modelled concentrations from the Defra background maps differ by less than 2% showing good agreement.

Table 2-3: Comparison of SCDC NO_2 urban background monitoring with Defra projected background concentrations

Location	X	Y	SCDC annual mean NO_2 monitored concentration for 2019	Defra projected background NO_2 concentration for 2019	Percentage Difference
ORCH	544558	261579	14.9	14.7	1.4%

Source: SCDC ASR 2021 and Defra AIR (Defra, 2020)

Data capture was 99% in 2019

2.3.6 Defra's TG22 (Defra and Devolved Administrations, 2022) recommends that background maps or local authority/Defra monitoring data be used as a representative value for the background concentrations in the assessment. Based on the comparison presented in Table 2-3, Defra's projected background concentrations for NOx, NO_2, PM_{10}, $PM_{2.5}$ and SO_2 have been used to represent the background pollutant concentrations at the receptors modelled within this assessment.

Table 2-4: Projected background concentrations at modelled receptor locations

Receptor ID	XY	NOx	NO_2	PM_{10}	$PM_{2.5}$	SO_2
2019						
HH1, HH6	548_261	19.6	14.4	17.8	10.8	1.2
HH2, E2	545_261	19.3	14.2	17.5	11.2	1.7
HH3, HH11	550_260	12.8	9.8	17.0	10.1	1.0

Receptor ID	XY	NOx	NO_2	PM_{10}	$PM_{2.5}$	SO_2
HH4, HH5, HH8, HH13	548_260	14.7	11.1	15.6	9.9	1.3
HH7	550_259	16.7	12.5	18.3	10.9	1.0
HH9, HH12	549_261	14.1	10.7	16.8	10.1	1.0
HH10	549_262	12.6	9.6	16.0	9.8	1.1
E1, E9	547_261	19.5	14.3	16.3	10.5	1.4
E3, E6	549_260	17.7	13.2	18.5	11.0	1.1
E4, E8	551_259	16.2	12.2	17.9	10.8	0.9
E5	550_261	11.8	9.1	16.1	9.7	0.9
E7	551_262	10.4	8.1	16.1	9.6	0.8
2026						
HH1, HH6	548_261	14.6	11.0	16.6	9.9	1.2
HH2, E2	545_261	14.0	10.6	16.3	10.2	1.7
HH3, HH11	550_260	9.7	7.5	15.9	9.1	1.0
HH4, HH5, HH8, HH13	548_260	11.4	8.8	14.5	9.0	1.3
HH7	550_259	11.8	9.1	17.2	9.9	1.0
HH9, HH12	549_261	10.6	8.2	15.6	9.2	1.0
HH10	549_262	9.7	7.6	14.8	8.9	1.1
E1, E9	547_261	14.4	10.8	15.1	9.5	1.4
E3, E6	549_260	12.8	9.8	17.4	10.1	1.1
E4, E8	551_259	11.3	8.8	16.7	9.8	0.9
E5	550_261	9.1	7.1	15.0	8.8	0.9
E7	551_262	8.1	6.4	15.0	8.7	0.8
2028						
HH1, HH6	548_261	13.8	10.5	16.6	9.9	1.2
HH2, E2	545_261	13.2	10.0	16.3	10.2	1.7
HH3, HH11	550_260	9.2	7.2	15.9	9.1	1.0
HH4, HH5,	548_260	11.0	8.4	14.5	9.0	1.3

Receptor ID	XY	NOx	NO_2	PM_{10}	$PM_{2.5}$	SO_2
HH8, HH13						
HH7	550_259	11.1	8.6	17.2	9.9	1.0
HH9, HH12	549_261	10.1	7.9	15.6	9.2	1.0
HH10	549_262	9.4	7.3	14.8	8.9	1.1
E1, E9	547_261	13.6	10.3	15.1	9.5	1.4
E3, E6	549_260	12.1	9.3	17.3	10.0	1.1
E4, E8	551_259	10.6	8.2	16.7	9.8	0.9
E5	550_261	8.7	6.8	15.0	8.8	0.9
E7	551_262	7.8	6.2	15.0	8.7	0.8

Note: Defra does not provide projection data for SO_2. Therefore, Defra's modelled concentration for 2020 have been applied to future years.

There is no predicted reduction in PM_{10} and $PM_{2.5}$ between 2026 and 2028 when presented to one decimal place.

XY column shows the British National Grid first three X coordinates followed by the first three Y coordinates. E.g. 547,261 = 547500, 261500

2.3.7 As the concentrations from the background maps and monitoring data are long-term (annual) average concentrations, short-term background concentrations have been estimated by doubling the long-term background concentrations. This is in accordance with TG22, Box 7.16 (Defra and Devolved Administrations, 2022).

Background nitrogen and acid deposition

2.3.8 Information on baseline levels of nitrogen and acid deposition for designated sites is available from APIS (APIS, 2022). The background deposition rates and critical loads[2] from APIS for ecological receptors sensitive to nitrogen and acid deposition are presented in Table 2-5.

[2] A critical load is a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.

Table 2-5: Critical loads (CLO) range and background deposition

Receptor ID	Receptor name and designation	APIS habitat	Nitrogen CLO range (kg N/ha/yr)	BG nitrogen deposition (kg N/ha/yr)	Acid CLO - CLMaxN (keq/ha/yr)	Acid CLO - CLMaxS (keq/ha/yr)	BG acid deposition[a] (keq/ha/yr)
E1	Milton Road Hedgerows WS	Hedgerows	10-20	33.9	10.8	10.6	2.6
E2	Kings Hedges Hedgerow WS	Hedgerows	10-20	33.9	10.8	10.6	2.6
E3	Low Fen Drove Way Grasslands and Hedges CWS	Calcareous grassland	15-20	18.9	4.9	4.0	1.5
E4	Wilbraham Fens SSSI	Fen, Marsh and Swamp	15-30	17.8	4.3	4.1	1.4
E5	Allicky Farm Pond CWS	Fen, Marsh and Swamp	15-30	17.9	not sensitive	not sensitive	1.4
E6	Low Fen Drove Way Grasslands and Hedges CWS	Calcareous grassland	15-20	18.9	4.9	4.0	1.5
E7	Stow-cum-Quy Fen SSSI	Calcareous grassland	15-20	17.9	4.9	4.0	1.4
E8	Wilbraham Fens SSSI	Fen, Marsh and Swamp	15-30	17.8	4.3	4.1	1.4
E9	Ditton Meadows WS	Coastal and Floodplain Grazing Marsh	20-30	18.9	4.0	4.0	1.5

Source: www.apis.ac.uk

WS – City Wildlife Site; LNR – Local Nature Reserve; SSSI – Site of Special Scientific Interest; CLO - critical load; BG - background

(a) Background acid deposition is the sum of acidifying nitrogen and sulphur species

2.4 Assessment of effects at ecological receptors

2.4.1 Rates of nitrogen and acid deposition are directly related to concentrations of atmospheric pollutants which contain nitrogen and sulphur. The impact of ecological designated sites should be assessed against the site relevant:

- critical levels – Pollutants of concern: NOx and SO_2
- nutrient nitrogen critical loads – Pollutants of concern: NO_2 and ammonia (NH_3)
- acid deposition critical loads – Pollutants of concern: NO_2, ammonia (NH_3) and SO_2

Critical levels – atmospheric NOx and SO_2

2.4.2 Critical levels for the protection of vegetation and ecosystems are specified within relevant European air quality directives as transposed into UK law. For both European and national sites, process contributions and predicted environmental concentrations of NOx and SO_2 have been calculated for comparison against the critical levels. Background NO_x and SO_2 concentrations applied to each designated site are identified in Table 2-4.

Critical loads – nitrogen deposition (Eutrophication) and acidification

2.4.3 Critical loads are a quantitative estimate of exposure to deposition of one or more pollutants, below which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge. Process contributions to nitrogen and acid deposition have been derived from dispersion modelling.

2.4.4 In addition to the contribution of NO_2 to nitrogen deposition and acid deposition, there is also a relatively new recommendation from the IAQM (Holman et al., 2020) and CIEEM (Chartered Institute of Ecology and Envrionmental Management, 2021) to consider NH_3 contribution to nitrogen deposition from road vehicles. For this assessment the NH_3 contribution has also been accounted for when calculating acid deposition from road emissions. Whilst this is a relatively new area of assessment, and the tools and methodology are being developed, this report has considered the contribution of NH_3 at ecological designations to nitrogen deposition and acid deposition from road vehicle emissions.

2.4.5 Deposition rates were calculated using empirical methods within Habitats Directive Guidance (AQTAG.06) (Air Quality Advisory Group, 2014) and the National Highways 'Ammonia Nitrogen Deposition Tool (v3)'. The calculation steps are as follows

- Assign relevant dry deposition velocity to pollutant and habitat (m/s)
  - NO_2: 0.0015 m/s for grassland, 0.003 m/s for forest
  - NH_3: 0.02 m/s for grassland, 0.03 m/s for forest
  - SO_2: 0.012 m/s for grassland, 0.024 m/s for forest

- Dry deposition flux (µg/m^2/s) = ground level concentration (µg/m^3) x deposition velocity (m/s)
- Convert units from µg/m^2/s to units of kg/ha/yr by multiplying the dry deposition flux by standard conversion factors (95.9 for NO_2);
- Use 'Ammonia Nitrogen Deposition Tool (v3)' to calculate ammonia concentration and nitrogen deposition from road NOx
- Add predicted dry nitrogen deposition from NO_2 and NH_3 to get total nitrogen deposition process contribution (kg/ha/yr)
- Convert dry deposition flux (µg/m^2/s) to units of equivalents (keq/ha/yr), which is a measure of how acidifying the chemical species can be, by multiplying the dry deposition flux (µg/m^2/s) by standard conversion factors (6.84 for NO_2, 18.5 for NH_3 and 9.84 for SO_2).
- Add predicted dry N and S deposition (keq/ha/year) to determine total acid deposition.

2.4.6 Wet deposition in the near field is not significant compared with dry deposition for N, and therefore for the purposes of this assessment, wet deposition has not been considered.

2.4.7 Predicted contributions to nitrogen and acid deposition were compared with the relevant critical load function for each habitat type associated with each designated site, as derived from Air Pollution Information System (APIS) (APIS, 2022). To assess a worst-case, it has been assumed that the greatest deposition rates within each designation occur within each habitat type (in practice, the greatest deposition rates may occur where none of these habitats are present).

2.4.8 For nitrogen deposition, the Proposed Developments contribution is assessed as a percentage, rounded to the nearest whole number, of the minimum critical load for the habitat.

2.4.9 For acid deposition, the proposed WWTP's energy plant contribution of combined nitrogen and sulphur species are assessed as percentage rounded to the nearest whole number against the CLMaxS and CLMaxN.

2.4.10 For acid deposition, the contribution of nitrogen species from the traffic contribution of the Proposed Development are added to the background acid deposition, which includes both nitrogen and sulphur species. Total acid deposition is assessed as a percentage rounded to the nearest whole number against the CLMaxN. Assessment of traffic impacts using the public highway

2.4.11 This section describes the approach undertaken to assess the air quality impact of construction and operation traffic associated with the Proposed Development on nearby sensitive receptors.

3 Assessment of Traffic Emissions

3.1 Model selection

3.1.1 The assessment has used a dispersion model called ‘ADMS-Roads’ (version 5.0.1.3); a PC-based model of dispersion in the atmosphere of pollutants released from road traffic sources, produced and validated by Cambridge Environmental Research Consultants (CERC). This model is widely used in the UK, including by local authorities for Review and Assessment purposes and to support planning application assessments.

3.2 Traffic data

3.2.1 Traffic flows in 24-hour Annual Average Daily Traffic (AADT) flow format were provided by the Proposed Development’s traffic consultants for:

- Base year 2019 (adjusted from a 2022 base year for local roads)
- Construction phase
  - Do-Minimum 2026 (a future-year scenario in which the Proposed Development has not been built; includes committed developments)
  - Do-Construction 2026 (a future-year scenario in which peak construction traffic movements take place; includes committed developments)
- Operational phase
  - ‘Do-Minimum’ 2028 (a future-year scenario in which the Proposed Development has not been built; includes committed developments)
  - ‘Do-Something’ 2028 (a future-year scenario in which the Proposed Development has been built; includes committed developments and decommissioning traffic for the existing Cambridge WWTP which will occur when the proposed WWTP is operational).

3.2.2 2026 has been selected as the assessment year for the construction phase as this is the peak year that construction traffic will be travelling to and from the Proposed Development. The Proposed Developments construction traffic movements used in this assessment are for a peak day and as such represent an extremely conservative assumption as they will be compared with annual averaging periods.

3.2.3 2028 has been selected as assess the operational phase at is it the year in which the Proposed Development is expected to be fully operational. This is considered the worst-case year as pollutant emission factors and background concentrations improve in future years with improvements in vehicle technology and uptake of cleaner vehicles on the roads.

3.2.4 At junctions, speeds have been reduced in accordance with the LAQM (TG22) (Defra, 2021) guidance which states that:

‘For a busy junction, assume that traffic approaching the junction slows to an average of 20kph. These should allow for a junction, which suffers from a lot of congestion and stopping traffic. In general, these speeds are relevant for approach distances of approximately 25m;

For other junctions (non-motorway) and roundabouts where some slowing of traffic occurs, you should assume that the speed is 10kph slower than the average free flowing speed’.

3.3 Emission factors

3.3.1 The Emission Factor Toolkit (EFT) (Version 11.0), released November 2021, has been used to provide emission factors for use within the traffic modelling. A split of traffic composition including AADT and percentage of HDVs has been used to generate emission factors for each road link included in the model.

3.4 NOx to NO_2 relationship

3.4.1 The model used for this assessment provides outputs for NOx which need to be converted to NO_2 to allow comparison with the relevant air quality objectives and assess its contribution to nitrogen deposition. Defra provides a spreadsheet-based method, which is available from Defra’s Air Information Resource Website (Defra, 2020), for calculating annual mean NOx to NO_2 conversions. This method has been used within the assessment and is the most appropriate way of determining NO_2 concentrations from road NOx contributions.

3.5 NOx to NH_3 relationship

3.5.1 The model used for this assessment provides outputs for NOx which need to be converted to NH3 to assess its contribution to nitrogen deposition. National Highways provides a spreadsheet-based method (‘Ammonia Nitrogen Deposition Tool (v3)’) for calculating annual mean NOx to NH_3 conversions. This method has been used within the assessment and is the most appropriate way of determining NH_3 contribution to nitrogen deposition from road NOx contributions.

4 Assessment of the Operational Energy Plant

4.1 Energy plant model selection

4.1.1 The assessment uses a dispersion model called ADMS (version 5.2); a PC-based model produced and validated by Cambridge Environmental Research Consultants (CERC) of the dispersion in the atmosphere of pollutants released from energy plant sources.

4.2 Modelled scenarios

4.2.1 The emission sources which have been included within this assessment are

- Two 3.4MW thermal input steam raising boilers (one duty, one standby)
- Two 1.5MW thermal input CHPs
- One flare

4.2.2 The boilers and CHPs are capable of operating on both natural gas and biogas. The flare would only operate on biogas. The emissions of pollutants such as NOx and SO_2 are greater from biogas than natural gas combustion, therefore, only scenarios assuming the boilers, CHPs and flare operating on biogas have been modelled.

4.2.3 Two scenarios have been modelled for this assessment:

- Scenario 1 (normal operation): One biogas boiler and two biogas CHPs
- Scenario 2 (abnormal operation): One biogas boiler, two biogas CHPs and one flare

4.2.4 To undertake a conservative assessment, it has been assumed for both scenarios that one boiler and two CHPs will be operating at full load continuously all year. In practice, the operation of the CHPs with heat recovery would negate the requirement for the operation of the boiler and overall site emissions would therefore be lower than those included in the modelling. The results have been compared to the long and short term AQALs.

4.2.5 For Scenario 2, it has also been conservatively assumed that the flare will be operating continuously all year at maximum load. However, the flaring stack would only be used when

- there is too much biogas produced for combustion in the CHPs or boilers;
- during a failure event on site to safely dispose of any biogas; or
- to safely dispose of biogas with a high sulphur content (sour biogas) that may be produced as a result of the digestion process and which cannot be used in the CHPs or boilers.

4.2.6 During a failure event or where sour biogas is produced, and the flare is required to operate, the CHPs and boilers are either unlikely to operate or would operate on natural gas. The event that would result in the largest emissions to air from the energy plant is the production of too much biogas produced for combustion in the CHPs or boilers. This situation would require all energy plant to operate on biogas. As emissions to air associated with biogas combustion are greater than those associated with natural gas, scenario 2 is considered a worst case, hypothetical scenario.

4.2.7 Scenario 2 has been compared to short term AQALs only as it would not occur for extended periods of time so would not operate for periods commensurate with the long term AQALs known as air quality objectives set for the protection of human health and critical levels and critical loads set for the protection of ecology.

4.3 Emissions data

4.3.1 The Proposed Development includes the provision of two 3.4MW thermal input boilers, two 1.5MW thermal input CHPs and one flare. As the proposed energy plant has a thermal input between than 1MW and 50MW they are required to meet the requirements of the Medium Combustion Plant Directive (MCPD)[3] (European Union, 2015). Chapter 7: Air Quality presents relevant mitigation for energy plant.

4.3.2 Emission used in this assessment are based on an average plant load of 100%, operating continuously all year, and assumes that exhaust gases will contain the maximum concentration of pollutants proposed i.e. are based on the MCPD emission limit values. This approach is considered to result in a conservative assessment as the annual average plant loads are likely to be below 100% due to maintenance activities and downtime and actual emission concentrations are likely to be lower than the maximum emission limit value specified in the MCPD.

Table 4-1: Stack emission parameters for biogas

Parameter	Units	Boilers (per unit)	CHP (per unit)	Multiflue (one boiler, two CHPs)	Flare
Stack location	x,y	549608, 260809	549608, 260809	549608, 260809	549736, 260812
Stack height (above finished ground level)	m	19[(a)]	19[(a)]	19[(a)]	15
Stack diameter	m	0.5	0.47	0.83	2.6
Exit temperature	°C	140	150	146	1000

[3] The Medium Combustion Plant Directive (MCPD) (Directive 2015/2193) regulates emissions of NOx into the air from combustion plants with a rated thermal input equal to or greater than 1 megawatt thermal (MWth) and less than 50 MWth. Schedule 25A of the Environmental Permitting (Amendment) Regulations 2018 implements this directive.

Parameter	Units	Boilers (per unit)	CHP (per unit)	Multiflue (one boiler, two CHPs)	Flare
Efflux velocity	m/s	14.7	15.2	15.0	7.7
Volumetric flow rate (actual)	Am^3/s	2.9[(b)]	2.6[(c)]	8.2	41.1[(d)]
Volumetric flow rate (normalised)	Nm^3/s	1.9[(e)]	3.1[(f)]	-	7.5[(e)]
NOx emission concentration	mg/Nm^3	200	190	-	150
NOx mass emission rate	g/s	0.38	0.58	1.55	1.13
SO_2 emission concentration	mg/Nm^3	100	40	-	-
SO_2 mass emission rate	g/s	0.19	0.12	0.44	0.8[(g)]

Notes: *Arithmetic discrepancies may occur in the table and are a result of rounding.*

Emissions concentrations are conservatively based on MCPD emission limit values rather than the lower emission guarantees provided by plant suppliers

(a) A stack height of 19m has been modelled based on the findings from the stack height determination, presented in Appendix 7.2: Dispersion Model Result (App Doc Ref 5.4.7.2), and the height of nearby buildings. Maximum design parameters include a stack height of 24m. The lower the stack height the higher the predicted concentration will be. Therefore, 19m is worst case and final stack design should not be lower than 19m.

(b) Actual conditions = 2.5% O_2, 15.9% H_2O

(c) Actual conditions = 7.9% O_2, 11.6% H_2O

(d) Actual conditions = 3% O_2, 12.5% H_2O

(e) Normalised conditions = 3% O_2, 0°C, 1013 mbar, dry

(f) Normalised conditions = 15% O_2, 0°C, 1013 mbar, dry

(g) Based on an H_2S content in biogas of 500ppmv

4.4 Buildings

4.4.1 The movement of air over and around buildings generates areas of flow circulation, which can lead to increased ground level concentrations in the building wakes. Where building heights are greater than about 30 - 40% of the stack height, downwash effects can be significant. ADMS includes a building effects module to calculate the dispersion of pollution from sources near large structures. The buildings likely to have a dominant effect (i.e. with the greatest dimensions likely to promote turbulence) which have been included within the model are listed in Table 4-2 and illustrated in Figure 4.1[4].

Table 4-2: Building dimensions used within the assessment

Figure ID	Name	Shape	X (m)	Y (m)	Height (m)	Length /Diameter (m)	Width (m)
1	HPH Tank 1	Circular	549621.2	260831	15	13.8	-
2	Boiler House	Rectangular	549622	260809.7	8.5	20	20
3	Gas to Grid 1	Rectangular	549611.6	260780.9	4	8.6	14.1
3	Not named 3	Rectangular	549595.5	260810.4	3	8.3	10.1
4	Digester 1	Circular	549661.1	260825.4	18	22	-
5	Digester 2	Circular	549660.9	260854.5	18	22	-
6	HPH Tank 2	Circular	549609.7	260827.8	15	7	-
7	HPH Tank 3	Circular	549601.8	260827.7	15	7	-
8	HPH Tank 4	Circular	549593.8	260827.7	15	7	-
9	Gas to Grid 2	Rectangular	549627	260784.5	3	14	8.5
10	Gas to Grid 3	Circular	549634.3	260786	12	3.8	-
11	Gas to Grid 4	Circular	549634.2	260779.9	12	3.8	-
12	Not named 1	Circular	549566.8	260856.4	10	10.8	-
13	Sludge Import Screening 1	Rectangular	549542.8	260859	10	18	28
14	Gas Bag	Circular	549659.6	260786.3	16	16.6	-
15	Sludge Import Screening 2	Circular	549568	260898	8.5	16.2	-

[4] The building dimensions and layouts included in the dispersion model reflect the Proposed WWTP layout at the time of the assessment. Whilst minor changes to the Proposed WWTP layout have occurred (see Chapter 2 Project Description), they would not change the overall conclusions of this assessment.

Figure ID	Name	Shape	X (m)	Y (m)	Height (m)	Length /Diameter (m)	Width (m)
16	Sludge Import Screening 3	Circular	549588	260898	8.5	16.2	-
17	Sludge Import Screening 4	Circular	549608	260898	8.5	16.2	-
18	Sludge Import Screening 5	Circular	549608	260920	8.5	16.2	-
19	Sludge Import Screening 6	Circular	549568	260918	8.5	16.2	-
20	Not named 2	Rectangular	549552.3	260887.5	5	10	7
21	Not named 3	Rectangular	549595	260810	3	8.3	10.1
22	Not named 4	Rectangular	549515.6	260848.7	3	26	8

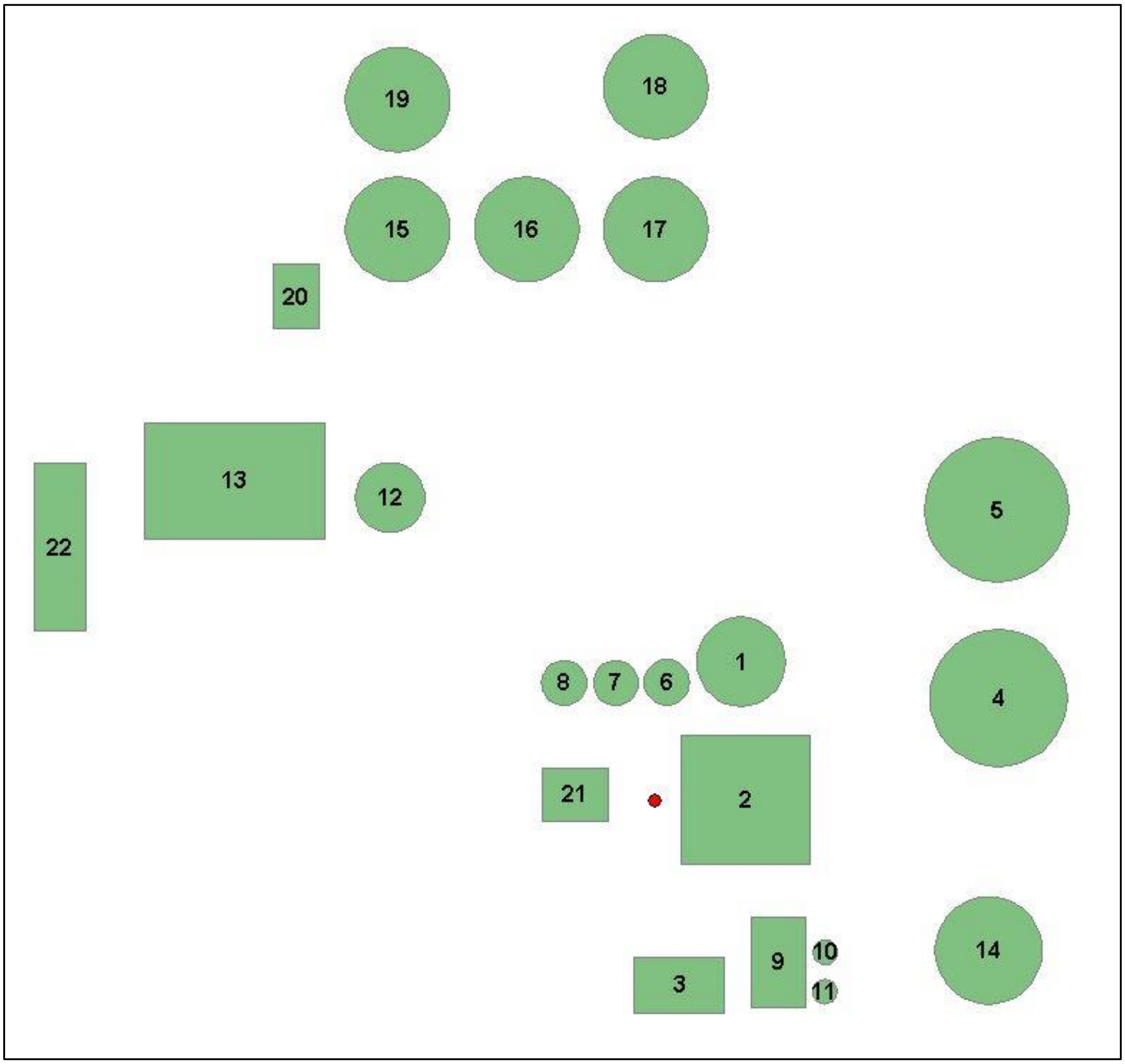


Figure 4.1: Buildings used within assessment

Note: Red point is the boiler/CHP stack

4.5 Terrain data

4.5.1 The presence of elevated terrain can significantly affect (usually increase) ground level concentrations of pollutants emitted from elevated sources such as stacks by reducing the distance between the plume centre line and ground level. Terrain can also increase turbulence and, hence, plume mixing which can also reduce ground level concentrations. Guidance provided by CERC states that terrain effects should only considered in the model where the gradient exceeds 1:10.

4.5.2 The design of the proposed WWTP includes creating a depression in the existing terrain to help soften landscape and visual impacts (Chapter 2: Project Description). Therefore, 'OS Terrain® 50' data has been included in the dispersion model and modified to account for the new depression relative to surrounding ground level and the addition of the 5m earth bank that surrounds the proposed WWTP.

4.6 NOx to NO_2 relationship

4.6.1 The NOx emissions associated with combustion activities such as boilers at the proposed WWTP will typically comprise approximately 90-95% nitrogen monoxide (NO) and 5-10% nitrogen dioxide (NO_2) at source. As described previously, the NO oxidises in the atmosphere in the presence of sunlight, ozone and volatile organic compounds to form NO_2, which is the principal concern in terms of environmental health effects.

4.6.2 There are various techniques available for estimating the portion of the NOx that is converted to NO_2, which will increase with distance from the source. The Environment Agency specified generator modelling guidance (Environment Agency, 2019) identifies that a 70% conversion of NOx to NO_2 should be used for calculation of annual average concentrations and a 35% conversion of NOx to NO_2 should be used for calculation of short-term concentrations. The Environment Agency's recommended conversion rates have been used in this assessment.

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