Dispersion Modelling Assessment

AUM a Crematorium by Anoopam Mission, Denham

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Executive Summary

Redmore Environmental Ltd was commissioned by Marchini Curran Associates on behalf of Anoopam Mission to undertake a Dispersion Modelling Assessment in support of a crematorium on land at the Shree Swaminarayan Spiritual Cultural & Community Centre, The Lea, Denham.

Planning consent for the development was granted in 2021 subject to a number of conditions, including a requirement for the use of electric cremators. It is proposed to vary the condition in order to allow the use of gas cremators to provide further flexibility during the design process. The variation in fuel type has the potential to affect the air quality impacts previously assessed. As such, a Dispersion Modelling Assessment was undertaken in order to determine baseline conditions and confirm the use of gas cremators is not predicted to result in significant air quality effects.

Dispersion modelling was undertaken in order to predict pollutant concentrations at sensitive locations as a result of emissions from the crematorium. The results indicated that impacts on pollutant concentrations were not predicted to be significant at any human or ecological receptor location in the vicinity of the site. As such, the use of gas cremators and the proposed stack height of 9.75m above ground level is considered appropriate.

Based on the assessment results, air quality impacts associated with cremation emissions are not considered a constraint to the proposals.

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1.0 INTRODUCTION

1.1 Background

1.1.1 Redmore Environmental Ltd was commissioned by Marchini Curran Associates on behalf of Anoopam Mission to undertake a Dispersion Modelling Assessment in support of a crematorium on land at the Shree Swaminarayan Spiritual Cultural & Community Centre, The Lea, Denham.

1.1.2 Atmospheric emissions during cremations have the potential to cause air quality impacts within the vicinity of the site. As such, a Dispersion Modelling Assessment was undertaken in order to determine baseline conditions and confirm the proposed stack height is not predicted to result in significant air quality effects.

1.2 Site Location

1.2.1 The site is located on land at the Shree Swaminarayan Spiritual Cultural & Community Centre, The Lea, Denham, at approximate National Grid Reference (NGR): 505100, 186020. Reference should be made to Figure 1 for a site location plan.

1.2.2 The proposed development is for a new crematorium designed specifically to respond to the ritual needs of the Hindu community, in the grounds of the Shree Swaminarayan Spiritual Cultural & Community Centre, the UK base of Anoopam Mission.

1.2.3 The new accommodation will comprise the crematorium building itself (ritual and ceremonial, operational and administrative spaces, inclusive of three cremators), a separate, smaller 'canteen' with washing facilities (for those partaking of a ritual meal) and associated car parking amidst new and existing woodland.

1.2.4 Planning consent for the development was granted on appeal on 16th December 2021 (reference: APP/N0410/W/21/3270138), subject to a number of conditions. These include the following:

> "23. The crematorium facility hereby approved shall only utilise electric cremators."

1.2.5 It is proposed to investigate the use of gas cremators at the site through an amendment to the above condition. The variation in fuel type has the potential to affect the previously assessed air quality impacts. As such, a Dispersion Modelling Assessment was undertaken in order to determine baseline conditions and confirm the use of gas cremators is not predicted to result in significant air quality effects. The findings are provided in the following report.

1.3 Scope of Works

1.3.1 The development will result in atmospheric emissions during cremations. This process is covered by Section 5.1 Part B (b) of the Environmental Permitting (England and Wales) Regulations (2016). As such, the applicant is required to obtain an Environmental Permit for the facility from the Local Authority (LA) prior to operation. Conditions of operation will align with the requirements of 'Process Guidance Note 5/2 (12): Statutory Guidance for Crematoria'[1] produced by the Department for Environment, Food and Rural Affairs (DEFRA). This requires a suitable stack height for the facility to be determined using 'Technical Guidance Note (Dispersion) D1'[2] or dispersion modelling. As such, dispersion modelling has been undertaken due to the improved accuracy of the process when compared with a D1 calculation.

1.3.2 In relation to verification of stack heights, DEFRA guidance 'Process Guidance Note 5/2 (12): Statutory Guidance for Crematoria'[3] states:

> "The calculation procedure of D1 is usually used to calculate the required stack height but alternative dispersion models may be used in agreement with the regulator."

1.3.3 In relation to the use of the D1 calculation method[4], the Institute of Air Quality Management (IAQM) Position Statement 'Use of Screening Tools for Preliminary Determination of the Significance of Pollutant Sources'[5] states:

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1 Process Guidance Note 5/2 (12): Statutory Guidance for Crematoria, DEFRA, 2012.

2 Technical Guidance Note (Dispersion) D1, Her Majesty's Inspectorate of Pollution, 1993.

3 Process Guidance Note 5/2 (12): Statutory Guidance for Crematoria, DEFRA, 2012.

4 Technical Guidance Note (Dispersion) D1, Her Majesty's Inspectorate of Pollution, 1993.

5 Use of Screening Tools for Preliminary Determination of the Significance of Pollutant Sources, IAQM, 2020.

> "There are many screening tools available to air quality professionals. These include the 'D1' stack height guidance, Environment Agency screening tools formerly known as 'H1', the DMRB air quality spreadsheet and LAQM screening tools. Most screening tools have been developed for specific situations or use in certain circumstances. Understanding the purpose of and evidence behind each tool can inform a judgement as to where it may be used appropriately. As an example, the 'D1' stack height calculations were derived based on ground level short-term SO_2 [sulphur dioxide] concentrations due to stack emissions and consider the 98th percentile of 15-minute mean concentrations. A stack height based on 'D1' calculations for a single, isolated stack, far away from buildings or elevated receptors, applied to pollutants and averaging periods for which it is designed may well be appropriate. However, actual situations are rarely that simple and added complexities may result in the D1 stack height being either significantly too low or too high."

1.3.4 Based on the above, the D1 calculation method[6] is considered unsuitable for a project of this nature for the following reasons:

- The most significant pollutant emitted from crematoria in relation to impacts on air quality at both human and ecological receptors is nitrogen oxides (NO_x) as nitrogen dioxide (NO_2), not SO_2;
- Compliance with the relevant short term averaging period for NO_2 is measured as a 99.8th percentile (%ile) of 1-hour means, not 98th %ile of 15-minute means;
- A number of other pollutants are emitted from crematoria, as considered within this assessment, that also have averaging periods that differ from 98th %ile of 15-minute means;
- There are multiple stacks, not a single stack; and,
- The stacks are located on top of a building, not remote from structures.

1.3.5 Dispersion modelling, which is an industry standard assessment method that provides significantly enhanced analysis performance when compared to the D1 calculation method, was therefore used throughout this project. It is noted that dispersion modelling has been used when undertaking Air Quality Assessments in support of planning applications for the following crematoria:

6 Technical Guidance Note (Dispersion) D1, Her Majesty's Inspectorate of Pollution, 1993.

- Land South West Of Moose Turkey Farm Skipton On Swale North Yorkshire (Hambleton District Council planning reference: 20/00716/FUL);
- Norton Road, Stafford, Cannock, WS12 2EJ (Cannock Chase Council planning reference: CH/18/380);
- Unit 6 Fellmongers Yard Valley Road Bradford West Yorkshire (City of Bradford Metropolitan District Council planning reference: 21/03174/FUL); and,
- Land Off Oxted Road (a25), Oxted (Tandridge District Council planning reference: 2021/258).

1.4 Author

1.4.1 This report was authored by Jethro Redmore, Director at Redmore Environmental Ltd. Jethro holds a BEng in Energy Engineering from Leeds University and a MSc in Environmental Pollution Control, also from Leeds University. He is a Chartered Environmentalist (CEnv), a Member of the Institute of Air Quality Management (MIAQM), a Member of the Institute of Environmental Sciences (MIEnvSc) and a Practitioner of the Institute of Environmental Management and Assessment (PIEMA). Jethro has previously sat on the council of the IAQM and been involved in working groups for the production of technical guidance. In his role as Director at Redmore Environmental he is responsible for directing the air quality assessments undertaken by the company. He was previously employed as Associate Director by Resource and Environmental Consultants Ltd, Senior Air Quality Consultant by Hyder Consulting, Senior Air Quality Consultant by WYG and Air Quality Technician by RPS.

1.4.2 Jethro has worked as a professional environmental scientist for approximately 18 years. He has been responsible for conducting environmental studies for crematoria, incinerators, major road improvement and construction schemes, power stations, oil refineries and other major industrial complexes. In addition, he has carried out numerous air quality assessments of mineral, commercial and retail proposals as well as providing specialist advice in the field of air quality and odour to Local Authorities and National Environmental Agencies.

2.0 LEGISLATION AND POLICY

2.1 Legislation

2.1.1 The Air Quality Standards Regulations (2010) and subsequent amendments include Air Quality Limit Values (AQLVs) for the following pollutants:

- Nitrogen dioxide (NO_2);
- Sulphur dioxide (SO_2);
- Lead;
- Particulate matter with an aerodynamic diameter of less than 10µm (PM_{10});
- Particulate matter with an aerodynamic diameter of less than 2.5µm;
- Benzene (C_6H_6); and,
- Carbon monoxide (CO).

2.1.2 Air quality target values were also provided for a number of additional pollutants.

2.1.3 The Air Quality Strategy (AQS) was produced by the Department for Environment, Food and Rural Affairs (DEFRA) and published in April 2023[7]. The document contains standards, objectives and measures for improving ambient air quality, including a number of Air Quality Objectives (AQOs). These are maximum ambient pollutant concentrations that are not to be exceeded either without exception or with a permitted number of exceedences over a specified timescale. These are generally in line with the AQLVs, although the requirements for the determination of compliance vary.

2.1.4 Table 1 presents the AQOs for pollutants considered within this assessment.

Table 1 Air Quality Objectives

Pollutant	Air Quality Objective	
	Concentration (µg/m^3)	Averaging Period
NO_2	40	Annual mean
	200	1-hour mean, not to be exceeded on more than 18 occasions per annum

[7] The AQS: Framework for Local Authority Delivery, DEFRA, 2023.

Pollutant	Air Quality Objective	
	Concentration (µg/m³)	Averaging Period
PM_{10}	40	Annual mean
	50	24-hour mean, not to be exceeded on more than 35 occasions per annum
SO_2	125	24-hour mean; not to be exceeded more than 3 times per annum
	350	1-hour mean; not to be exceeded more than 24 times per annum
	266	15-minute mean; not to be exceeded more than 35 times per annum
CO	10,000	8-hour running mean
C_6H_6	5	Annual mean

2.1.5 Table 2 summarises the advice provided in DEFRA guidance[8] on where the AQOs for pollutants considered within this report apply.

Table 2 Examples of Where the Air Quality Objectives Apply

Averaging Period	Objective Should Apply At	Objective Should Not Apply At
Annual mean	All locations where members of the public might be regularly exposed	Building façades of offices or other places of work where members of the public do not have regular access Hotels, unless people live there as their permanent residence Gardens of residential properties Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
24-hour mean and 8-hour mean	All locations where the annual mean objective would apply, together with hotels Gardens of residential properties	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term

8 Local Air Quality Management Technical Guidance (TG22), DEFRA, 2022.

Averaging Period	Objective Should Apply At	Objective Should Not Apply At
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets) Those parts of car parks, bus stations and railway stations etc which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer	Kerbside sites where the public would not be expected to have regular access
15-minute mean	All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer	-

2.2 Environmental Assessment Levels

2.2.1 An Environmental Assessment Level (EAL) is the concentration of a substance, which, in a particular environmental medium, the regulators regard as an appropriate comparator value. This enables comparison between the environmental effects of different substances in that medium and between environmental effects in different media, enabling the summation of those effects.

2.2.2 Ideally EALs to fulfil this objective would be defined for each pollutant:

- Based on the sensitivity of particular habitats or receptors (in particular three main types of receptor should be considered, protection of human health, protection of natural ecosystems and protection of specific sensitive receptors, e.g. materials, commercial activities requiring a particular environmental quality);
- Be produced according to a standardised protocol to ensure that they are consistent, reproducible and readily understood;
- Provide similar measure of protection for different receptors both within and between media; and,
- Take account of habitat specific environmental factors such as pH, nutrient status, bioaccumulation, transfer and transformation processes where necessary.

2.2.3 EALs used in this assessment were obtained from Environment Agency (EA) guidance 'Air emissions risk assessment for your environmental permit' and are summarised in Table 3.

Table 3 Environmental Assessment Levels

Pollutant	Environmental Assessment Level (µg/m³)	
	Long Term (Annual)	Short Term (1-hour)
Hydrogen chloride (HCl)	-	750
Mercury (Hg)	0.25	0.6
C_6H_6	-	195

2.3 Critical Loads and Levels

2.3.1 A critical load is defined by the UK Air Pollution Information System (APIS)[9] as:

> "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. The exceedance of a critical load is defined as the atmospheric deposition of the pollutant above the critical load."

2.3.2 A critical level is defined as:

> "Threshold for direct effects of pollutant concentrations according to current knowledge. Exceedance of a critical level is defined as the atmospheric concentration of the pollutant above the critical level."

2.3.3 A critical load refers to deposition of a pollutant, while a critical level refers to pollutant concentrations in the atmosphere (which usually have direct effects on vegetation or human health).

2.3.4 When pollutant loads (or concentrations) exceed the critical load or level it is considered that there is a risk of harmful effects. The excess over the critical load or level is termed the

[9] UK Air Pollution Information System, www.apis.ac.uk.

exceedence. A larger exceedence is often considered to represent a greater risk of damage.

2.3.5 Maps of critical loads and levels and their exceedences have been used to show the potential extent of pollution damage and aid in developing strategies for reducing pollution. Decreasing deposition below the critical load is seen as means for preventing the risk of damage. However, even a decrease in the exceedence may infer that less damage will occur.

2.3.6 Table 4 presents the critical levels for the protection of vegetation for pollutants considered within this assessment.

Table 4 Critical Levels for the Protection of Vegetation

Pollutant	Critical Level	
	Concentration (µg/m^3)	Averaging Period
Oxides of nitrogen (NO_x)	30	Annual mean
	75	24-hour mean
SO_2	20	Annual mean for higher plants
	10	Annual mean for sensitive lichen communities and bryophytes and ecosystems where lichens and bryophytes are an important part of the ecosystem's integrity

2.3.7 Critical loads have been designated within the UK based on the sensitivity of the receiving habitat and have been identified for the relevant designations considered within the assessment in Section 3.5.

2.4 Local Air Quality Management

2.4.1 Local Authorities (LAs) are required to periodically review and assess air quality within their area of jurisdiction under the system of Local Air Quality Management (LAQM). This review and assessment of air quality involves comparing present and likely future pollutant concentrations against the AQOs. If it is predicted that levels at locations of relevant exposure, as summarised in Table 2, are likely to be exceeded, the LA is required to declare an Air Quality Management Area (AQMA). For each AQMA the LA is required to

produce an Air Quality Action Plan, the objective of which is to reduce pollutant concentrations in pursuit of the AQOs.

2.5 National Planning Policy

2.5.1 The revised National Planning Policy Framework[10] (NPPF) was published in September 2023 and sets out the Government's planning policies for England and how these are expected to be applied.

2.5.2 The purpose of the planning system is to contribute to the achievement of sustainable development. In order to ensure this, the NPPF recognises three overarching objectives including the following of relevance to air quality:

> "c) - to protect and enhance our natural, built and historic environment; including making effective use of land, improving biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy."

2.5.3 Chapter 15 of the NPPF details objectives in relation to conserving and enhancing the natural environment. It states that:

> "174. Planning policies and decisions should contribute to and enhance the natural and local environment by:
>
> […]
>
> e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans […]"

10 NPPF, Ministry of Housing, Communities and Local Government, 2023.

2.5.4 The NPPF specifically recognises air quality as part of delivering sustainable development and states that:

> "186. Planning policies and decisions should sustain and contribute towards compliance with relevant limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas and Clean Air Zones, and the cumulative impacts from individual sites in local areas. Opportunities to improve air quality or mitigate impacts should be identified, such as through traffic and travel management, and green infrastructure provision and enhancement. So far as possible these opportunities should be considered at the plan-making stage, to ensure a strategic approach and limit the need for issues to be reconsidered when determining individual applications. Planning decisions should ensure that any new development in Air Quality Management Areas and Clean Air Zones is consistent with the local air quality action plan."

2.5.5 The implications of the NPPF have been considered throughout this assessment.

2.6 National Planning Practice Guidance

2.6.1 The National Planning Practice Guidance[11] (NPPG) web-based resource was launched by the Department for Communities and Local Government on 6th March 2014 and updated on 1st November 2019 to support the NPPF and make it more accessible. The air quality pages are summarised under the following headings:

1. What air quality considerations does planning need to address?
2. What is the role of plan-making with regard to air quality?
3. Are air quality concerns relevant to neighbourhood planning?
4. What information is available about air quality?
5. When could air quality considerations be relevant to the development management process?
6. What specific issues may need to be considered when assessing air quality impacts?
7. How detailed does an air quality assessment need to be?
8. How can an impact on air quality be mitigated?

[11] https://www.gov.uk/guidance/air-quality--3.

2.6.2 These were reviewed and the relevant guidance considered as necessary throughout the undertaking of this assessment.

2.7 Local Planning Policy

2.7.1 South Bucks District Council (SBDC) adopted the Core Strategy Development Plan Document (DPD)[12] in February 2011. The Core Strategy DPD is the key document in the South Bucks Local Plan and provides planning policy for the former South Bucks area of Buckinghamshire Council (BC).

2.7.2 A review of the Core Strategy DPD indicated the following policy in relation to air quality of relevance to the assessment:

> "Core Policy 13: Environmental and Resource Management
>
> The Council will seek to ensure the prudent and sustainable management of the District's environmental resources by:
>
> […]
>
> - Seeking improvements in air quality, especially in the Air Quality Management Area adjacent to the motorways and close to Burnham Beeches SAC.
>
> New development will be directed away from existing sources of noise and air pollution to avoid adverse impacts on local communities. The Council will work closely with other local authorities to minimise aircraft noise from Heathrow Airport.
>
> […]."

2.7.3 This policy has been considered throughout the report by considering potential air quality impacts as a result of the proposals.

[12] Core Strategy DPD, SBDC, 2011.

3.0 BASELINE

3.1 Introduction

3.1.1 Existing air quality conditions in the vicinity of the site were identified in order to provide a baseline for assessment. These are detailed in the following Sections.

3.2 Local Air Quality Management

3.2.1 As required by the Environment Act (1995), BC and the former SBDC have undertaken Review and Assessment of air quality within their area of jurisdiction. This process has indicated that annual mean concentrations of NO_2 are above the relevant AQO. As such, one AQMA has been declared within the former SBDC district. This is described as follows:

> "An area comprising the M4, M25 and M40 and adjacent land."

3.2.2 The development is located approximately 90m north of the SBDC AQMA. As such, any NO_2 emissions from the scheme may cause further deterioration of air quality within this sensitive area. This has been considered throughout the assessment.

3.2.3 The development is also located approximately 50m west of the Hillingdon AQMA. This has been declared due to exceedences of the annual mean AQO for NO_2 and is described as follows:

> "The area from the southern boundary north to the border defined by, the A40 corridor from the western borough boundary, east to the intersection with the Yeading Brook north until its intersection with the Chiltern-Marylebone railway line."

3.2.4 The Hillingdon AQMA was also considered throughout the assessment as necessary.

3.3 Air Quality Monitoring

Local Authority Monitoring

3.3.1 Monitoring of pollutant concentrations is undertaken by BC throughout their area of jurisdiction. Recent NO_2 results recorded in the vicinity of the development are shown in Table 5.

Table 5 Monitoring Results - NO_2

Monitoring Site		Monitored Annual Mean NO_2 Concentration ($\mu g/m^3$)			
		2019	2020	2021	2022
5	New Denham, Oxford Rd/Knighten Way	31.6	22.0	24.5	20.5

3.3.2 As shown in Table 5, annual mean NO_2 concentrations were below the AQO of $40\mu g/m^3$ at the 5 - New Denham, Oxford Rd/Knighten Way monitor in recent years.

3.3.3 Reference should be made to Figure 2 for a map of the survey position.

3.3.4 BC do not undertake monitoring of any other pollutants within the vicinity of the site.

Mercury Monitoring

3.3.5 Monitoring of Hg concentrations is carried out by DEFRA throughout the UK. The closest survey site to the proposed development is London Westminster at NGR: 529778, 178957. The most recent data available is from 2018, as summarised in Table 6.

Table 6 Monitoring Result - Hg

Species	Monitored Annual Mean Hg Concentration (ng/m^3)
Hg	2.68

Hydrogen Chloride Monitoring

3.3.6 Concentrations of HCl are monitored in the UK through the UK Eutrophying and Acidifying Pollutants (UKEAP) network. The closest survey site to the proposed development is

London Cromwell Road at NGR: 526529, 178966. The most recent data available is from 2015, as summarised in Table 7.

Table 7 Monitoring Result - HCl

Species	Monitored Annual Mean HCl Concentration (µg/m³)
HCl	0.37

3.4 Background Pollutant Concentrations

3.4.1 Predictions of background pollutant concentrations on a 1km by 1km grid basis have been produced by DEFRA for the entire of the UK to assist Local Authorities in their Review and Assessment of air quality. The site is located in grid square NGR: 505500, 186500. Data for this location was downloaded from the DEFRA website[13] for the purpose of the assessment and is summarised in Table 8.

Table 8 Background Pollutant Concentration Predictions

Pollutant	Predicted Background Pollutant Concentration (µg/m³)
NO_2	13.46
PM_{10}	14.11
SO_2	3.69
CO	386
C_6H_6	0.433

3.4.2 It should be noted that concentrations of NO_2 and PM_{10} are predicted for 2023, C_6H_6 for 2010 and SO_2 and CO for 2001. These are the most recent predictions available from DEFRA and are therefore considered to provide a reasonable representation of background concentrations in the vicinity of the site.

13 http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html.

3.5 Sensitive Receptors

3.5.1 A sensitive receptor is defined as any location which may be affected by changes in air quality. These have been defined for human and ecological receptors in the following Sections.

Human Receptors

3.5.2 A desk-top study was undertaken in order to identify any sensitive human receptor locations in the vicinity of the site that required specific consideration during the assessment. These are summarised in in Table 9 and represent worst case locations due to their proximity to the development.

Table 9 Sensitive Human Receptor Locations

Receptor		NGR (m)	
		X	Y
R1	Residential - Priory Close	504558.5	186129.9
R2	Residential - Priory Close	504531.1	186063.6
R3	Residential - Lindsey Road	504476.9	186279.3
R4	Residential - Moat Place	504535.8	185584.1
R5	Residential - Oxford Road	504660.0	185425.2
R6	Residential - Lime Walk	505205.7	185557.7
R7	Residential	505726.4	185504.5

3.5.3 Reference should be made to Figure 3 for a map of the sensitive human receptor locations.

Ecological Receptors

3.5.4 Atmospheric emissions from the proposals have the potential to impact on receptors of ecological sensitivity within the vicinity of the development. The Conservation of Habitats and Species Regulations (2010) and subsequent amendments require competent authorities to review applications and consents that have the potential to impact on

ecological sites. A review of designations within the vicinity of the proposals indicated the following for consideration within the assessment:

- Denham Quarry Park Local Nature Reserve (LNR);
- Denham Country Park LNR;
- Frays Valley LNR;
- Fray's Farm Meadows Site of Special Scientific Interest (SSSI);
- Denham Lock Wood SSSI; and,
- Kingcup Meadows and Oldhouse Wood SSSI.

3.5.5 For the purpose of the modelling assessment discrete receptors were placed at the closest point of each designation to the site to ensure the maximum potential impact was predicted. These are summarised in Table 10.

Table 10 Ecological Receptor Locations

Receptor		NGR (m)	
		X	Y
E1	Denham Quarry Park LNR	505254.1	186065.7
E2	Denham Quarry Park LNR	505202.4	186118.2
E3	Denham Quarry Park LNR	505160.6	186162.3
E4	Denham Quarry Park LNR	505114.9	186211.7
E5	Denham Quarry Park LNR	505077.7	186251.3
E6	Denham Quarry Park LNR	505035.1	186276.4
E7	Denham Quarry Park LNR	504966.6	186334.9
E8	Denham Quarry Park LNR	504894.3	186350.2
E9	Denham Quarry Park LNR	504781.9	186350.3
E10	Denham Country Park LNR	505318.8	186060.7
E11	Denham Country Park LNR	505289.0	186126.2
E12	Denham Country Park LNR	505254.5	186167.9
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	505376.0	185772.8
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	505410.1	185850.6

Receptor		NGR (m)	
		X	Y
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	505465.5	185892.2
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	505534.7	185999.8
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	505513.4	186114.9
E18	Frays Valley LNR	505441.0	186172.4
E19	Frays Valley LNR	505369.6	186226.8
E20	Frays Valley LNR and Denham Lock Wood SSSI	505311.0	186256.6
E21	Frays Valley LNR and Denham Lock Wood SSSI	505422.9	186210.9
E22	Frays Valley LNR and Denham Lock Wood SSSI	505505.2	186151.4
E23	Kingcup Meadows and Oldhouse Wood SSSI	503639.7	184895.8
E24	Kingcup Meadows and Oldhouse Wood SSSI	503455.1	185090.3
E25	Kingcup Meadows and Oldhouse Wood SSSI	502966.3	185367.2

3.5.6 Reference should be made to Figure 3 for a map of the ecological receptors.

3.5.7 Critical loads have been designated within the UK based on the sensitivity and relevant features of the receiving habitat. A review of the APIS[14] and the Multi-Agency Geographic Information for the Countryside (MAGIC)[15] websites, as well as the relevant site designations and publicly available information, was undertaken in order to identify the most suitable habitat description and associated critical load for the area of each designation considered within the assessment.

3.5.8 The relevant nitrogen deposition critical loads are presented in Table 11.

[14] http://www.apis.ac.uk/.

[15] Multi-Agency Geographic Information for the Countryside, www.magic.gov.uk.

Table 11 Critical Loads for Nitrogen Deposition

Receptor	Ecological Designation	Feature	APIS Habitat	Nitrogen Critical Load (kgN/ha/yr)	
				Low	High
E1 to E9	Denham Quarry Park LNR	Broadleaved, Mixed and Yew Woodland	Broadleaved deciduous woodland	10	15
E10 to E12	Denham Country Park LNR	Broadleaved, Mixed and Yew Woodland	Broadleaved deciduous woodland	10	26
E13 to E17	Fray's Farm Meadows SSSI	Fen, marsh and swamp (Carex acutiformis swamp)	Not sensitive	-	-
E18 and E19	Frays Valley LNR	Fen, marsh and swamp (Carex acutiformis swamp)	Not sensitive	-	-
E20 to E22	Denham Lock Wood SSSI	Alnus glutinosa - Urtica dioica Woodland	Broadleaved deciduous woodland	10	15
E23 and E24	Kingcup Meadows and Oldhouse Wood SSSI	Cynosurus Cristatus - Centaurea Nigra Grassland	Low and medium altitude hay meadows	10	20
E25	Kingcup Meadows and Oldhouse Wood SSSI	Alnus glutinosa - Carex paniculata Woodland	Broadleaved deciduous woodland	10	15

3.5.9 The site features were also reviewed to identify the habitat types most sensitive to acid deposition. These are summarised in Table 12.

Table 12 Critical Loads for Acid Deposition

Receptor	Designation	Feature	APIS Habitat	Acid Critical Load (keq/ha/yr)		
				CLMinN	CLMaxS	CLMaxN
E1 to E9	Denham Quarry Park LNR	Broadleaved, Mixed and Yew Woodland	Broadleafed/ Coniferous unmanaged woodland	0.357	10.761	11.118
E10 to E12	Denham Country Park LNR	Broadleaved, Mixed and Yew Woodland	Broadleafed/ Coniferous unmanaged woodland	0.357	10.761	11.118

Receptor	Designation	Feature	APIS Habitat	Acid Critical Load (keq/ha/yr)		
				CLMinN	CLMaxS	CLMaxN
E13 to E17	Fray's Farm Meadows SSSI	Fen, marsh and swamp (Carex acutiformis swamp)	Not sensitive	-	-	-
E18 and E19	Frays Valley LNR	Fen, marsh and swamp (Carex acutiformis swamp)	Not sensitive	-	-	-
E20 to E22	Denham Lock Wood SSSI	Alnus glutinosa - Urtica dioica Woodland	Unmanaged Broadleafed/ Coniferous Woodland	0.357	10.761	11.118
E23 and E24	Kingcup Meadows and Oldhouse Wood SSSI	Cynosurus Cristatus - Centaurea Nigra Grassland	Calcareous grassland (using base cation)	1.071	4	5.071
E25	Kingcup Meadows and Oldhouse Wood SSSI	Alnus glutinosa - Carex paniculata Woodland	Unmanaged Broadleafed/ Coniferous Woodland	0.357	1.704	2.061

3.5.10 Baseline NO_x and SO_2 concentrations, as well as nitrogen and acid deposition rates, at each ecological receptor were obtained from the from the APIS website[16]. These are summarised in Table 13.

Table 13 Baseline Pollution Levels at Ecological Receptors

Receptor		Annual Mean Conc. (µg/m³)		Baseline Deposition Rate		
		NO_x	SO_2	Nitrogen (kgN/ha/yr)	Acid (keq/ha/yr)	
					Nitrogen	Sulphur
E1	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E2	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E3	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18

16 http://www.apis.ac.uk/.

Receptor		Annual Mean Conc. (µg/m³)		Baseline Deposition Rate		
		NO_x	SO_2	Nitrogen (kgN/ha/yr)	Acid (keq/ha/yr)	
					Nitrogen	Sulphur
E4	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E5	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E6	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E7	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E8	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E9	Denham Quarry Park LNR	24.55	1.07	56.14	4.01	0.18
E10	Denham Country Park LNR	24.55	1.07	56.14	4.01	0.18
E11	Denham Country Park LNR	24.55	1.07	56.14	4.01	0.18
E12	Denham Country Park LNR	24.55	1.07	56.14	4.01	0.18
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	35.45	1.21	30.8	2.2	0.2
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	35.45	1.21	30.8	2.2	0.2
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	35.45	1.21	30.8	2.2	0.2
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	35.45	1.21	30.8	2.2	0.2
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	35.45	1.21	30.8	2.2	0.2
E18	Frays Valley LNR	35.45	1.21	30.8	2.2	0.2
E19	Frays Valley LNR	35.45	1.21	30.8	2.2	0.2
E20	Frays Valley LNR and Denham Lock Wood SSSI	20.1	1.3	25.7	4	0.2
E21	Frays Valley LNR and Denham Lock Wood SSSI	20.1	1.3	25.7	4	0.2
E22	Frays Valley LNR and Denham Lock Wood SSSI	20.1	1.3	25.7	4	0.2
E23	Kingcup Meadows and Oldhouse Wood SSSI	33.1	1.6	26.1	1.2	0.2

Receptor		Annual Mean Conc. (µg/m³)		Baseline Deposition Rate		
		NO_x	SO_2	Nitrogen (kgN/ha/yr)	Acid (keq/ha/yr)	
					Nitrogen	Sulphur
E24	Kingcup Meadows and Oldhouse Wood SSSI	33.1	1.6	26.1	1.2	0.2
E25	Kingcup Meadows and Oldhouse Wood SSSI	33.1	1.6	26.1	2.2	0.2

4.0 METHODOLOGY

4.1 Introduction

4.1.1 Combustion emissions during cremations have the potential to cause air quality impacts in the vicinity of the site. These have been quantified through dispersion modelling in accordance with the methodology outlined in the following Sections.

4.2 Dispersion Model

4.2.1 Dispersion modelling was undertaken using ADMS-6 (v6.0.0.1), which is developed by Cambridge Environmental Research Consultants (CERC) Ltd. ADMS-6 is a short-range dispersion modelling software package that simulates a wide range of buoyant and passive releases to atmosphere. It is a new generation model utilising boundary layer height and Monin-Obukhov length to describe the atmospheric boundary layer and a skewed Gaussian concentration distribution to calculate dispersion under convective conditions.

4.2.2 The model utilises hourly meteorological data to define conditions for plume rise, transport and diffusion. It estimates the concentration for each source and receptor combination for each hour of input meteorology and calculates user-selected long-term and short-term averages.

4.3 Modelling Scenarios

4.3.1 The scenarios considered in the modelling assessment for human receptors are summarised in Table 14.

Table 14 Human Receptor Assessment Scenarios

Parameter	Modelled As	
	Short Term	Long Term
NO_2	99.8th percentile (%ile) 1-hour mean	Annual mean
PM_{10}	90.4th %ile 24-hour mean	Annual mean
SO_2	99.9th %ile 15-minute mean	-

Parameter	Modelled As	
	Short Term	Long Term
	99.7th %ile 1-hour mean	
	99.2nd %ile 24-hour mean	
HCl	1-hour mean	-
CO	8-hour rolling mean	-
Hg	1-hour mean	Annual mean
Total Volatile Organic Compounds (TVOCs) as C_6H_6	1-hour mean	Annual mean

4.3.2 The scenarios considered for ecological receptors in the modelling assessment are summarised in Table 15.

Table 15 Ecological Receptor Assessment Scenarios

Parameter	Modelled As	
	Short Term	Long Term
NO_x	24-hour mean	Annual mean
SO_2	-	Annual mean
Nitrogen deposition	-	Annual deposition
Acid deposition	-	Annual deposition

4.3.3 Predicted pollutant concentrations were summarised in the following formats:

- Process Contribution (PC) - Predicted pollutant concentration as a result of emissions from the development only; and
- Predicted Environmental Concentration (PEC) - Total predicted pollutant concentration as a result of emissions from the development and existing baseline levels.

4.3.4 Predicted ground level pollutant concentrations and deposition rates were compared with the relevant AQOs, EALs, critical levels and critical loads. These criteria are collectively referred to as Environmental Quality Standards (EQSs).

4.4 Assessment Area

4.4.1 The assessment area was defined based on the development location, anticipated pollutant dispersion patterns and the positioning of sensitive receptors. Ambient concentrations were predicted over NGR: 504355, 185135 to 505855, 186635. One Cartesian grid with a resolution of 10m was used within the model to produce data suitable for contour plotting using the Surfer software package.

4.4.2 Reference should be made to Figure 4 for a graphical representation of the assessment grid extents.

4.5 Process Conditions

4.5.1 The development includes three cremators. However, one will be reserved for use as a back-up whilst two will be operated on a staggered schedule throughout the hours of 10:00 to 22:00 to allow up to 8 services per day. As such, only two sources were included within the model. A summary of the inputs is provided in Table 16. These were provided by DFW Europe B.V, the proposed Technology Supplier. Identical inputs were used for both cremators.

Table 16 Process Conditions

Parameter	Unit	Value
Stack position	NGR	As shown on Figure 4
Stack height	m	9.75
Stack diameter	m	0.25
Exhaust gas temperature	°C	135
Exhaust gas moisture content	%	10.8
Exhaust gas flow rate	m^3/s	0.46
Exhaust gas flow rate (dry, 0°C, 11% O_2)	Nm^3/s	0.28
Exhaust gas efflux velocity	m/s	9.46

4.5.2 Reference should be made to Figure 4 for a map of the emission point locations.

4.6 Emissions

4.6.1 Anticipated pollutant concentrations in the exhaust gas stream were obtained from Stack Emissions Monitoring undertaken on DFW Europe B.V gas cremators, as proposed for the development. These are summarised in Table 17.

Table 17 Pollutant Emission Concentrations

Pollutant	Pollutant Emission Concentration (mg/Nm³) (Dry, 11% O_2)
Particulate matter (PM)	18.3
NO_x	76.0
SO_2	1.0
HCl	18.3
CO	23.4
Hg	0.003
TVOC	8.1

4.6.2 The pollutant mass emission rates for use in the assessment were derived from the concentrations shown in Table 17 and the flow rate shown in Table 16. The results are summarised in Table 18. It should be noted that identical emission rates were utilised for both cremators.

Table 18 Pollutant Mass Emission Rate - Per Cremator

Pollutant	Pollutant Mass Emission Rate (g/s)
PM	0.0051
NO_x	0.0211
SO_2	0.0003
HCl	0.0051
CO	0.0065
Hg	0.000001
TVOC	0.0022

4.6.3 The emission rate for PM is stated as total dust. However, for the purposes of dispersion modelling it was considered that the entire PM emission consisted of only PM_{10}. This allowed the maximum ground level impacts to be assessed with respect to the EQS. Actual emissions of PM are unlikely to only consist of only one PM fraction, resulting in a worst-case assessment.

4.6.4 The emission rate for TVOCs is stated as Total Organic Carbon (TOC). However, similar to PM_{10}, for the purposes of dispersion modelling it was considered that the entire TOC emission consisted of only C_6H_6. This allowed the maximum ground level impacts to be assessed with respect to the EQS. Actual plant emissions of VOCs are unlikely to only consist of one species, resulting in a worst-case assessment. It should be noted that emissions were modelled as TOC and results factored to C_6H_6 using the relative atomic mass to carbon ratio.

4.6.5 Predicted long-term pollutant concentrations were factored in order to present the proposed operational schedule of 12-hours per day. This overestimates actual emissions as both cremators will not be used constantly during this period. Predicted short-term pollutant concentrations were based on 24-hour operation in order to ensure worst-case meteorological conditions were represented within the results.

4.7 NO_x to NO_2 Conversion

4.7.1 Emissions of total NO_x from combustion processes are predominantly in the form of nitric oxide (NO). Excess oxygen in the combustion gases and further atmospheric reactions cause the oxidation of NO to NO_2. Comparisons of ambient NO and NO_2 concentrations in the vicinity of point sources in recent years has indicated that it is unlikely that more than 30% of the NO_x is present at ground level as NO_2.

4.7.2 Ambient NO_x concentrations were predicted through dispersion modelling. Concentrations of NO_2 shown in the results section assume 70% conversion from NO_x to NO_2 for annual means and 35% conversion for 1-hour concentrations, based upon EA guidance[17].

[17] Environmental permitting: air dispersion modelling reports, EA, 2021.

4.8 Building Effects

4.8.1 The dispersion of substances released from elevated sources can be influenced by the presence of buildings close to the emission point. Structures can interrupt the wind flows and cause significantly higher ground-level concentrations close to the source than would arise in the absence of the buildings.

4.8.2 Analysis of the site layout indicated that a number of structures should be included within the model in order to take account of effects on pollutant dispersion. Input geometries are shown in Table 19.

Table 19 Building Geometries

Building	NGR (m)		Height (m)	Length (m)	Width (m)	Angle (°)
	X	Y				
Building 1	505105.7	185885.8	9.0	16.0	43.9	0
Building 2	505105.7	185903.8	8.1	20.1	32.1	0
Building 3	505106.2	185923.3	4.6	18.8	36.9	0

4.9 Meteorological Data

4.9.1 Meteorological data used in the assessment was taken from Heathrow Airport meteorological station over the period 1st January 2016 to 31st December 2020 (inclusive). This observation station is located at NGR: 506947, 176515, which is approximately 9.7km south-east of the site. It is anticipated that conditions would be reasonably similar over a distance of this magnitude. The data was therefore considered suitable for an assessment of this nature.

4.9.2 All meteorological files used in the assessment were provided by Atmospheric Dispersion Modelling Ltd, which is an established distributor of data within the UK. Reference should be made to Figure 5 for wind roses of the utilised meteorological records.

4.10 Roughness Length

4.10.1 Roughness length (z_0) is a modelling parameter applied to allow consideration of surface height roughness elements. A z_0 of 0.5m was used to describe the modelling extents. This is

considered appropriate for the morphology of the area and is suggested within ADMS-6 as being suitable for 'parkland, open suburbia'.

4.10.2 A z_0 of 0.3m was used to describe the meteorological site. This is considered appropriate for the morphology of the area and is suggested within ADMS-6 as being suitable for 'agricultural areas (max)'.

4.11 Monin-Obukhov Length

4.11.1 The Monin-Obukhov length provides a measure of the stability of the atmosphere. A minimum Monin-Obukhov length of 100 was used to describe the modelling extents and the meteorological site. This value is considered appropriate for the nature of both areas and is suggested within ADMS-6 as being suitable for 'large conurbations > 1 million'.

4.12 Terrain Data

4.12.1 Ordnance Survey OS Terrain 50 data was included in the model for the site and surrounding area in order to take account of the specific flow field produced by variations in ground height throughout the assessment extents. This was pre-processed using the method suggested by CERC.

4.13 Nitrogen Deposition

4.13.1 Nitrogen deposition rates were calculated using the conversion factors provided within EA document 'Technical Guidance on Detailed Modelling approach for an Appropriate Assessment for Emissions to Air AQTAG 06'[18]. Predicted pollutant concentrations were multiplied by the relevant deposition velocity and conversion factor to calculate the speciated dry deposition flux. The conversion factors used for the determination of nitrogen deposition are presented within Table 20.

[18] Technical Guidance on Detailed Modelling approach for an Appropriate Assessment for Emissions to Air AQTAG 06, EA, 2014.

Table 20 Conversion Factors to Determine Dry Deposition Flux for Nitrogen Deposition

Pollutant	Deposition Velocity (m/s)		Conversion Factor (µg/m²/s to kg/ha/yr of pollutant species)
	Grassland	Forest	
NO_2	0.0015	0.003	95.9

4.13.2 The relevant deposition velocity for each ecological receptor was selected from Table 20 based on the vegetation type present within the designation.

4.14 Acid Deposition

4.14.1 Acid deposition occurs as a result of NO_2, SO_2 and HCl. Predicted ground level pollutant concentrations of these species were converted to kilo-equivalent ion depositions (keq/ha/yr) for comparison with the critical load for acid deposition at each of the identified ecological receptors. The conversion to units of equivalents, a measure of the potential acidifying effect of a species, was undertaken using the standard conversion factors shown in Table 21.

Table 21 Conversion Factors to Determine Dry Deposition Flux for Acid Deposition

Pollutant	Deposition Velocity (m/s)		Conversion Factor (µg/m²/s to keq/ha/yr of pollutant species)
	Grassland	Forest	
NO_2	0.0015	0.003	6.84
SO_2	0.012	0.024	9.84
HCl	0.025	0.06	8.63

4.14.2 The following formula was used to calculate predicted PCs as a proportion of the critical load function:

PC as %CL function = ((PC of S+N+HCl deposition)/CLmaxN) x 100

4.14.3 The above formula was obtained from the APIS website[19].

[19] http://www.apis.ac.uk/.

4.15 Baseline Concentrations

4.15.1 Review of existing data was undertaken in Section 3.3 in order to identify suitable baseline values for use in the assessment. These were subsequently utilised to represent existing concentrations at sensitive human receptors in the vicinity of the site. A summary of the relevant values is provided in Table 22.

Table 22 Baseline Pollutant Concentrations Used in Assessment

Pollutant	Baseline Pollutant Concentration Used in Assessment (µg/m³)	Source
NO_2	20.5	Local Monitor
PM_{10}	14.11	DEFRA Mapping
SO_2	3.69	DEFRA Mapping
CO	386	DEFRA Mapping
C_6H_6	0.433	DEFRA Mapping
HCl	0.37	UKEAP Network
Hg	0.00268	DEFRA - Heavy Metals

4.15.2 Baseline pollutant levels at the ecological receptors were obtained from the DEFRA and APIS websites, as summarised in Table 13.

4.15.3 It is not possible to add short-term peak baseline and process concentrations. This is because the conditions which give rise to peak ground-level concentrations of substances emitted from an elevated source at a particular location and time are likely to be different to the conditions which give rise to peak concentrations due to emissions from other sources. This point is addressed in in EA guidance 'Air emissions risk assessment for your environmental permit'[20], which advises that an estimate of the maximum combined pollutant concentration can be obtained by adding the maximum predicted short-term concentration due to emissions from the source to twice the annual mean baseline concentration. This approach was adopted throughout the assessment.

[20] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit.

4.16 Assessment Criteria

Human Receptors

4.16.1 The significance of predicted air quality impacts at sensitive human receptors was determined in accordance with the guidance provided within the Institute of Air Quality Management (IAQM) document 'Land-Use Planning & Development Control: Planning for Air Quality'[21]. Using this methodology impacts on annual mean concentrations are defined based on the interaction between the predicted pollutant concentration with the development in place (PEC) and the magnitude of change (PC), as outlined in Table 23.

Table 23 Significance of Impact - Annual Mean Concentrations

Concentration at Receptor in Assessment Year (PEC)	Predicted Concentration Change as Proportion of EQS (PC) (%)			
	1	2 - 5	6 - 10	> 10
75% or less of EQS	Negligible	Negligible	Slight	Moderate
76 - 94% of EQS	Negligible	Slight	Moderate	Moderate
95 - 102% of EQS	Slight	Moderate	Moderate	Substantial
103 - 109% of EQS	Moderate	Moderate	Substantial	Substantial
110% or more of EQS	Moderate	Substantial	Substantial	Substantial

4.16.2 The matrix shown in Table 23 is intended to be used by rounding the change in percentage pollutant concentration to whole numbers, which makes it clearer which cell the impact falls within. It should be noted that changes of 0%, i.e. less than 0.5%, are described as **negligible**.

4.16.3 The significance of impacts on short-term pollutant concentrations at sensitive human receptors was determined in accordance with the criteria outlined in the IAQM document 'Land-Use Planning & Development Control: Planning for Air Quality'[22], as summarised in Table 24.

[21] Land-Use Planning & Development Control: Planning for Air Quality, IAQM, 2017.

[22] Land-Use Planning & Development Control: Planning for Air Quality, IAQM, 2017.

Table 24 Significance of Impact - Short Term Concentrations

Predicted Concentration Change as Proportion of EQS (PC) (%)	Significance of Impact
Less than 10	Negligible
11 - 20	Slight
21 - 50	Moderate
Greater than 51	Substantial

4.16.4 Following the prediction of impacts at discrete receptor locations, the IAQM[23] provides guidance on determining the overall air quality impact significance of the operation of a development and states that an assessment must reach a conclusion on the likely significance of the predicted impact. It should be noted that this is a binary judgement of either **significant** or **not significant**. The determination of significance relies on professional judgement and reasoning has been provided as far as practicable. This has been considered throughout the assessment when defining predicted impacts.

Ecological Receptors

4.16.5 EA guidance 'Air emissions risk assessment for your environmental permit'[24] states that PCs at SSSIs can be screened as insignificant if they meet the following criteria:

- The short-term PC is less than 10% of the short-term environmental standard for protected conservation areas;
- The long-term PC is less than 1% of the long-term environmental standard for protected conservation areas; or,
- The long-term PC is greater than 1% and the long term PEC is less than 70% of the long term environmental standard.

4.16.6 PCs at LNRs can be screened as insignificant if they meet the following criteria:

- The short-term PC is less than 100% of the short-term environmental standard for protected conservation areas; and,

23 Land-Use Planning & Development Control: Planning for Air Quality, IAQM, 2017.

24 https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit.

- The long-term PC is less than 100% of the long-term environmental standard for protected conservation areas.

4.16.7 Predicted PCs have been compared to the relevant EQSs and the criteria stated above. Where the impact is within these parameters, the EA concludes that impacts associated with an installation are acceptable.

4.17 Modelling Uncertainty

4.17.1 Uncertainty in dispersion modelling predictions can be associated with a variety of factors, including:

- Model uncertainty - due to model limitations;
- Data uncertainty - due to errors in input data, including emission estimates, operational procedures, land use characteristics and meteorology; and,
- Variability - randomness of measurements used.

4.17.2 Potential uncertainties in the model results were minimised as far as practicable and worst-case inputs used in order to provide a robust assessment. This included the following:

- Choice of model - ADMS-6 is a commonly used atmospheric dispersion model and results have been verified through a number of studies to ensure predictions are as accurate as possible;
- Meteorological data - Modelling was undertaken using five annual meteorological data sets from an observation station local to the site. The analysis was based on the worst-case year for each averaging period to ensure maximum concentrations were considered;
- Surface characteristics - The z_0 and Monin-Obukhov length were determined for both the dispersion and meteorological sites based on the surrounding land uses and guidance provided by CERC. Terrain data was included and processed using the method outlined by CERC;
- Plant operating conditions - Operational parameters were obtained from the proposed Technology Supplier. As such, these are considered to be representative of normal operating conditions;

- Emission rates - The emission rates were obtained from monitoring undertaken at a representative crematorium. As such, these are considered to be representative of anticipated releases. Emissions were assumed to occur over a longer period than actual operation in order to ensure a worst-case assessment;
- Background concentrations - Background pollutant levels were obtained from local and national monitoring networks, as well as the DEFRA and APIS websites;
- Receptor locations - A Cartesian Grid was included in the model in order to provide suitable data for contour plotting. Receptor points were also included at sensitive locations to provide additional consideration of these areas; and,
- Variability - All model inputs were as accurate as possible and worst-case conditions were considered as necessary in order to ensure a robust assessment of potential pollutant concentrations.

4.17.3 Results were considered in the context of the relevant EQSs and IAQM or EA significance criteria. It is considered that the use of the stated measures to reduce uncertainty and the use of worst-case assumptions when necessary has resulted in model accuracy of an acceptable level.

5.0 RESULTS

5.1 Introduction

5.1.1 Dispersion modelling was undertaken with the inputs described in Section 4.0. The results are outlined in the following Sections.

5.2 Maximum Pollutant Concentrations

5.2.1 The maximum predicted pollutant concentrations at any point within the modelling extents for any meteorological data set are summarised in Table 25.

Table 25 Maximum Predicted Pollutant Concentrations

Pollutant	Averaging Period	EQS (µg/m³)	PC (µg/m³)	PC Proportion of EQS (%)	PEC (µg/m³)	PEC Proportion of EQS (%)
NO_2	Annual	40	3.36	8.4	23.86	59.6
	99.8th %ile 1-hour	200	12.00	6.0	53.00	26.5
PM_{10}	Annual	40	1.16	2.9	15.27	38.2
	90.4th %ile 24-hour	50	3.47	6.9	31.69	63.4
SO_2	99.0th %ile 24-hour	125	0.29	0.2	10.27	8.2
	99.73rd %ile 1-hour	350	0.48	0.1	10.46	3.0
	99.9th %ile 15-minute	266	0.52	0.2	10.50	3.9
HCl	1-hour	750	10.14	1.4	10.51	1.4
CO	8-hour rolling	10,000	8.92	0.1	602.92	6.0
Hg	Annual	0.25	0.0002	0.1	0.0029	1.1
	1-hour	0.6	0.0016	0.3	0.0069	1.2
C_6H_6	Annual	5	0.56	11.1	0.99	19.8
	1-hour	195	4.86	2.5	5.73	2.9

5.2.2 As shown in Table 25, there were no predicted exceedences of any EQS at any location for any pollutant or averaging period of interest.

5.2.3 Review of the results indicated:

- The PC proportion of the annual mean EQS for Hg was less than 1%. As such, impacts at all locations are predicted to be **negligible**, in accordance with the IAQM criteria outlined in Table 23; and,
- The PC proportion of the short-term EQS for NO_2, PM_{10}, SO_2, HCl, CO, Hg and C_6H_6 was less than 10%. As such, impacts at all locations are predicted to be **negligible**, in accordance with the IAQM criteria outlined in Table 24.

5.2.4 Maximum predicted annual mean NO_2, PM_{10} and C_6H_6 concentrations were above 1% of the relevant EQSs. As such, impacts at the individual receptor locations were assessed further in the following Section.

5.3 Human Receptors

Nitrogen Dioxide

5.3.1 Annual mean NO_2 PECs at the sensitive human receptors, inclusive of background levels, are summarised in Table 26.

Table 26 Predicted Annual Mean NO_2 Concentrations

Receptor		Predicted Annual Mean NO_2 PEC (µg/m³)				
		2016	2017	2018	2019	2020
R1	Residential - Priory Close	20.51	20.51	20.51	20.51	20.51
R2	Residential - Priory Close	20.51	20.51	20.51	20.51	20.51
R3	Residential - Lindsey Road	20.50	20.50	20.51	20.51	20.50
R4	Residential - Moat Place	20.51	20.51	20.51	20.51	20.51
R5	Residential - Oxford Road	20.52	20.51	20.52	20.51	20.51
R6	Residential - Lime Walk	20.53	20.53	20.52	20.52	20.52
R7	Residential	20.51	20.51	20.51	20.51	20.51

5.3.2 As indicated in Table 26, NO_2 PECs were below the annual mean EQS of 40µg/m^3 at all sensitive receptor locations for all meteorological data sets.

5.3.3 Reference should be made to Figure 6 for a graphical representation of predicted annual mean NO_2 concentrations throughout the assessment extents. It should be noted that the values shown in the Figures are predictions from the meteorological data set which resulted in the maximum pollutant concentration for that species. For example, the maximum annual mean NO_2 concentration was predicted using the 2017 meteorological data set. As such, the contours shown in Figure 6 were produced from the 2017 model outputs.

5.3.4 The significance of predicted impacts on annual mean NO_2 concentrations at the sensitive receptors are summarised in Table 27. These consider the maximum predicted change in concentration from the five meteorological datasets as a worst-case.

Table 27 Predicted Impacts on Annual Mean NO_2 Concentrations

Receptor		Predicted Concentration (PEC)	Predicted Concentration Change as Proportion of EQS (PC) (%)	Impact Significance
R1	Residential - Priory Close	Below 75% of EQS	0	Negligible
R2	Residential - Priory Close	Below 75% of EQS	0	Negligible
R3	Residential - Lindsey Road	Below 75% of EQS	0	Negligible
R4	Residential - Moat Place	Below 75% of EQS	0	Negligible
R5	Residential - Oxford Road	Below 75% of EQS	0	Negligible
R6	Residential - Lime Walk	Below 75% of EQS	0	Negligible
R7	Residential	Below 75% of EQS	0	Negligible

5.3.5 As indicated in Table 27, impacts on annual mean NO_2 concentrations as a result of the proposed development were predicted to be **negligible** at all sensitive receptors.

Particulate Matter

5.3.6 Annual mean PM_{10} PECs at the sensitive human receptors, inclusive of background levels, are summarised in Table 28.

Table 28 Predicted Annual Mean PM_{10} Concentrations

Receptor		Predicted Annual Mean PM_{10} PEC (µg/m³)				
		2016	2017	2018	2019	2020
R1	Residential - Priory Close	14.11	14.11	14.11	14.11	14.11
R2	Residential - Priory Close	14.11	14.11	14.11	14.11	14.11
R3	Residential - Lindsey Road	14.11	14.11	14.11	14.11	14.11
R4	Residential - Moat Place	14.11	14.11	14.11	14.11	14.11
R5	Residential - Oxford Road	14.12	14.11	14.12	14.11	14.11
R6	Residential - Lime Walk	14.12	14.12	14.12	14.12	14.12
R7	Residential	14.11	14.11	14.11	14.11	14.11

5.3.7 As indicated in Table 28, PM_{10} PECs were below the annual mean EQS of 40µg/m³ at all sensitive receptor locations for all meteorological data sets.

5.3.8 Reference should be made to Figure 7 for a graphical representation of predicted annual mean NO_2 concentrations throughout the assessment extents.

5.3.9 The significance of predicted impacts on annual mean PM_{10} concentrations at the sensitive receptors are summarised in Table 29. These consider the maximum predicted change in concentration from the five meteorological datasets as a worst-case.

Table 29 Predicted Impacts on Annual Mean PM_{10} Concentrations

Receptor		Predicted Concentration (PEC)	Predicted Concentration Change as Proportion of EQS (PC) (%)	Impact Significance
R1	Residential - Priory Close	Below 75% of EQS	0	Negligible
R2	Residential - Priory Close	Below 75% of EQS	0	Negligible

Receptor		Predicted Concentration (PEC)	Predicted Concentration Change as Proportion of EQS (PC) (%)	Impact Significance
R3	Residential - Lindsey Road	Below 75% of EQS	0	Negligible
R4	Residential - Moat Place	Below 75% of EQS	0	Negligible
R5	Residential - Oxford Road	Below 75% of EQS	0	Negligible
R6	Residential - Lime Walk	Below 75% of EQS	0	Negligible
R7	Residential	Below 75% of EQS	0	Negligible

5.3.10 As indicated in Table 29, impacts on annual mean PM_{10} concentrations as a result of the proposed development were predicted to be **negligible** at all sensitive receptors.

Volatile Organic Compounds

5.3.11 Annual mean C_6H_6 PECs at the sensitive human receptors, inclusive of background levels, are summarised in Table 30.

Table 30 Predicted Annual Mean C_6H_6 Concentrations

Receptor		Predicted Annual Mean C_6H_6 PEC (µg/m³)				
		2016	2017	2018	2019	2020
R1	Residential - Priory Close	0.4340	0.4340	0.4341	0.4341	0.4338
R2	Residential - Priory Close	0.4340	0.4340	0.4342	0.4341	0.4338
R3	Residential - Lindsey Road	0.4337	0.4337	0.4338	0.4338	0.4336
R4	Residential - Moat Place	0.4347	0.4341	0.4346	0.4344	0.4346
R5	Residential - Oxford Road	0.4355	0.4344	0.4355	0.4350	0.4351
R6	Residential - Lime Walk	0.4373	0.4368	0.4363	0.4367	0.4358
R7	Residential	0.4348	0.4351	0.4344	0.4346	0.4344

5.3.12 As indicated in Table 30, C_6H_6 PECs were below the annual mean EQS of 5µg/m³ at all sensitive receptor locations for all meteorological data sets.

5.3.13 Reference should be made to Figure 8 for a graphical representation of predicted annual mean C_6H_6 concentrations throughout the assessment extents.

5.3.14 The significance of predicted impacts on annual mean C_6H_6 concentrations at the sensitive receptors are summarised in Table 31. These consider the maximum predicted change in concentration from the five meteorological datasets as a worst-case.

Table 31 Predicted Impacts on Annual Mean C_6H_6 Concentrations

Receptor		Predicted Concentration (PEC)	Predicted Concentration Change as Proportion of EQS (PC) (%)	Impact Significance
R1	Residential - Priory Close	Below 75% of EQS	0	Negligible
R2	Residential - Priory Close	Below 75% of EQS	0	Negligible
R3	Residential - Lindsey Road	Below 75% of EQS	0	Negligible
R4	Residential - Moat Place	Below 75% of EQS	0	Negligible
R5	Residential - Oxford Road	Below 75% of EQS	0	Negligible
R6	Residential - Lime Walk	Below 75% of EQS	0	Negligible
R7	Residential	Below 75% of EQS	0	Negligible

5.3.15 As indicated in Table 31, impacts on annual mean C_6H_6 concentrations as a result of the proposed development were predicted to be **negligible** at all sensitive receptors.

5.4 Ecological Receptors

Nitrogen Oxides

5.4.1 Predicted annual mean NO_x PECs at the ecological receptor locations, inclusive of background levels, are summarised in Table 32.

Table 32 Predicted Annual Mean NO_x Concentrations

Receptor		Predicted Annual Mean NO_x PEC ($\mu g/m^3$)				
		2016	2017	2018	2019	2020
E1	Denham Quarry Park LNR	24.70	24.70	24.68	24.71	24.70
E2	Denham Quarry Park LNR	24.67	24.67	24.67	24.68	24.69
E3	Denham Quarry Park LNR	24.63	24.63	24.64	24.65	24.65
E4	Denham Quarry Park LNR	24.60	24.60	24.61	24.62	24.62
E5	Denham Quarry Park LNR	24.59	24.59	24.60	24.60	24.60
E6	Denham Quarry Park LNR	24.58	24.58	24.59	24.59	24.59
E7	Denham Quarry Park LNR	24.57	24.57	24.58	24.57	24.58
E8	Denham Quarry Park LNR	24.57	24.57	24.57	24.57	24.57
E9	Denham Quarry Park LNR	24.56	24.56	24.57	24.56	24.56
E10	Denham Country Park LNR	24.65	24.67	24.64	24.66	24.66
E11	Denham Country Park LNR	24.64	24.65	24.64	24.66	24.65
E12	Denham Country Park LNR	24.63	24.63	24.63	24.64	24.64
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	35.53	35.55	35.52	35.52	35.51
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	35.54	35.57	35.53	35.53	35.52
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	35.52	35.55	35.52	35.52	35.52
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	35.50	35.52	35.50	35.50	35.50
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	35.49	35.50	35.49	35.49	35.49
E18	Frays Valley LNR	35.50	35.50	35.49	35.50	35.50
E19	Frays Valley LNR	35.50	35.50	35.50	35.51	35.50
E20	Frays Valley LNR and Denham Lock Wood SSSI	20.15	20.15	20.15	20.16	20.16
E21	Frays Valley LNR and Denham Lock Wood SSSI	20.15	20.15	20.14	20.15	20.15
E22	Frays Valley LNR and Denham Lock Wood SSSI	20.14	20.15	20.14	20.14	20.14
E23	Kingcup Meadows and Oldhouse Wood SSSI	33.10	33.10	33.10	33.10	33.10
E24	Kingcup Meadows and Oldhouse Wood SSSI	33.10	33.10	33.10	33.10	33.10
E25	Kingcup Meadows and Oldhouse Wood SSSI	33.10	33.10	33.10	33.10	33.10

5.4.2 Maximum predicted annual mean NO_x concentrations at the ecological receptor locations are summarised in Table 33.

Table 33 Maximum Predicted Annual Mean NO_x Concentrations

Receptor		Maximum Predicted Annual Mean NO_x Concentration (µg/m³)		Proportion of EQS (%)	
		PC	PEC	PC	PEC
E1	Denham Quarry Park LNR	0.16	24.71	0.5	82.4
E2	Denham Quarry Park LNR	0.14	24.69	0.5	82.3
E3	Denham Quarry Park LNR	0.10	24.65	0.3	82.2
E4	Denham Quarry Park LNR	0.07	24.62	0.2	82.1
E5	Denham Quarry Park LNR	0.05	24.60	0.2	82.0
E6	Denham Quarry Park LNR	0.04	24.59	0.1	82.0
E7	Denham Quarry Park LNR	0.03	24.58	0.1	81.9
E8	Denham Quarry Park LNR	0.02	24.57	0.1	81.9
E9	Denham Quarry Park LNR	0.02	24.57	0.1	81.9
E10	Denham Country Park LNR	0.12	24.67	0.4	82.2
E11	Denham Country Park LNR	0.11	24.66	0.4	82.2
E12	Denham Country Park LNR	0.09	24.64	0.3	82.1
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	0.10	35.55	0.3	118.5
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	0.12	35.57	0.4	118.6
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	0.10	35.55	0.3	118.5
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	0.07	35.52	0.2	118.4
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	0.05	35.50	0.2	118.3
E18	Frays Valley LNR	0.05	35.50	0.2	118.3
E19	Frays Valley LNR	0.06	35.51	0.2	118.4

Receptor		Maximum Predicted Annual Mean NO_x Concentration (µg/m³)		Proportion of EQS (%)	
		PC	PEC	PC	PEC
E20	Frays Valley LNR and Denham Lock Wood SSSI	0.06	20.16	0.2	67.2
E21	Frays Valley LNR and Denham Lock Wood SSSI	0.05	20.15	0.2	67.2
E22	Frays Valley LNR and Denham Lock Wood SSSI	0.05	20.15	0.2	67.2
E23	Kingcup Meadows and Oldhouse Wood SSSI	0.00	33.10	0.0	110.3
E24	Kingcup Meadows and Oldhouse Wood SSSI	0.00	33.10	0.0	110.3
E25	Kingcup Meadows and Oldhouse Wood SSSI	0.00	33.10	0.0	110.3

5.4.3 As shown in Table 33, PCs were below 1% of the EQS at all ecological receptors. As such, predicted effects on annual mean NO_x concentrations are considered to be **not significant**, in accordance with the stated criteria.

5.4.4 Predicted 24-hour mean NO_x PECs at the receptor locations, inclusive of background levels, are summarised in Table 34.

Table 34 Predicted 24-hour Mean NO_x Concentrations

Receptor		Predicted 24-hour Mean NO_x PEC (µg/m³)				
		2016	2017	2018	2019	2020
E1	Denham Quarry Park LNR	50.76	50.60	50.80	50.75	50.50
E2	Denham Quarry Park LNR	50.53	50.32	50.53	50.41	50.78
E3	Denham Quarry Park LNR	50.19	50.09	50.12	50.21	50.41
E4	Denham Quarry Park LNR	49.99	49.84	50.01	49.95	49.97
E5	Denham Quarry Park LNR	49.85	49.70	49.84	49.84	49.85
E6	Denham Quarry Park LNR	49.73	49.66	49.73	49.70	49.72
E7	Denham Quarry Park LNR	49.59	49.49	49.51	49.46	49.51

Receptor		Predicted 24-hour Mean NO_x PEC (µg/m³)				
		2016	2017	2018	2019	2020
E8	Denham Quarry Park LNR	49.49	49.48	49.47	49.40	49.46
E9	Denham Quarry Park LNR	49.41	49.44	49.43	49.35	49.36
E10	Denham Country Park LNR	50.36	50.40	50.23	50.29	50.07
E11	Denham Country Park LNR	50.14	50.01	50.20	50.20	50.07
E12	Denham Country Park LNR	50.00	49.92	50.04	49.91	50.06
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	72.14	72.46	71.91	71.87	72.26
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	72.24	72.17	72.03	71.87	72.03
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	71.84	71.87	71.86	71.66	71.84
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	71.58	71.60	71.66	71.40	71.46
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	71.30	71.37	71.41	71.28	71.30
E18	Frays Valley LNR	71.52	71.52	71.43	71.48	71.36
E19	Frays Valley LNR	71.50	71.42	71.53	71.53	71.44
E20	Frays Valley LNR and Denham Lock Wood SSSI	40.76	40.71	40.78	40.74	40.80
E21	Frays Valley LNR and Denham Lock Wood SSSI	40.82	40.77	40.78	40.78	40.63
E22	Frays Valley LNR and Denham Lock Wood SSSI	40.63	40.68	40.68	40.61	40.56
E23	Kingcup Meadows and Oldhouse Wood SSSI	66.28	66.26	66.28	66.27	66.27
E24	Kingcup Meadows and Oldhouse Wood SSSI	66.26	66.25	66.26	66.27	66.25
E25	Kingcup Meadows and Oldhouse Wood SSSI	66.23	66.24	66.26	66.25	66.24

5.4.5 Maximum predicted 24-hour mean NO_x concentrations at the receptor locations are summarised in Table 35.

Table 35 Maximum Predicted 24-hour Mean NO_x Concentrations

Receptor		Maximum Predicted 24-hour Mean NO_x Concentration (µg/m³)		Proportion of EQS (%)	
		PC	PEC	PC	PEC
E1	Denham Quarry Park LNR	1.70	50.80	2.3	67.7
E2	Denham Quarry Park LNR	1.68	50.78	2.2	67.7
E3	Denham Quarry Park LNR	1.31	50.41	1.7	67.2
E4	Denham Quarry Park LNR	0.91	50.01	1.2	66.7
E5	Denham Quarry Park LNR	0.75	49.85	1.0	66.5
E6	Denham Quarry Park LNR	0.63	49.73	0.8	66.3
E7	Denham Quarry Park LNR	0.49	49.59	0.7	66.1
E8	Denham Quarry Park LNR	0.39	49.49	0.5	66.0
E9	Denham Quarry Park LNR	0.34	49.44	0.4	65.9
E10	Denham Country Park LNR	1.30	50.40	1.7	67.2
E11	Denham Country Park LNR	1.10	50.20	1.5	66.9
E12	Denham Country Park LNR	0.96	50.06	1.3	66.7
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	1.56	72.46	2.1	96.6
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	1.34	72.24	1.8	96.3
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	0.97	71.87	1.3	95.8
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	0.76	71.66	1.0	95.5
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	0.51	71.41	0.7	95.2
E18	Frays Valley LNR	0.62	71.52	0.8	95.4
E19	Frays Valley LNR	0.63	71.53	0.8	95.4
E20	Frays Valley LNR and Denham Lock Wood SSSI	0.60	40.80	0.8	54.4
E21	Frays Valley LNR and Denham Lock Wood SSSI	0.62	40.82	0.8	54.4

Receptor		Maximum Predicted 24-hour Mean NO_x Concentration (µg/m³)		Proportion of EQS (%)	
		PC	PEC	PC	PEC
E22	Frays Valley LNR and Denham Lock Wood SSSI	0.48	40.68	0.6	54.2
E23	Kingcup Meadows and Oldhouse Wood SSSI	0.08	66.28	0.1	88.4
E24	Kingcup Meadows and Oldhouse Wood SSSI	0.07	66.27	0.1	88.4
E25	Kingcup Meadows and Oldhouse Wood SSSI	0.06	66.26	0.1	88.3

5.4.6 As shown in Table 35, PCs were below 10% of the EQS at all ecological receptors. As such, predicted effects on 24-hour mean NO_x concentrations are considered to be **not significant**, in accordance with the stated criteria.

Sulphur Dioxide

5.4.7 Predicted annual mean SO_2 PECs at the ecological receptor locations, inclusive of background levels, are summarised in Table 36.

Table 36 Predicted Annual Mean SO_2 Concentrations

Receptor		Predicted Annual Mean SO_2 PEC (µg/m³)				
		2016	2017	2018	2019	2020
E1	Denham Quarry Park LNR	1.072	1.072	1.072	1.072	1.072
E2	Denham Quarry Park LNR	1.072	1.072	1.072	1.072	1.072
E3	Denham Quarry Park LNR	1.071	1.071	1.071	1.071	1.071
E4	Denham Quarry Park LNR	1.071	1.071	1.071	1.071	1.071
E5	Denham Quarry Park LNR	1.071	1.071	1.071	1.071	1.071
E6	Denham Quarry Park LNR	1.070	1.070	1.071	1.071	1.071
E7	Denham Quarry Park LNR	1.070	1.070	1.070	1.070	1.070
E8	Denham Quarry Park LNR	1.070	1.070	1.070	1.070	1.070

Receptor		Predicted Annual Mean SO_2 PEC ($\mu g/m^3$)				
		2016	2017	2018	2019	2020
E9	Denham Quarry Park LNR	1.070	1.070	1.070	1.070	1.070
E10	Denham Country Park LNR	1.071	1.072	1.071	1.072	1.072
E11	Denham Country Park LNR	1.071	1.071	1.071	1.071	1.071
E12	Denham Country Park LNR	1.071	1.071	1.071	1.071	1.071
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	1.211	1.211	1.211	1.211	1.211
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	1.211	1.212	1.211	1.211	1.211
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	1.211	1.211	1.211	1.211	1.211
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	1.211	1.211	1.211	1.211	1.211
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	1.211	1.211	1.211	1.211	1.211
E18	Frays Valley LNR	1.211	1.211	1.211	1.211	1.211
E19	Frays Valley LNR	1.211	1.211	1.211	1.211	1.211
E20	Frays Valley LNR and Denham Lock Wood SSSI	1.301	1.301	1.301	1.301	1.301
E21	Frays Valley LNR and Denham Lock Wood SSSI	1.301	1.301	1.301	1.301	1.301
E22	Frays Valley LNR and Denham Lock Wood SSSI	1.301	1.301	1.301	1.301	1.301
E23	Kingcup Meadows and Oldhouse Wood SSSI	1.600	1.600	1.600	1.600	1.600
E24	Kingcup Meadows and Oldhouse Wood SSSI	1.600	1.600	1.600	1.600	1.600
E25	Kingcup Meadows and Oldhouse Wood SSSI	1.600	1.600	1.600	1.600	1.600

5.4.8 Maximum predicted annual mean SO_2 concentrations at the ecological receptor locations are summarised in Table 37.

Table 37 Maximum Predicted Annual Mean SO_2 Concentrations

Receptor		Maximum Predicted Annual Mean SO_2 Concentration ($\mu g/m^3$)		Proportion of EQS (%)	
		PC	PEC	PC	PEC
E1	Denham Quarry Park LNR	0.002	1.072	0.0	10.7

Receptor		Maximum Predicted Annual Mean SO_2 Concentration (µg/m³)		Proportion of EQS (%)	
		PC	PEC	PC	PEC
E2	Denham Quarry Park LNR	0.002	1.072	0.0	10.7
E3	Denham Quarry Park LNR	0.001	1.071	0.0	10.7
E4	Denham Quarry Park LNR	0.001	1.071	0.0	10.7
E5	Denham Quarry Park LNR	0.001	1.071	0.0	10.7
E6	Denham Quarry Park LNR	0.001	1.071	0.0	10.7
E7	Denham Quarry Park LNR	0.000	1.070	0.0	10.7
E8	Denham Quarry Park LNR	0.000	1.070	0.0	10.7
E9	Denham Quarry Park LNR	0.000	1.070	0.0	10.7
E10	Denham Country Park LNR	0.002	1.072	0.0	10.7
E11	Denham Country Park LNR	0.001	1.071	0.0	10.7
E12	Denham Country Park LNR	0.001	1.071	0.0	10.7
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	0.001	1.211	0.0	12.1
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	0.002	1.212	0.0	12.1
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	0.001	1.211	0.0	12.1
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	0.001	1.211	0.0	12.1
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	0.001	1.211	0.0	12.1
E18	Frays Valley LNR	0.001	1.211	0.0	12.1
E19	Frays Valley LNR	0.001	1.211	0.0	12.1
E20	Frays Valley LNR and Denham Lock Wood SSSI	0.001	1.301	0.0	13.0
E21	Frays Valley LNR and Denham Lock Wood SSSI	0.001	1.301	0.0	13.0
E22	Frays Valley LNR and Denham Lock Wood SSSI	0.001	1.301	0.0	13.0

Receptor		Maximum Predicted Annual Mean SO_2 Concentration (µg/m³)		Proportion of EQS (%)	
		PC	PEC	PC	PEC
E23	Kingcup Meadows and Oldhouse Wood SSSI	0.000	1.600	0.0	16.0
E24	Kingcup Meadows and Oldhouse Wood SSSI	0.000	1.600	0.0	16.0
E25	Kingcup Meadows and Oldhouse Wood SSSI	0.000	1.600	0.0	16.0

5.4.9 As shown in Table 37, PCs were below 1% of the EQS at all ecological receptors. As such, predicted effects on annual mean SO_2 concentrations are considered to be **not significant**, in accordance with the stated criteria.

Nitrogen Deposition

5.4.10 Predicted annual nitrogen PC deposition rates at the ecological receptor locations are summarised in Table 38.

Table 38 Predicted Annual Nitrogen Deposition Rates

Receptor		Predicted Annual PC Nitrogen Deposition Rate (kgN/ha/yr)				
		2016	2017	2018	2019	2020
E1	Denham Quarry Park LNR	0.0295	0.0309	0.0271	0.0325	0.0303
E2	Denham Quarry Park LNR	0.0232	0.0242	0.0235	0.0271	0.0272
E3	Denham Quarry Park LNR	0.0160	0.0164	0.0174	0.0193	0.0201
E4	Denham Quarry Park LNR	0.0110	0.0107	0.0126	0.0132	0.0137
E5	Denham Quarry Park LNR	0.0083	0.0079	0.0098	0.0100	0.0102
E6	Denham Quarry Park LNR	0.0067	0.0062	0.0079	0.0079	0.0079
E7	Denham Quarry Park LNR	0.0043	0.0041	0.0052	0.0050	0.0050
E8	Denham Quarry Park LNR	0.0034	0.0033	0.0041	0.0037	0.0038
E9	Denham Quarry Park LNR	0.0026	0.0026	0.0031	0.0028	0.0026

Receptor		Predicted Annual PC Nitrogen Deposition Rate (kgN/ha/yr)				
		2016	2017	2018	2019	2020
E10	Denham Country Park LNR	0.0210	0.0233	0.0191	0.0224	0.0217
E11	Denham Country Park LNR	0.0191	0.0199	0.0176	0.0212	0.0197
E12	Denham Country Park LNR	0.0164	0.0171	0.0160	0.0188	0.0184
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0079	0.0100	0.0067	0.0070	0.0059
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0088	0.0120	0.0083	0.0084	0.0072
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0074	0.0102	0.0070	0.0072	0.0066
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0051	0.0070	0.0049	0.0052	0.0055
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0041	0.0050	0.0038	0.0042	0.0045
E18	Frays Valley LNR	0.0048	0.0052	0.0043	0.0051	0.0049
E19	Frays Valley LNR	0.0053	0.0055	0.0049	0.0059	0.0054
E20	Frays Valley LNR and Denham Lock Wood SSSI	0.0103	0.0107	0.0100	0.0118	0.0114
E21	Frays Valley LNR and Denham Lock Wood SSSI	0.0095	0.0101	0.0085	0.0103	0.0095
E22	Frays Valley LNR and Denham Lock Wood SSSI	0.0079	0.0093	0.0072	0.0082	0.0084
E23	Kingcup Meadows and Oldhouse Wood SSSI	0.0004	0.0002	0.0003	0.0003	0.0003
E24	Kingcup Meadows and Oldhouse Wood SSSI	0.0003	0.0002	0.0003	0.0003	0.0003
E25	Kingcup Meadows and Oldhouse Wood SSSI	0.0003	0.0002	0.0003	0.0004	0.0003

5.4.11 Maximum predicted annual nitrogen deposition rates at the receptor locations are summarised in Table 39.

Table 39 Maximum Predicted Annual Nitrogen Deposition Rates

Receptor		Maximum Predicted Annual PC Nitrogen Deposition Rate (kgN/ha/yr)	Proportion of EQS (%)	
			Low EQS	High EQS
E1	Denham Quarry Park LNR	0.0325	0.33	0.22
E2	Denham Quarry Park LNR	0.0272	0.27	0.18
E3	Denham Quarry Park LNR	0.0201	0.20	0.13
E4	Denham Quarry Park LNR	0.0137	0.14	0.09
E5	Denham Quarry Park LNR	0.0102	0.10	0.07
E6	Denham Quarry Park LNR	0.0079	0.08	0.05
E7	Denham Quarry Park LNR	0.0052	0.05	0.03
E8	Denham Quarry Park LNR	0.0041	0.04	0.03
E9	Denham Quarry Park LNR	0.0031	0.03	0.02
E10	Denham Country Park LNR	0.0233	0.23	0.16
E11	Denham Country Park LNR	0.0212	0.21	0.14
E12	Denham Country Park LNR	0.0188	0.19	0.13
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0100	-	-
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0120	-	-
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0102	-	-
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0070	-	-
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	0.0050	-	-
E18	Frays Valley LNR	0.0052	-	-
E19	Frays Valley LNR	0.0059	-	-
E20	Frays Valley LNR and Denham Lock Wood SSSI	0.0118	0.12	0.08
E21	Frays Valley LNR and Denham Lock Wood SSSI	0.0103	0.10	0.07

Receptor		Maximum Predicted Annual PC Nitrogen Deposition Rate (kgN/ha/yr)	Proportion of EQS (%)	
			Low EQS	High EQS
E22	Frays Valley LNR and Denham Lock Wood SSSI	0.0093	0.09	0.06
E23	Kingcup Meadows and Oldhouse Wood SSSI	0.0004	0.00	0.00
E24	Kingcup Meadows and Oldhouse Wood SSSI	0.0003	0.00	0.00
E25	Kingcup Meadows and Oldhouse Wood SSSI	0.0004	0.00	0.00

5.4.12 As shown in Table 39, PCs were below 1% of the EQS at all designations. As such, predicted impacts on annual nitrogen deposition at ecological receptors are considered to be **not significant**, in accordance with the stated criteria.

Acid Deposition

5.4.13 Maximum predicted annual acid deposition rates at the receptor locations are summarised in Table 40.

Table 40 Predicted Annual Acid Deposition Rates

Receptor		Maximum Predicted Annual Acid PC Deposition Rate (keq/ha/yr)		Proportion of EQS (%)
		Nitrogen	Sulphur and Chlorine	
E1	Denham Quarry Park LNR	0.00232	0.02076	0.2
E2	Denham Quarry Park LNR	0.00194	0.01737	0.2
E3	Denham Quarry Park LNR	0.00144	0.01286	0.1
E4	Denham Quarry Park LNR	0.00098	0.00874	0.1
E5	Denham Quarry Park LNR	0.00072	0.00648	0.1
E6	Denham Quarry Park LNR	0.00057	0.00507	0.1
E7	Denham Quarry Park LNR	0.00037	0.00335	0.0

Receptor		Maximum Predicted Annual Acid PC Deposition Rate (keq/ha/yr)		Proportion of EQS (%)
		Nitrogen	Sulphur and Chlorine	
E8	Denham Quarry Park LNR	0.00029	0.00260	0.0
E9	Denham Quarry Park LNR	0.00022	0.00200	0.0
E10	Denham Country Park LNR	0.00166	0.01489	0.1
E11	Denham Country Park LNR	0.00151	0.01351	0.1
E12	Denham Country Park LNR	0.00134	0.01202	0.1
E13	Fray's Farm Meadows SSSI and Frays Valley LNR	0.00071	0.00535	-
E14	Fray's Farm Meadows SSSI and Frays Valley LNR	0.00086	0.00644	-
E15	Fray's Farm Meadows SSSI and Frays Valley LNR	0.00073	0.00544	-
E16	Fray's Farm Meadows SSSI and Frays Valley LNR	0.00050	0.00374	-
E17	Fray's Farm Meadows SSSI and Frays Valley LNR	0.00036	0.00270	-
E18	Frays Valley LNR	0.00037	0.00280	-
E19	Frays Valley LNR	0.00042	0.00313	-
E20	Frays Valley LNR and Denham Lock Wood SSSI	0.00084	0.00751	0.1
E21	Frays Valley LNR and Denham Lock Wood SSSI	0.00074	0.00660	0.1
E22	Frays Valley LNR and Denham Lock Wood SSSI	0.00066	0.00591	0.1
E23	Kingcup Meadows and Oldhouse Wood SSSI	0.00003	0.00021	0.0
E24	Kingcup Meadows and Oldhouse Wood SSSI	0.00002	0.00016	0.0
E25	Kingcup Meadows and Oldhouse Wood SSSI	0.00003	0.00023	0.0

5.4.14 As shown in Table 40, PCs were below 1% of the EQS at all ecological receptors. As such, predicted impacts on annual acid deposition at ecological receptors are considered to be **not significant** in accordance with the stated criteria.

5.5 Overall Impact Significance

5.5.1 The overall significance of air quality impacts was determined as **not significant**. This was based on the following:

- Predicted impacts on long and short-term pollutant concentrations at all human receptors were classified as **negligible** in accordance with the IAQM guidance. This states that only if the impact **moderate** or **substantial**, the effect is considered **significant**. As effects are considered **not significant**, in accordance with the stated methodology; and,
- Predicted impacts on pollutant levels at all ecological receptors were classified as **not significant** in accordance with the EA guidance.

5.5.2 As air quality impacts were predicted to be **not significant**, the use of gas cremators and the proposed stack height are considered to be acceptable.

6.0 CONCLUSION

6.1.1 Redmore Environmental Ltd was commissioned by Marchini Curran Associates on behalf of Anoopam Mission to undertake a Dispersion Modelling Assessment in support of a crematorium on land at the Shree Swaminarayan Spiritual Cultural & Community Centre, The Lea, Denham.

6.1.2 Planning consent for the development was granted in 2021 subject to a number of conditions, including a requirement for the use of electric cremators. It is proposed to vary the condition in order to allow the use of gas cremators to provide further flexibility during the design process. The variation in fuel type has the potential to affect the air quality impacts previously assessed. As such, a Dispersion Modelling Assessment was undertaken in order to determine baseline conditions and confirm the use of gas cremators is not predicted to result in significant air quality effects.

6.1.3 Dispersion modelling was undertaken using ADMS-6 in order to predict pollutant levels at sensitive locations as a result of emissions from the plant. Impacts were quantified and the results compared with the relevant EQSs and significance criteria.

6.1.4 Predicted concentrations of all pollutants were below the relevant EQSs at all locations of human exposure for all meteorological data sets modelled. Review of the dispersion modelling results also indicated that impacts were predicted to be **negligible** at all receptors for all pollutants of interest. As such, overall impacts are considered to be **not significant**.

6.1.5 Impacts at relevant ecological sites were also predicted to be **not significant** at all identified designations.

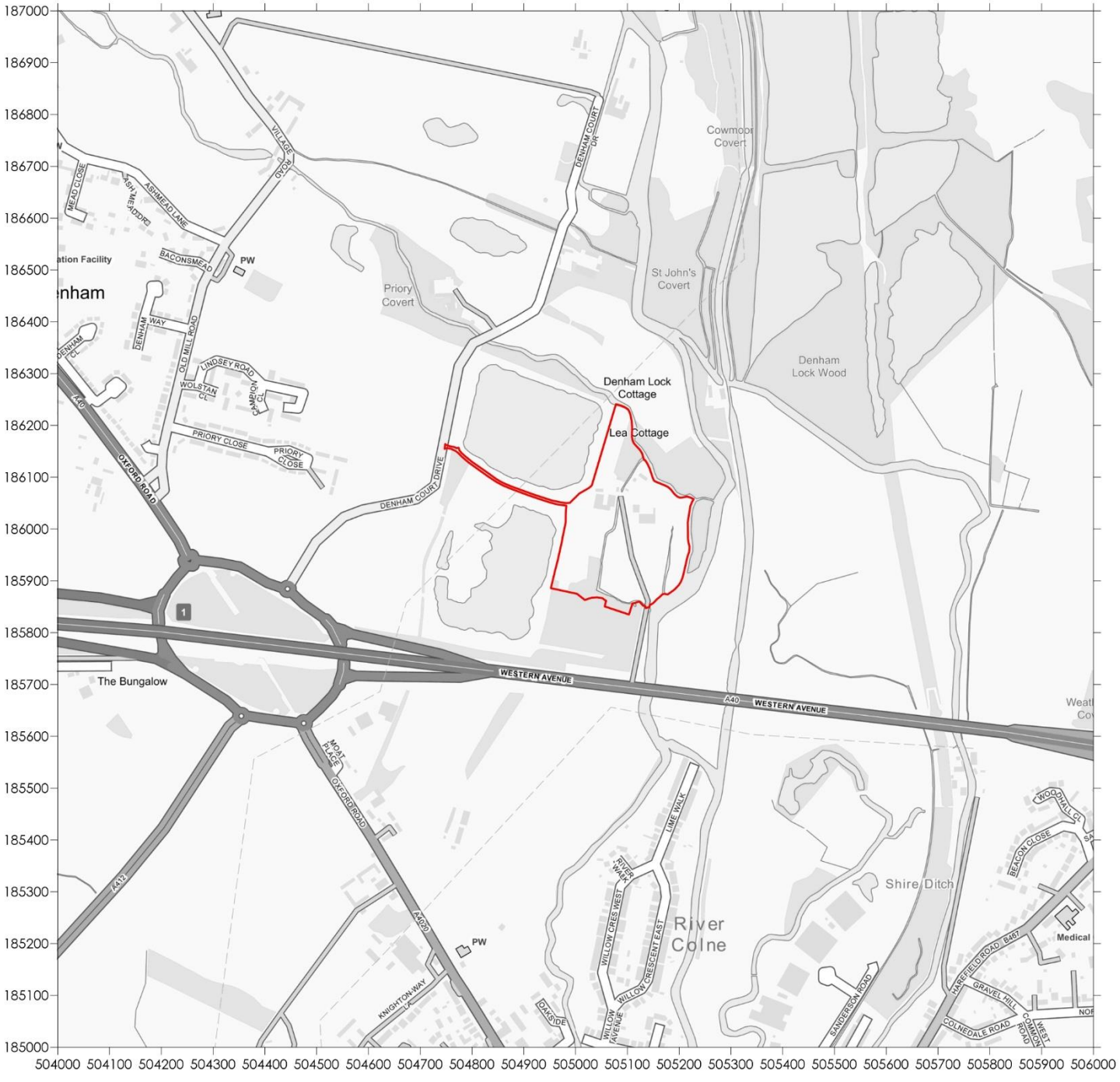
6.1.6 Based on the assessment results, the use of gas cremators and the proposed stack height of 9.75m above ground level are considered appropriate and air quality impacts associated with cremation emissions are not considered a constraint to the development.

7.0 ABBREVIATIONS

APIS	Air Pollution Information System
AQLV	Air Quality Limit Value
AQMA	Air Quality Management Area
AQO	Air Quality Objective
AQS	Air Quality Strategy
BC	Buckinghamshire Council
C_6H_6	Benzene
CERC	Cambridge Environmental Research Consultants
CO	Carbon monoxide
DEFRA	Department for Environment, Food and Rural Affairs
DPD	Development Plan Document
EA	Environment Agency
EAL	Environmental Assessment Level
ELV	Emission Limit Value
EQS	Environmental Quality Standard
HCl	Hydrogen chloride
Hg	Mercury
IAQM	Institute of Air Quality Management
LAQM	Local Air Quality Management
LNR	Local Nature Reserve
MAGIC	Multi-Agency Geographic Information for the Countryside
NGR	National Grid Reference
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
PC	Process Contribution
PEC	Predicted Environmental Concentration
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10µm
SBDC	South Bucks District Council
SO_2	Sulphur dioxide
SSSI	Site of Special Scientific Interest
UKEAP	UK Eutrophying and Acidifying Pollutants
VOC	Volatile Organic Compound
z_0	Roughness length

%ile	Percentile

Figures



Legend

Site Boundary

Title

Figure 1 - Site Location

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Dispersion Modelling Assessment AUM a Crematorium by Anoopam Mission, Denham

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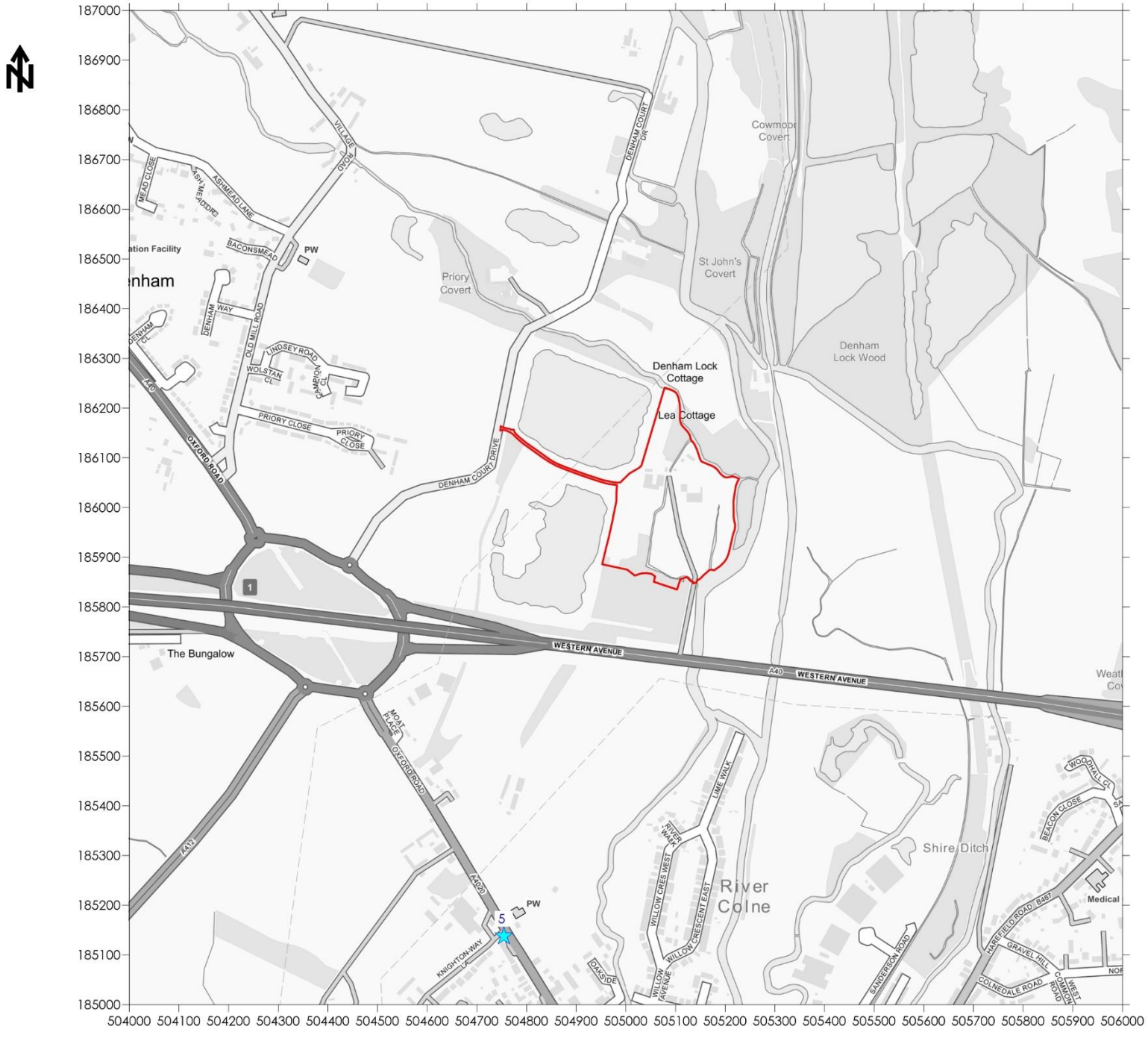

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Site Boundary

Monitor

Title

Figure 2 - Monitoring Location

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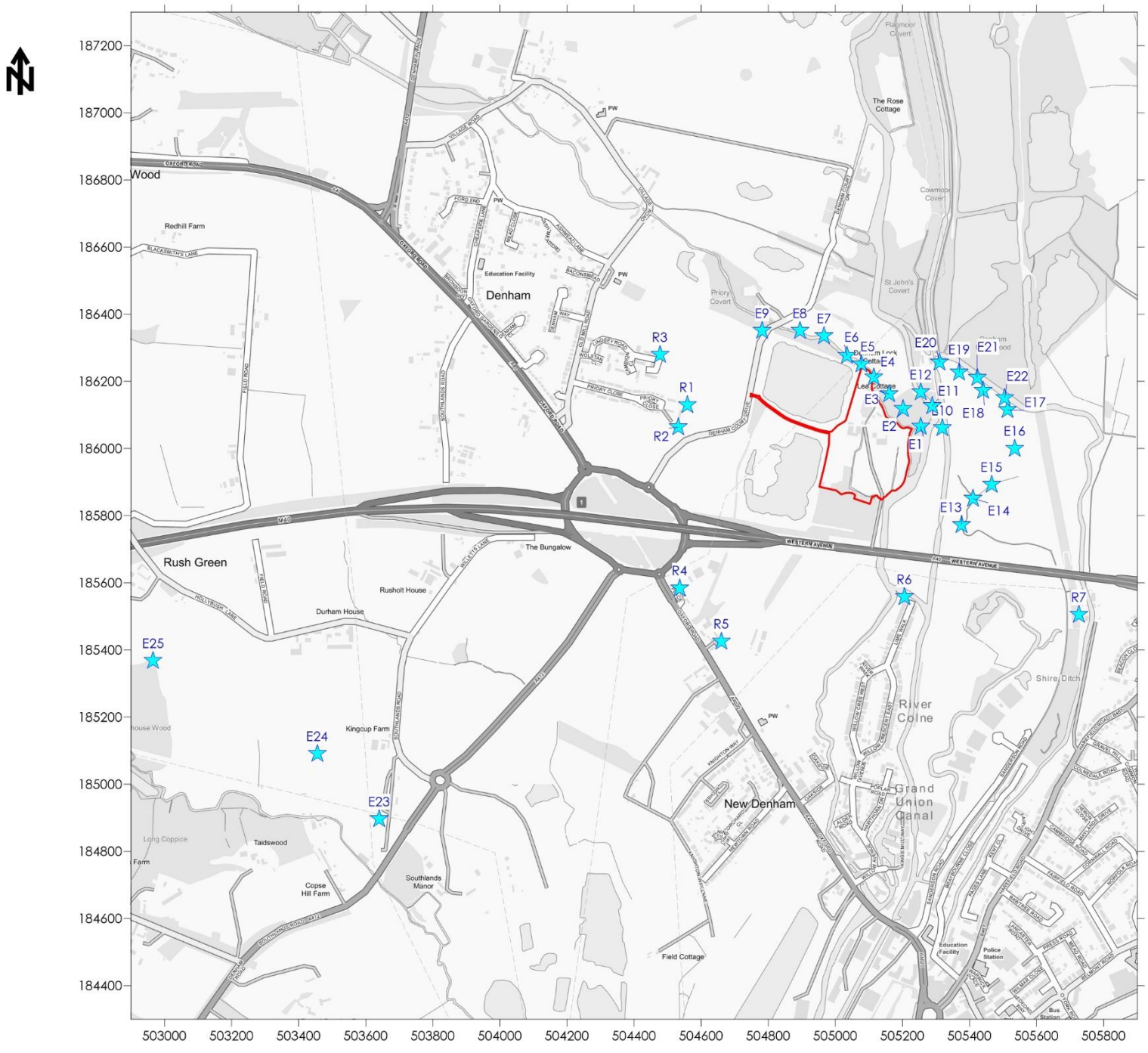

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Site Boundary

Receptor

Title

Figure 3 - Sensitive Receptors

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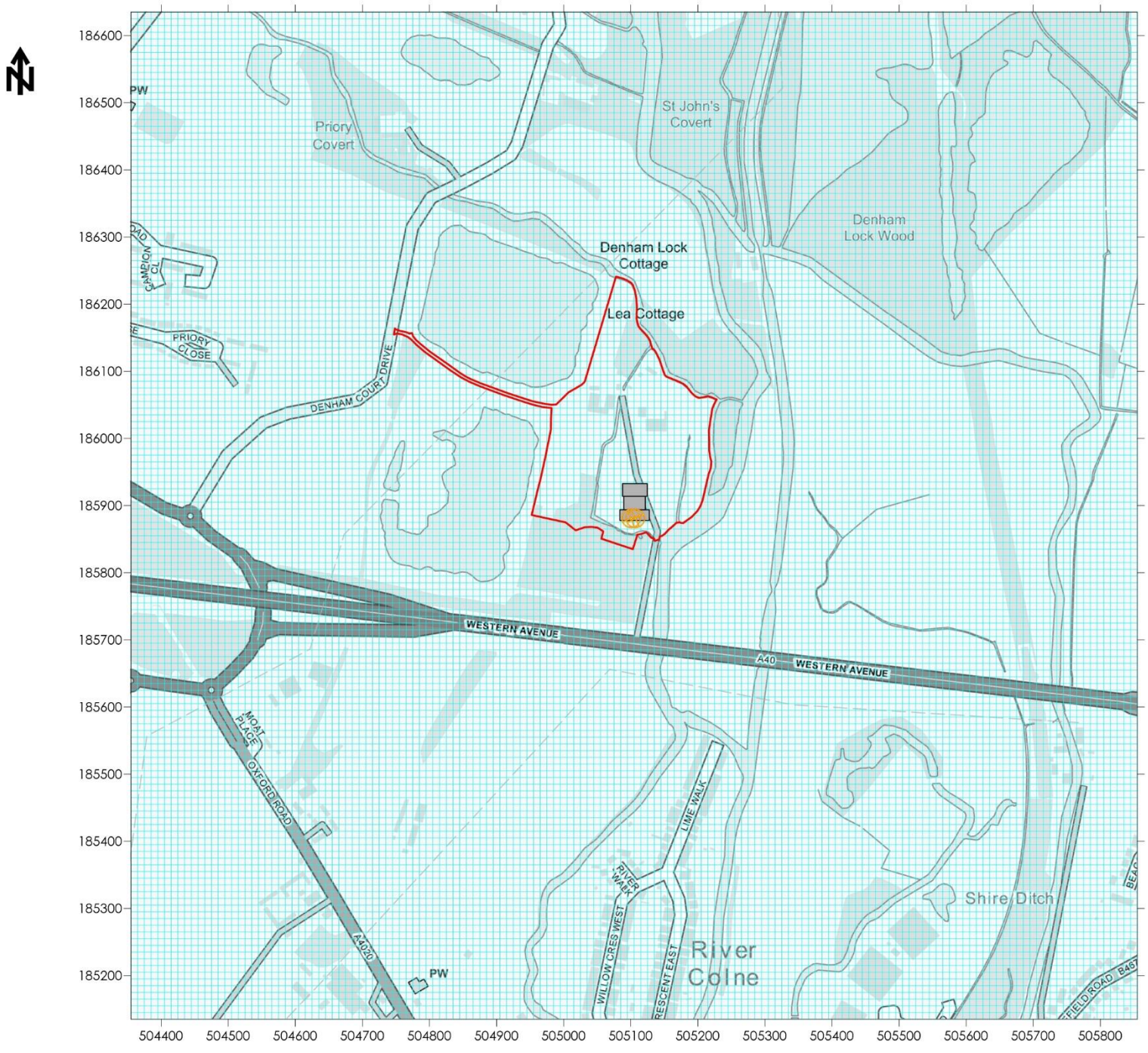

Legend

- Site Boundary
- Point Source
- Building
- Output Grid

Title
Figure 4 - ADMS-5 Inputs

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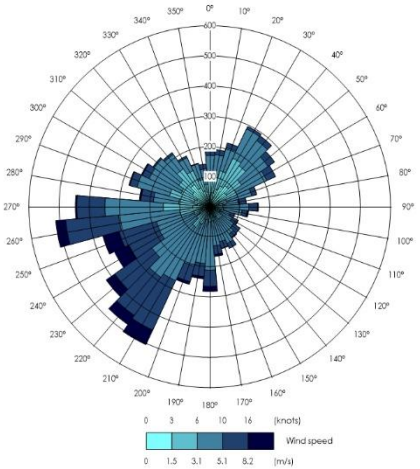
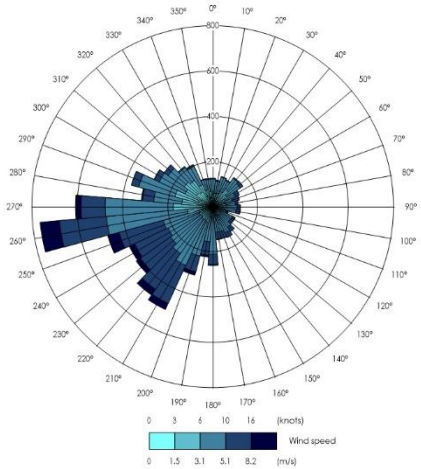


2016 Meteorological Data



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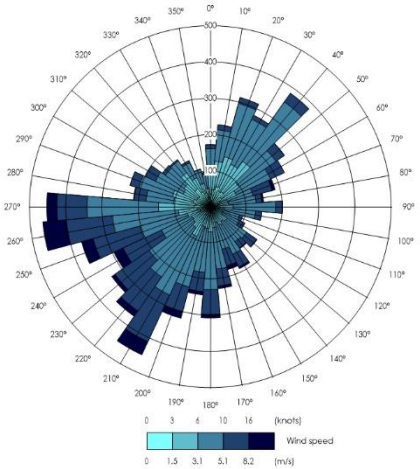
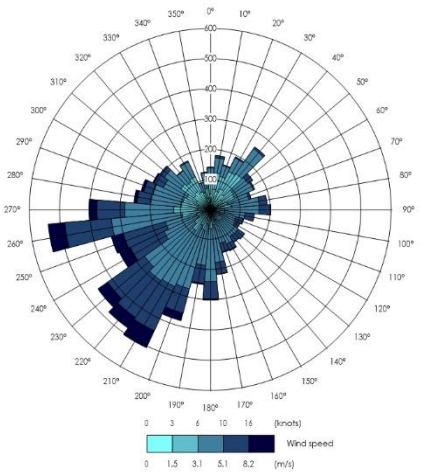
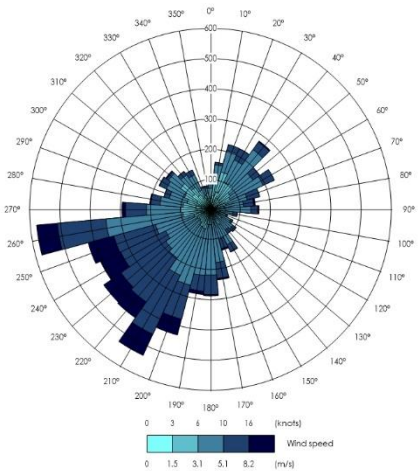


2018 Meteorological Data



2019 Meteorological Data



2020 Meteorological Data

Legend

Title
Figure 5 - Wind Roses of 2016 to 2020 Heathrow Airport Meteorological Data

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Site Boundary

Annual Mean NO_2 Concentration ($\mu g/m^3$)

23.5
23
22.5
22
21.5
21

Title

Figure 6 - Predicted Annual Mean NO_2 Concentration ($\mu g/m^3$) 2017 Meteorological Data

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Site Boundary

Annual Mean PM_{10} Concentration ($\mu g/m^3$)

15.2
15
14.8
14.6
14.4
14.2

Title

Figure 7 - Predicted Annual Mean PM_{10} Concentration ($\mu g/m^3$) 2017 Meteorological Data

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Site Boundary

Annual Mean C_6H_6 Concentration ($\mu g/m^3$)

0.9
0.8
0.7
0.6
0.5

Title

Figure 8 - Predicted Annual Mean C_6H_6 Concentration ($\mu g/m^3$) 2017 Meteorological Data

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