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Peak Gen Power Limited

Havant Power Plant

Air Quality Impact Assessment

Final Report

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Report for

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1	Final Report 18460i1	October 2018
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Executive summary

Purpose of this report

Peak Gen Power Limited (Peak Gen) operates a power plant at Havant, Hampshire that generates electricity to export power to the National Grid when demand outstrips supply. It operates under a number of different operating profiles and National Grid contracted services. It operates intermittently and not every day. It is one of several similar installations operated by Peak Gen.

In January 2019, the Environmental Permitting Regulations 2018, which transpose the EU's Medium Combustion Plant (MCP) Directive into UK law, come into force. Under these regulations, the Havant installation will require a permit from the Environment Agency. This report has been produced for the purpose of assessing the potential impacts on local air quality of the installation, in support of a permit application.

About the assessment

The installation consists of 10 diesel engines, with a total electrical export capacity of 20 MWe. The purpose of the installation is to meet intermittent shortfalls in generating capacity on the National Grid. As such, it is usually called for short periods of time, typically just over an hour. To meet emissions standards, the engines will be fitted with Selective Catalytic Reduction (SCR) technology to reduce emissions of oxides of nitrogen (NO_x).

The dispersion of emissions in this assessment is predicted using an appropriate dispersion model, with results presented in tabular form and as contours of ground level concentrations on a background map of the area. The assessment considers short and long-term effects in relation to the air quality standards set in legislation and in Government and international guidance. The pollutants covered by the assessment are oxides of nitrogen (NO_x), nitrogen dioxide (NO_2), particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), sulphur dioxide (SO_2) and ammonia.

Summary of conclusions

The impact assessment demonstrates that, under the anticipated operational profile of the plant, exceedances of any air quality assessment level are unlikely at the local receptors identified to protect human health or ecological sites; or, where there are exceedances predicted, these are overwhelmingly due to the existing background and the additional contribution from the installation is negligible.

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1. Introduction

1.1 Background, aims and objectives

Peak Gen Power Limited (Peak Gen) operates a power plant at Havant, Hampshire that generates electricity to export power to the National Grid when demand outstrips supply. It operates under a number of different operating profiles and National Grid contracted services. It operates intermittently and not every day. It is one of several similar installations operated by Peak Gen.

In January 2019, the Environmental Permitting Regulations 2018, which transpose the EU's Medium Combustion Plant (MCP) Directive into UK law, come into force. Under these regulations, the Havant installation will require a permit from the Environment Agency. This report has been produced for the purpose of assessing the potential impacts on local air quality of the installation, in support of a permit application.

The installed engines are 16V4000G63 diesel (compression-ignition) engines manufactured by MTU. The total electrical export is 20 MW_e. The installation will operate for up to 500 hours per year with the individual operating calls lasting from a few minutes to a number of hours. Historical data suggests an average run time of 87 minutes for all running types except the Fast Reserve service which has an average run time of 14 minutes.

The dispersion of emissions in this assessment is predicted using an appropriate dispersion model, with results presented in tabular form and as contours of ground level concentrations on a background map of the area. The assessment considers short and long-term effects in relation to the air quality standards set in legislation and in Government and international guidance.

1.2 Site description

The installation is located on the Broadmarsh industrial estate on the south side of Havant. The immediately surrounding area is industrial and commercial, with Langstone Harbour to the south. The nearest residential properties are about 200 m away. The grid reference for the site is 470435, 105896. The site location is shown in Figure 1.1.

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Figure 1.1   Site location
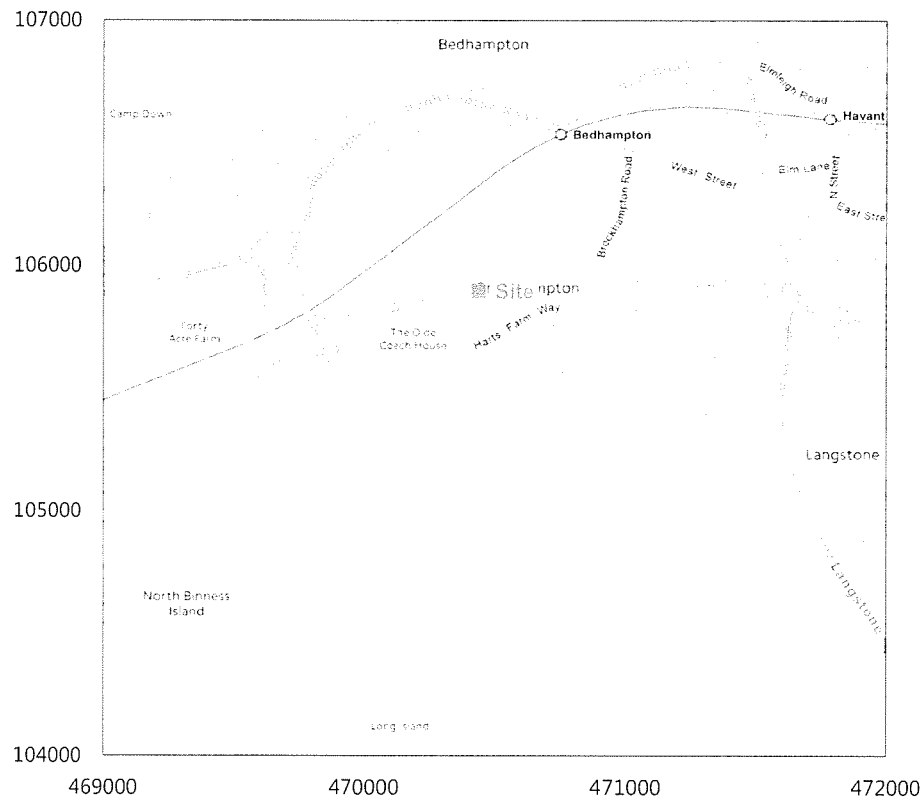
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1.3   Sources of information

The information used to assess air quality includes:

- Process and emissions data provided by Peak Gen;

- Baseline air quality data from surveys undertaken by Government bodies, Local Authorities and third parties;

- Ordnance Survey maps of the local area; and

- Meteorological data supplied by Atmospheric Dispersion Modelling Limited.

1.4   Report and structure

The remainder of the report is set out as in the table below.

Table 1.1   Report Structure

Section	Aims and Objectives
Section 2	Describes the dispersion model, assessment methodology, model inputs and assumptions used in the assessment, and details the ambient air quality in the area
Section 3	Details the assessment criteria
Section 4	Presents an assessment of the potential air quality impacts arising from the site emissions
Section 5	Contains a summary and conclusions of the assessment

Table 1.1   Report Structure

2. Assessment methodology

2.1 The dispersion model

The model used in this assessment is the latest version of the ADMS 5.2 atmospheric dispersion model developed and validated by Cambridge Environmental Research Consultants (CERC). The model was used to predict the ground level concentration of compounds emitted to atmosphere from the installation. The model has been used extensively throughout the UK for regulatory compliance purposes and is accepted as an appropriate air quality modelling tool by the Environment Agency and local authorities.

ADMS 5.2 parameterises stability and turbulence in the atmospheric boundary layer by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the boundary layer to be more accurately defined than by the stability classification methods of earlier dispersion models. In ADMS, the concentration distribution follows a symmetrical Gaussian profile in the vertical and crosswind directions in neutral and stable conditions. However, the vertical profile in convective conditions follows a skewed Gaussian distribution to take account of the inhomogeneous nature of the vertical velocity distribution in the Convective Boundary Layer.

A number of complex modules, including the effects of plume rise, complex terrain, coastlines, concentration fluctuations, radioactive decay and buildings effects, are also included in the model, as well as the facility to calculate long-term averages of hourly mean concentration, dry and wet deposition fluxes, and percentile concentrations, from either statistical meteorological data or hourly average data.

A range of input parameters is required including, among others, data describing the local area, meteorological measurements and emissions data. The data used in modelling the emissions are given in the following sections of this chapter.

2.2 Process emissions

The installation as modelled here consists of 10 generators, each operating at 2 MW$_e$. Each engine sits within its own container building with its own individual stack.

Model input parameters are given in Table 2.1 and Table 2.2. A schematic of the stack locations is given in Figure 2.6 below. The process data has been derived from manufacturer's performance data provided by Peak Gen.

NO$_x$ emissions data are based on the average measured NO$_x$ data of 940.6 mg Nm^{-3} for the first 5 minutes of generator running (without effective SCR) and 190 mg Nm^{-3} with effective SCR. Details of how average NO$_x$ emission rates are calculated are given in the following paragraphs. Emissions of CO and PM are based on manufacturer's data of 291 mg Nm^{-3} for CO and 23 mg Nm^{-3} for PM$_{10}$ and PM$_{2.5}$. Emissions of SO$_2$ are based on using ultra-low sulphur fuel with a sulphur content of 0.001% (10 ppm). These figures are given at exhaust reference conditions of 273 K, 101.3 kPa, 15% oxygen content and dry gas.

Estimates of ammonia emissions are not available, so instead a value of 7.5 mg Nm^{-3} (10 ppm) has been back-calculated at which there is no risk of causing any exceedances by a comfortable margin; this is expected to be considerably higher emission rate actually achieved. This will be confirmed by stack monitoring.

Table 2.1   Modelled stack characteristics

Parameter	Each engine
Release height (m)	4.955
Flue diameter (m)	0.5
Efflux velocity (m s^{-1})	31.2
Efflux temperature (°C)	491
Actual oxygen (%)	8.6
Moisture (%)	2.7

Table 2.2   Modelled stack emission rates

Pollutant	Emission rate (per engine) (g s^{-1})
NO_x	1.14
PM_{10}	0.10
$PM_{2.5}$	0.10
CO	1.32
SO_2	0.0025
Ammonia	0.03

For calculating average NO_x emissions, it should be noted that there are three relevant averaging periods, i.e. periods over which average concentrations or deposition rates of NO_x or NO_2 should be assessed, namely:

- One calendar year (i.e. annual mean);
- One calendar day (24 hours); and
- One hour (starting on the hour).

The installation operates for short periods at a time. Historical data indicates that the average run time (across six Peak Gen installations) is 87 minutes for all running types except Fast Reserve, with about 66 calls per year per installation. For Fast Reserve calls, the average run time is 14 minutes with an average of 166 calls per year per installation. This compares with a regulatory limit of 500 hours of operation for each installation.

It is assumed that for each call, the engines start from cold and therefore SCR is not effective for 5 minutes; after this time, the catalyst is at operating temperature and the SCR is effective for the remainder of the run. The worst case for a 1-hour period is then to have 5 minutes operating at 940.6 mg Nm^{-3} and 55 minutes operating at 190 mg Nm^{-3}, giving an average NO_x emission concentration over the hour of 252.6 mg Nm^{-3}. Subsequent calls may operate with a still-warm, and therefore partly effective, catalyst, but this has conservatively been ignored. Therefore, for calculating the hourly mean concentrations, an emission rate of 252.6 mg Nm^{-3} has been used.

For calculating the annual mean concentrations, the same emission rate (252.6 mg Nm^{-3}) has been used. Since the average call lasts for 87 minutes, this is slightly conservative as it assumes more cold starts than

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historical data suggests. In order to ensure that a representative range of meteorological conditions is captured, ADMS is set to run with this emission rate for every hour of the year, in other words for 8760 hours per year. In fact, the installation will operate for a maximum of 500 hours per year, so the resulting annual mean concentrations are adjusted by a factor of 500/8760 = 0.057.

For calculating the daily mean concentrations, a similar approach is taken. Since the installation is expected to operate for 10 hours per day at most, the daily mean concentration is calculated and adjusted by a factor of 10/24.

For calculating average concentrations of other pollutants, the SCR issue does not arise. However, the same issue around annual operating hours arises, so annual mean concentrations of PM_{10}, $PM_{2.5}$, SO_2 and ammonia are calculated by modelling emissions for every hour of the year and adjusting the ADMS output by a factor of 0.057.

2.3   Meteorology

For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of sites where the required meteorological measurements are made. The year of meteorological data that is used for a modelling assessment can also have a significant effect on ground level concentrations.

This assessment has used meteorological data from the Thorney Island meteorological station, for the period 2013 – 2017. Figure 2.1 to Figure 2.5 show the wind roses for each year modelled, illustrating the frequency of monitored wind direction and wind speed.

Figure 2.1   2013 wind rose
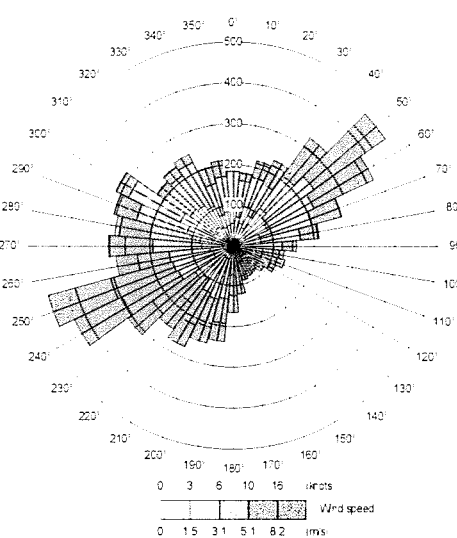
Figure 2.2   2014 wind rose
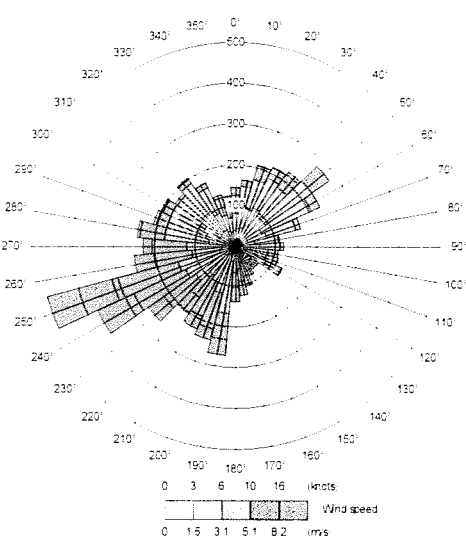
Figure 2.3   2015 wind rose
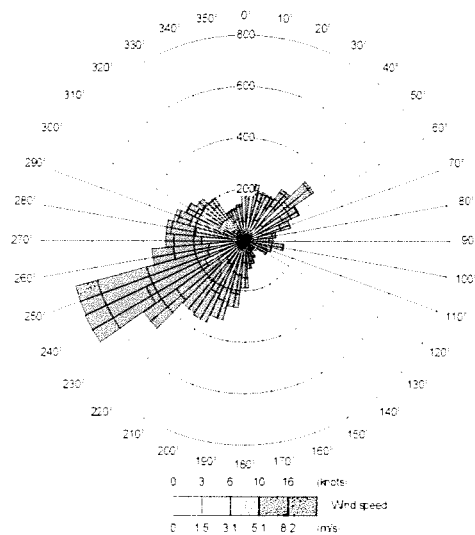
Figure 2.4   2016 wind rose
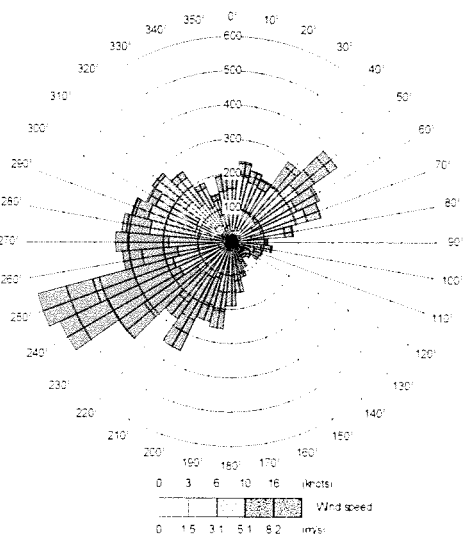
Figure 2.5   2017 wind rose
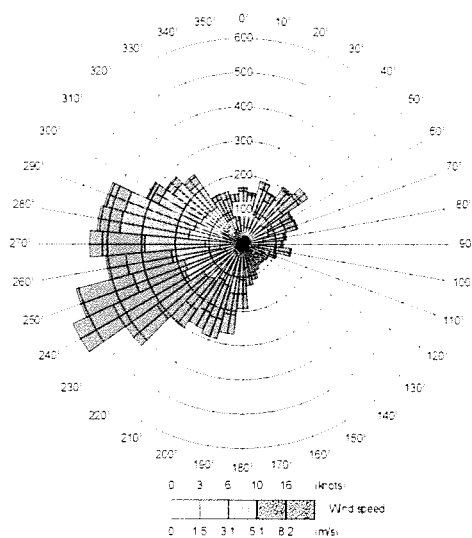
Gaussian plume models, such as ADMS, cannot, as standard, model calm weather conditions, since this results in a discontinuity produced by a 'divide by zero' calculation. Most Gaussian plume models simply skip lines of meteorological data where calm conditions occur. Met lines will also be skipped where any of the required meteorological input parameters are missing. The generally accepted best practice requirement is to ensure that no more than 10% of meteorological data is omitted from the model run. Table 2.3 demonstrates that this requirement is satisfied for each year's meteorological data.

Table 2.3   Meteorological data capture

Year	Number of met lines used	Number of met lines with inadequate data	Percentage of lines used
2013	8520	240	97.3%
2014	8633	127	98.6%
2015	8486	274	96.9%
2016	8659	125	98.6%
2017	8376	384	95.6%

2.4   Surface characteristics

The predominant surface characteristics and land use in a model domain have an important influence in determining turbulent fluxes and, hence, the stability of the boundary layer and atmospheric dispersion. Factors pertinent to this determination are detailed below.

Surface roughness

Roughness length, z_0, represents the aerodynamic effects of surface friction and is defined as the height at which the extrapolated surface layer wind profile tends to zero. This value is an important parameter used by meteorological pre-processors to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and, consequently, the degree of turbulent mixing.

The surface roughness length is related to the height of surface elements; typically, the surface roughness length is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and congested areas than in rural and open areas. Oke (1987) and CERC (2003) suggest typical roughness lengths for various land use categories (Table 2.4).

Table 2.4   Typical surface roughness lengths for various land use categories

Type of Surface	z_0 (m)
Ice	0.00001
Smooth snow	0.00005
Smooth sea	0.0002
Lawn grass	0.01
Pasture	0.2
Isolated settlement (farms, trees, hedges)	0.4
Parkland, woodlands, villages, open suburbia	0.5-1.0
Forests/cities/industrialised areas	1.0-1.5
Heavily industrialised areas	1.5-2.0

Increasing surface roughness increases turbulent mixing in the lower boundary layer. With respect to elevated sources under neutral and stable conditions, increasing the roughness length can have complex and conflicting effects on ground level concentrations:

- The increased mixing can bring portions of an elevated plume down towards ground level, resulting in increased ground level concentrations close to the emission source; and

- The increased mixing increases entrainment of ambient air into the plume and dilutes plume concentrations, resulting in reduced ground level concentrations further downwind from an emission source.

The overall impact on ground level concentration is, therefore, strongly correlated with the distance of a receptor from the emission source.

Surface energy budget

One of the key factors governing the generation of convective turbulence is the magnitude of the surface sensible heat flux. This, in turn, is a factor of the incoming solar radiation. However, not all solar radiation arriving at the Earth's surface is available to be emitted back to atmosphere in the form of sensible heat. By adopting a surface energy budget approach, it can be identified that, for fixed values of incoming short and long wave solar radiation, the surface sensible heat flux is inversely proportional to the surface albedo and latent heat flux.

The surface albedo is a measure of the fraction of incoming short-wave solar radiation reflected by the Earth's surface. This parameter is dependent upon surface characteristics and varies throughout the year. Oke (1987) recommends average surface albedo values of 0.6 for snow covered ground and 0.23 for non-snow covered ground, respectively.

The latent heat flux is dependent upon the amount of moisture present at the surface. Areas where moisture availability is greater will experience a greater proportion of incoming solar radiation released back to atmosphere in the form of latent heat, leaving less available in the form of sensible heat and, thus, decreasing convective turbulence. The modified Priestly-Taylor parameter (α) can be used to represent the amount of moisture available for evaporation. Holstag and van Ulden (1983) suggest values of 0.45 and 1.0 for dry grassland and moist grassland respectively.

Selection of appropriate surface characteristic parameters for the site

A detailed analysis of the effects of surface characteristics on ground level concentrations by Auld *et al.* (2002) led them to conclude that, with respect to uncertainty in model predictions:

> *"...the energy budget calculations had relatively little impact on the overall uncertainty".*

In this regard, it is not considered necessary to vary the surface energy budget parameters spatially or temporally, and annual averaged values have been adopted throughout the model domain for this assessment.

As snow covered ground is only likely to be present for a small fraction of the year, the surface albedo of 0.23 for non-snow covered ground advocated by Oke (1987) has been used whilst the model default α value of 1.0 has also been retained.

The area immediately around the site is mixed, with residential, industrial and open land uses all represented. In view of this, a variable roughness length file was used, providing spatially varying roughness lengths between 0.2 m and 1 m on a grid with 100 m resolution.

2.5 Buildings

Any large object has an impact on atmospheric flow and air turbulence within the locality of the object. This can result in maximum ground level concentrations that are significantly different (generally higher) from those encountered in the absence of buildings. The building 'zone of influence' is generally regarded as extending a distance of $5L$ (where L is the lesser of the building height or width) from the foot of the building in the horizontal plane and three times the height of the building in the vertical plane.

The containers housing the engines could influence the airflow close to the emissions sources. The engine containers consist of a large number of structures grouped closely together, so for the purposes of modelling they have been simplified down to two buildings. Table 2.5 and Figure 2.6 detail the buildings as they are included in the model. Other buildings are taken into account through the use of an appropriate surface roughness length.

Table 2.5   Modelled buildings

Building	X (m)	Y (m)	Height (m)	Length (m)	Width (m)	Angle (°)
Containers1	470431	105891	3	25	12	147
Containers2	470442	105904	3	16	12	148

Figure 2.6   Visualisation of buildings and release points included in the model
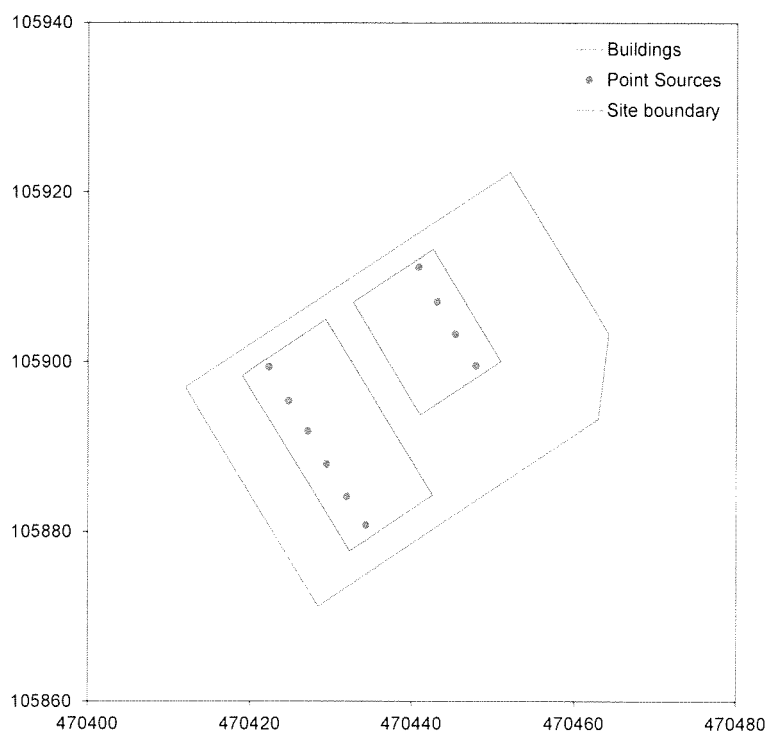
2.6   Terrain

The concentrations of an emitted pollutant found in elevated, complex terrain differ from those found in simple level terrain. There have been numerous studies on the effects of topography on atmospheric flows. The UK ADMLC provides a summary of the main effects of terrain on atmospheric flow and dispersion of pollutants (Hill *et al.*, 2005):

- *"Plume interactions with windward facing terrain features:*

  - *Plume interactions with terrain features whereby receptors on hills at a similar elevation to the plume experience elevated concentrations;*

  - *Direct impaction of the plume on hill slopes in stable conditions;*

  - *Flow over hills in neutral conditions can experience deceleration forces on the upwind slope, reducing the rate of dispersion and increasing concentrations; and*

  - *Recirculation regions on the upwind side of a hill can cause partial or complete entrainment of the plume, resulting in elevated ground level concentrations.*

- *Plume interactions with lee sides of terrain features:*

  - *Regions of recirculation behind steep terrain features can rapidly advect pollutants towards the ground culminating in elevated concentrations; and*

  - *As per the upwind case, releases into the lee of a hill in stable conditions can also be recirculated, resulting in increased ground level concentrations.*

- *Plume interactions within valleys:*

> ► *Releases within steep valleys experience restricted lateral dispersion due to the valley sidewalls. During stable overnight conditions, inversion layers develop within the valley essentially trapping all emitted pollutants. Following sunrise and the erosion of the inversion, elevated ground level concentrations can result during fumigation events; and*
>
> ► *Convective circulations in complex terrain due to differential heating of the valley side walls can lead to the impingement of plumes due to crossflow onto the valley sidewalls and the subsidence of plume centrelines, both having the impact of increasing ground level concentrations."*

These effects are most pronounced when the terrain gradients exceed 1 in 10, i.e. a 100 m change in elevation per 1 km step in the horizontal plane. The area immediately surrounding the site is relatively flat and does not meet this criterion, and therefore terrain modelling has not been included.

2.7 Modelled domain and receptors

Modelled domain

A 2 km × 2 km Cartesian grid centred on the site was modelled, with a receptor resolution of 20 m, to assess the impact of atmospheric emissions from the site on local air quality. This resolution is considered suitable for capturing the maximum process contribution from site emissions, given that the receptors of interest are more than 100 m from the source.

Human receptors

The receptors considered were chosen based on locations where people may be located and judged in terms of the likely duration of their exposure to pollutants and proximity to the site, following the guidance given in Section 3 of this report. Details of the locations of human receptors are given in Table 2.6 and Figure 2.7 and Figure 2.8.

For the purposes of assessing air quality impacts, workplace locations have been excluded from the assessment in accordance with Schedule 1, Part 1, Paragraph 2 of the Air Quality Standards Regulations 2010. These Regulations are detailed in Section 3 of this report and do not differentiate between whether this is a workplace location under the control of the operator, or an off-site workplace location.

Table 2.6   Details of modelled human receptors

ID	Description	Easting (m)	Northing (m)	Height (m)	Approximate distance from site (m)
H2	Residential 1	470329	106076	1.6	209
H3	Residential 2	470273	106054	1.6	226
H4	Residential 3	469945	106161	1.6	557

Figure 2.7   Locations of modelled human and ecological receptors (near site)
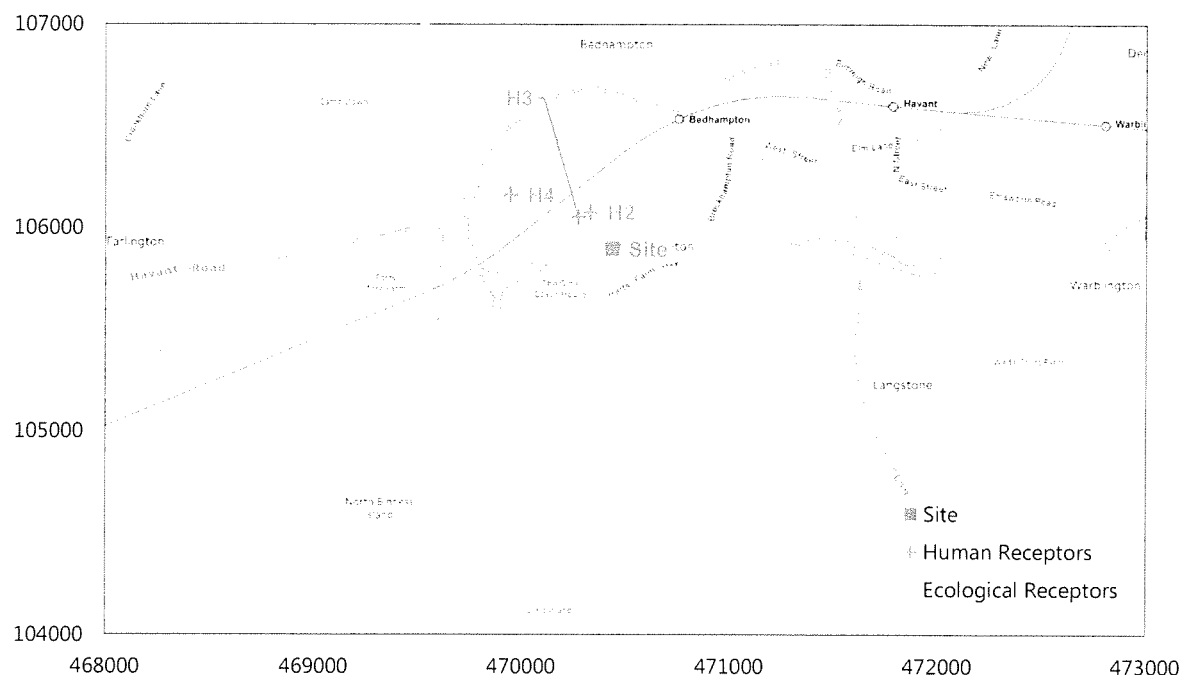
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Figure 2.8   Locations of modelled human and ecological receptors (further from site)
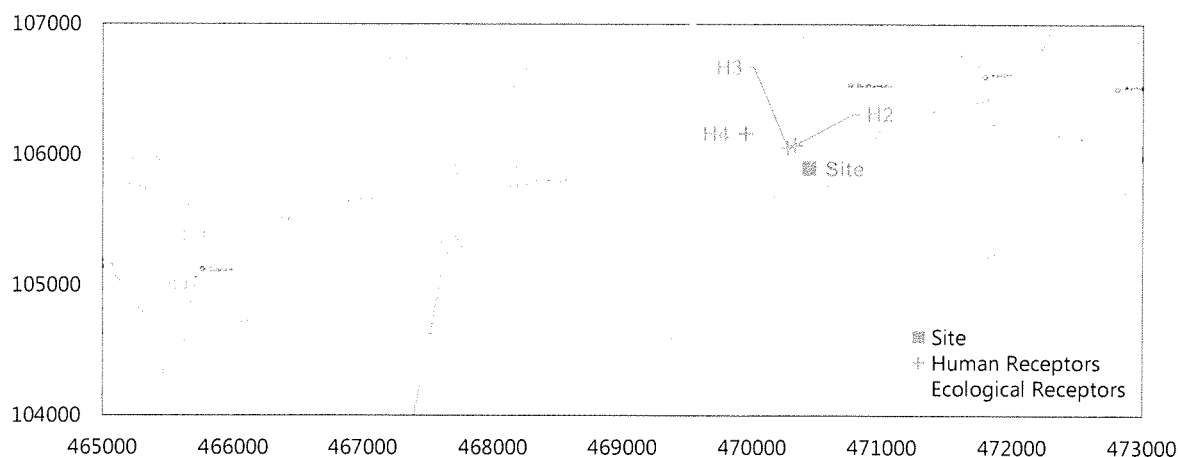
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Ecological receptors

The Environment Agency's "Air emissions risk assessment for your environmental permit" guidance (part of the "Risk assessments for specific activities: environmental permits") requires detailed dispersion modelling to be carried out based on local sensitive receptors. With regard to ecological receptors the guidance states:

> "You must consider the impact of your site on protected conservation areas....
>
> ...Check if there are any of the following within 10 km of your site (within 15 km if you operate a large electric power station or refinery):

> ‣ *Special protection areas (SPAs);*

> ‣ *Special areas of conservation (SACs); and*

> ‣ *Ramsar sites (protected wetlands).*

> *Check if there are any of the following within 2 km of your site:*

> ‣ *Sites of special scientific interest (SSSIs); and*

> ‣ *Local nature sites (ancient woods, local wildlife sites and national and local nature reserves), LNR".*

Following the above guidance, the following ecological receptors have been included in the assessment (Table 2.7 and Figure 2.7 and Figure 2.8).

Table 2.7   Details of modelled ecological receptors

ID	Description	Easting (m)	Northing (m)	Height (m)	Approximate distance from site (m)
E1	Ancient Woodland 1	469532	106992	0	1420
E2	Farlington Marshes LNR	468990	105431	0	1518
E3	Chichester and Langstone Harbours Ramsar/SPA 1	470389	105382	0	516
E4	Chichester and Langstone Harbours Ramsar/SPA 2	471184	105177	0	1038
E5	Chichester Harbour SSSI	472097	105106	0	1840
E6	Langstone Harbour SSSI	470388	105376	0	522
E7	Solent Maritime SAC	470382	105383	0	516
E8	Portsmouth Harbour Ramsar/SPA	465249	104568	0	5353

2.8   Conversion of NO to NO_2

Emissions of 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 nitrogen dioxide (NO_2). NO_X chemistry in the lower troposphere is strongly interlinked in a complex chain of reactions involving Volatile Organic Compounds (VOCs) and Ozone (O_3). Two of the key reactions interlinking NO and NO_2 are detailed below:

$$NO_2 + O_2 \xrightarrow{hv} NO + O_3 \qquad \text{(R1)}$$

$$NO + O_3 \rightarrow NO_2 + O_2 \qquad \text{(R2)}$$
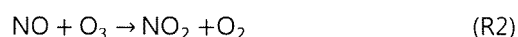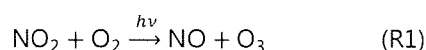
where *hv* is used to represent a photon of light energy (i.e. sunlight).

Taken together, reactions R1 and R2 produce no net change in O_3 concentrations, and NO and NO_2 adjust to establish a near steady state reaction (photo-equilibrium). However, the presence of VOCs and CO in the

atmosphere offer an alternative production route of NO_2 for photolysis, allowing O_3 concentrations to increase during the day with a subsequent decrease in the NO_2:NO_x ratio.

However, at night, the photolysis of NO_2 ceases, allowing reaction R2 to promote the production of NO_2, at the expense of O_3, with a corresponding increase in the NO_2:NO_x ratio.

Near to an emission source of NO, the result is a net increase in the rate of reaction R2, suppressing O_3 concentrations immediately downwind of the source, and increasing further downwind as the concentrations of NO begin to stabilise to typical background levels (Gillani and Pliem 1996).

Given the complex nature of NO_x chemistry, the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) have adopted a pragmatic, risk based approach in determining the conversion rate of NO to NO_2 which dispersion model practitioners can use in their detailed assessments (Environment Agency, no date). AQMAU guidance advises that the source term should be modelled as NO_x (as NO_2) and then suggests a tiered approach when considering ambient NO_2:NO_x ratios:

- **Screening Scenario:** 50% and 100% of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 50% of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments and 100% of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments;

- **Worst Case Scenario:** 35% and 70% of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 35% of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments and 70% of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments; and

- **Case Specific Scenario:** Operators are asked to justify their use of percentages lower than 35% for short-term and 70% for long-term assessments in their application reports.

In line with the AQMAU guidance, this assessment has used the 'Worst Case Scenario' approach in determining the conversion rate of NO to NO_2 as a robust assumption.

2.9   Deposition

The predominant route by which emissions will affect land in the vicinity of a process is by deposition of atmospheric emissions. Ecological receptors can potentially be sensitive to the deposition of pollutants, particularly nitrogen and sulphur compounds, which can affect the character of the habitat through eutrophication and acidification.

Deposition processes in the form of dry and wet deposition remove material from a plume and alter the plume concentration. Dry deposition occurs when particles are brought to the surface by gravitational settling and turbulence. They are then removed from the atmosphere by deposition on the land surface. Wet deposition occurs due to rainout scavenging (within clouds) and washout scavenging (below clouds) of the material in the plume. These processes lead to a variation with downwind distance of the plume strength, and may alter the shape of the vertical concentration profile as dry deposition only occurs at the surface.

Near to sources of pollutants (<2 km), dry deposition is generally the predominant removal mechanism for pollutants such as NO_x, SO_2 and NH_3 (Fangmeier *et al.* 1994; Environment Agency, 2011). Dry deposition may be quantified from the near-surface plume concentration and the deposition velocity (Chamberlin and Chadwick, 1953);

$$F_d = v_d C(x, y, 0)$$

where:

F_d = dry deposition flux (μg m^{-2} s^{-1})

v_d = deposition velocity (m s^{-1})

$C(x,y,0)$ = ground level concentration (μg m^{-3})

Environment Agency guidance AQTAG06 (Environment Agency, 2011) recommends deposition velocities for various pollutants dependent upon the habitat type (Table 2.8).

Table 2.8   Environment Agency recommended deposition velocities

Pollutant	Deposition Velocity (m s^{-1})	
	Grassland	Forest
NO$_2$	0.0015	0.003
SO$_2$	0.012	0.024
HCl	0.025	0.06
NH$_3$	0.02	0.03
HNO$_3$	0.04	0.04
SO$_4^{2-}$ (Sulphate aerosol)	0.01	0.01

Source: Environment Agency (2011)

In order to assess the impacts of deposition, habitat-specific critical loads and critical levels have been created. These are generally defined as (e.g. Nilsson and Grennfelt, 1988);

> "...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."

It is important to distinguish between a critical load and a critical level. The critical load relates to the quantity of a material deposited from air to the ground, whilst critical levels refer to the concentration of a material in air. The UK Air Pollution Information System (APIS) provides critical load data for ecological sites in the UK.

The critical loads used to assess the impact of compounds deposited to land which result in eutrophication and acidification are expressed in terms of kilograms of nitrogen deposited per hectare per year (kg N ha^{-1} y^{-1}) and kilo-equivalents deposited per hectare per year (keq ha^{-1} y^{-1}). The unit of 'equivalents' (eq) is used for the purposes of assessing acidification, rather than a unit of mass. The unit eq (1 keq $\equiv$ 1,000 eq) refers to molar equivalent of potential acidity resulting from e.g. sulphur, oxidised and reduced nitrogen, as well as base cations. Essentially, it means 'moles of charge' and is a measure of how acidifying a particular chemical species can be.

To convert the predicted concentration in air of NO$_2$, SO$_2$, NH$_3$, or HNO$_3$, the following algorithm is used.

$$DR_i = C_i v_{d_i} f_i$$

Where:

DR_i = annual deposition of N or S (kg N ha^{-1} y^{-1} or kg S ha^{-1} y^{-1})

C_i = annual mean concentration of the ith chemical species (μg m^{-3})

v_{d_i} = deposition velocity of ith species (Table 2.8)

f_i = factor to convert from μg m^{-2} s^{-1} to kg ha^{-1} y^{-1} for the ith species

Table 2.9 provides the relevant conversion factors as extracted from AQTAG06.

Table 2.9   Environment Agency factors for converting modelled deposition rates

Pollutant	Conversion factor ($\mu g\ m^{-2}\ s^{-1}$ to $kg\ ha^{-1}\ y^{-1}$ for the ith species)	
	Element	Factor f
NO$_2$	N	96
SO$_2$	S	157.7
HNO$_3$	N	70.1
NH$_3$	N	259.7

Source: Environment Agency (2011)

In order to convert deposition of N and S to acid equivalents, the following relationships can be used:

- $1\ keq\ ha^{-1}\ y^{-1} = 14\ kg\ N\ ha^{-1}\ y^{-1}$.
- $1\ keq\ ha^{-1}\ y^{-1} = 16\ kg\ S\ ha^{-1}\ y^{-1}$.

With respect to wet deposition, Environment Agency (2011) states:

"It is considered that wet deposition of SO₂, NO₂ and NH₃ is not significant within a short range."

Therefore, the assessment only considers dry deposition of nutrifying and acidifying N and S compounds.

2.10   Special treatments

Other treatments

Specialised model treatments, for short-term (puff) releases, coastal models, fluctuations or photochemistry were not used in this assessment.

2.11   Existing ambient data

Continuous monitoring data

Havant Borough Council did not undertake any continuous monitoring in 2016, the last year for which information is available.

Passive monitoring data

Havant Borough Council operated NO$_2$ diffusion tubes at 23 sites in 2016. The nearest of these is about 700 m from the site, Brockhampton Lane Urban Background. Annual mean NO$_2$ concentrations at this site were between 2012 and 2016 were in the range 25.3–28.1 $\mu g\ m^{-3}$. The other diffusion tube sites are more than 1 km from the site and are mostly in roadside locations, so are of limited value in understanding the air quality at receptors close to the installation.

Defra and APIS mapped background concentrations

Defra maintains a nationwide model (the Pollution Climate Mapping (PCM) model) of existing and future background air quality concentrations at a 1 km grid square resolution. The data sets include annual average concentration estimates for NO_x, NO_2, PM_{10}, $PM_{2.5}$, CO, SO_2 and benzene. The PCM model is semi-empirical in nature: it uses data from the national atmospheric emissions inventory (NAEI) to model the concentrations of pollutants at the centroid of each 1 km grid square but then calibrates these concentrations in relation to actual monitoring data.

Defra does not publish modelled concentrations of ammonia, but these can be obtained from the APIS website, where they are modelled on a 5 km resolution grid.

Annual mean background data from the PCM model and APIS for the receptors considered in this study is detailed in Table 2.10.

Table 2.10   Defra's annual mean background concentrations, 2018

ID	NO_x ($\mu g\ m^{-3}$)	NO_2 ($\mu g\ m^{-3}$)	PM_{10} ($\mu g\ m^{-3}$)	$PM_{2.5}$ ($\mu g\ m^{-3}$)	CO ($\mu g\ m^{-3}$)	SO_2 ($\mu g\ m^{-3}$)	Ammonia ($\mu g\ m^{-3}$)
H2	22.1	15.9	15.4	10.2	393	2.91	1.32
H3	22.1	15.9	15.4	10.2	393	2.91	1.32
H4	25.3	18.0	15.5	10.2	402	3.01	1.26
E1	25.3	18.0	15.5	10.2	402	3.01	1.26
E2	28.5	19.9	16.9	11.1	392	3.47	1.26
E3	25.1	17.7	14.5	9.4	374	3.58	1.32
E4	25.0	17.7	14.8	9.7	358	2.94	1.32
E5	19.1	14.0	14.0	9.1	342	2.79	1.32
E6	25.1	17.7	14.5	9.4	374	3.58	1.32
E7	25.1	17.7	14.5	9.4	374	3.58	1.32
E8	33.6	23.0	17.4	11.3	437	3.03	1.11

Local Air Quality Management

Havant Borough Council and Gosport Borough Council, under their Local Air Quality Management (LAQM) obligations, continually review and assess concentrations of key air pollutants in the boroughs to ascertain the requirement, or otherwise, to declare an Air Quality Management Area (AQMA). Following the review and assessments undertaken to date, Gosport Borough Council has not declared any AQMAs, and Havant Borough Council has declared AQMAs for annual mean NO_2 at the following locations:

- AQMA 1: Portland Street; and

- AQMA 2: Gosport Road.

These AQMAs both lie about 6 km from the installation site, and the impact of the installation at the AQMAs is therefore expected to be negligible.

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Background concentrations used in the assessment

Defra's modelled NO_2 concentrations close to the installation site are somewhat lower than those monitored at the Brockhampton Lane Urban Background diffusion tube. This monitor is considered reasonably representative of the human receptors and the E1 ecological receptor, so background NO_2 concentrations have been set to 26.7 µg m^{-3}, the average of the monitored concentrations here. For the other ecological receptors, which are along the coast, the Defra mapped concentrations have been used. For pollutants other than NO_2, the Defra mapped concentrations have been used in the absence of alternative data. These are presented in Table 2.10.

The annual average process contribution is added to the annual average background concentration to give a total concentration at each receptor location. This total concentration can then be compared against the relevant Air Quality Assessment Level (AQAL) and the likelihood of an exceedance determined.

It is not technically rigorous to add predicted short-term or percentile concentrations to ambient background concentrations, since peak contributions from different sources would not necessarily coincide at the same time or at the same location. Without hourly ambient background monitoring data available it is difficult to make an assessment against the achievement or otherwise of the short-term assessment criteria. For the current assessment, conservative short-term ambient levels have been derived by applying a factor of two to the annual mean background data as per the recommendation in Environment Agency (2016) guidance.

The APIS website provides information on background deposition of nitrogen and sulphur at sensitive ecological sites in the UK. APIS is widely recognised as the primary source of this information and has been used for this air quality assessment.

2.12   Sensitivity analysis and uncertainty

Sensitivity analysis

Wherever possible, this assessment has used worst-case scenarios, which will exaggerate the impact of the emissions on the surrounding area, including emissions, operational profile, ambient concentrations, meteorology and surface roughness. This assessment has considered 5 years of meteorological data, with data reported from the year(s) predicting the highest ground-level concentrations at the nearest sensitive receptor for comparison with the AQS.

Model uncertainty

Process emissions have been modelled under expected operation using the standard steady state algorithms in ADMS to determine the impact on local human receptors. In order to model atmospheric dispersion using standard Gaussian methods, the following assumptions have to be made and limitations accepted:

- Conservation of mass - the entire mass of emitted pollutant remains in the atmosphere and no allowance is made for loss due to chemical reactions or deposition processes (although the standard Gaussian model can be modified to include such processes, as is the case with ADMS). Portions of the plume reaching the ground are assumed to be dispersed back away from the ground by turbulent eddies (eddy reflection);

- Steady state emissions - emission rates are assumed to be constant and continuous over the time averaging period of interest; and

- Steady state meteorology - no variations in wind speed, direction or turbulent profiles occur during transport from the source to the receptor. This assumption is reasonable within a few kilometres of a source but may not be valid for receptor distances in the order of tens of kilometres. For example, for a receptor 50 km from a source and with a wind speed of 5 m s^{-1} it

will take nearly three hours for the plume to travel this distance during which time many different processes may change (e.g., the sun may rise or set and clouds may form or dissipate affecting the turbulent profiles). For this reason, Gaussian models are practically limited to predicting concentrations within ~20 km of a source.

As a result of the above, and in combination with other factors, not least attempting to replicate stochastic processes (e.g., turbulence) by deterministic methods, dispersion modelling is inherently uncertain, but is nonetheless a useful tool in plume footprint visualisation and prediction of ground level concentrations. The use of dispersion models has been widely used in the UK for both regulatory and compliance purposes for a number of years and is an accepted approach for this type of assessment.

This assessment has incorporated a number of worst-case assumptions, as described above, which will result in an overestimation of the predicted ground level concentrations from the process. As a result of these worst-case assumptions, the predicted results should be considered the upper limit of model uncertainty for a scenario where the actual site impact is determined. Therefore, the actual predicted ground level concentrations would be expected to be lower than those reported in this assessment and, in some cases, significantly lower.

3. Assessment criteria

3.1 Relevant legislation and guidance

EU legislation

Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe

Directive 2008/50/EC (the 'Directive'), which came into force in June 2008, consolidates existing EU-wide air quality legislation (with the exception of Directive 2004/107/EC) and provides a new regulatory framework for $PM_{2.5}$.

The Directive sets limits, or target levels, for selected pollutants that are to be achieved by specific dates and details procedures EU Member States should take in assessing ambient air quality. The limit and target levels relate to concentrations in ambient air. At Article 2(1), the Directive defines ambient air as:

> "...outdoor air in the troposphere, excluding workplaces as defined by Directive 89/654/EEC where provisions concerning health and safety at work apply and to which members of the public do not have regular access."

In accordance with Article 2(1), Annex III, Part A, paragraph 2 details locations where compliance with the limit values does not need to be assessed:

> "Compliance with the limit values directed at the protection of human health shall not be assessed at the following locations:
>
> a) Any locations situated within areas where members of the public do not have access and there is no fixed habitation;
>
> b) In accordance with Article 2(1), on factory premises or at industrial installations to which all relevant provisions concerning health and safety at work apply; and
>
> c) On the carriageway of roads; and on the central reservation of roads except where there is normally pedestrian access to the central reservation."

UK legislation

The Air Quality Standards Regulations 2010

The Air Quality Standards Regulations 2010 (the 'Regulations') came into force on the 11 June 2010 and transpose Directive 2008/50/EC into UK legislation. The Directive's limit values are transposed into the Regulations as 'Air Quality Standards' (AQS) with attainment dates in line with the Directive.

These standards are legally binding concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on the assessment of the effects of each pollutant on human health including the effects of sensitive groups or on ecosystems.

Similar to Directive 2008/50/EC, the Regulations define ambient air as;

> "...outdoor air in the troposphere, excluding workplaces where members of the public do not have regular access."

with direction provided in Schedule 1, Part 1, Paragraph 2 as to where compliance with the AQS' does not need to be assessed:

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"Compliance with the limit values directed at the protection of human health does not need to be assessed at the following locations:

a) Any location situated within areas where members of the public do not have access and there is no fixed habitation;

b) On factory premises or at industrial locations to which all relevant provisions concerning health and safety at work apply; and

c) On the carriageway of roads and on the central reservation of roads except where there is normally pedestrian access to the central reservation."

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The 2007 Air Quality Strategy for England, Scotland Wales and Northern Ireland provides a framework for improving air quality at a national and local level and supersedes the previous strategy published in 2000.

Central to the Air Quality Strategy are health-based criteria for certain air pollutants; these criteria are based on medical and scientific reports on how and at what concentration each pollutant affects human health. The objectives derived from these criteria are policy targets often expressed as a maximum ambient concentration not to be exceeded, without exception or with a permitted number of exceedances, within a specified timescale. At paragraph 22 of the 2007 Air Quality Strategy, the point is made that the objectives are:

"...a statement of policy intentions or policy targets. As such, there is no legal requirement to meet these objectives except where they mirror any equivalent legally binding limit values..."

The AQOs, based on a selection of the objectives in the Air Quality Strategy, were incorporated into UK legislation through the Air Quality Regulations 2000, as amended.

Paragraph 4(2) of The Air Quality (England) Regulations 2000 states:

"The achievement or likely achievement of an air quality objective prescribed by paragraph (1) shall be determined by reference to the quality of air at locations –

a) Which are situated outside of buildings or other natural or man-made structures above or below ground; and

b) Where members of the public are regularly present."

Consequently, compliance with the AQOs should focus on areas where members of the general public are present over the entire duration of the concentration averaging period specific to the relevant objective.

The Environment Act 1995

Part IV of the Environment Act 1995 requires that Local Authorities periodically review air quality within their individual areas. This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government's AQOs.

To carry out an air quality Review and Assessment under the LAQM process, the Government recommends a three-stage approach. This phased review process uses initial simple screening methods and progresses through to more detailed assessment methods of modelling and monitoring in areas identified to be at potential risk of exceeding the objectives in the Regulations.

Review and assessments of local air quality aim to identify areas where national policies to reduce vehicle and industrial emissions are unlikely to result in air quality meeting the Government's air quality objectives by the required dates.

For the purposes of determining the focus of Review and Assessment, Local Authorities should have regard to those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective.

Where the assessment indicates that some or all of the objectives may be potentially exceeded, the Local Authority has a duty to declare an AQMA. The declaration of an AQMA requires the Local Authority to implement an Air Quality Action Plan (AQAP), to reduce air pollution concentrations so that the required AQOs are met.

Other guideline values

In the absence of statutory standards for the other prescribed substances that may be found in the emissions, there are several sources of applicable air quality guidelines.

Air Quality Guidelines for Europe, the World Health Organisation (WHO)

The aim of the WHO Air Quality Guidelines for Europe (WHO, 2000) is to provide a basis for protecting public health from adverse effects of air pollutants and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or well-being. These guidelines are intended to provide guidance and information to international, national and local authorities making risk management decisions, particularly in setting air quality standards.

Environmental Assessment Levels (EALs)

The Environment Agency's Air emissions risk assessment for your environmental permit guidance provides methods for quantifying the environmental impacts of emissions to all media. It contains long and short-term Environmental Assessment Levels (EALs) and Environmental Quality Standards (EQS) for releases to air derived from a number of published UK and international sources. For the pollutants considered in this study, these EALs and EQS are equivalent to the AQS and AQOs set in force by the Air Quality Strategy for England, Scotland Wales and Northern Ireland.

The guidance includes an additional target of relevance to this assessment, namely a limit of 75 $\mu g\ m^{-3}$ on daily mean NO_x at ecological receptors. This is based on guidance from the World Health Organization (WHO, 2000), which says:

> "Experimental evidence exists that the CLE [critical level] decreases from around 200 $\mu g/m^3$ to 75 $\mu g/m^3$ when in combination with O_3 or SO_2 at or above their critical levels. In the knowledge that short-term episodes of elevated NOx concentrations are generally combined with elevated concentrations of O_3 or SO_2, 75 $\mu g/m^3$ is proposed for the 24 h mean."

In general, current conditions in the UK are such that elevated concentrations of O_3 or SO_2 are rare. In particular, SO_2 levels are much lower than they were in 2000 when the WHO guidance was written, UK emissions having fallen by 86% from 1.29 Mt to 0.18 Mt over that period. As such, it is considered that 200 $\mu g\ m^{-3}$ is the more appropriate assessment level for daily mean NO_x. This has been accepted by regulators including Natural England (NE), the EA and Natural Resources Wales in relation to air quality assessments for other development applications.

3.2   Air quality impacts of the process

The atmospheric emissions of the following pollutants have been identified as requiring detailed dispersion modelling:

- Oxides of nitrogen (NO_x as NO_2); and

- Carbon monoxide (CO).

A brief description of each pollutant is given in Table 3.1.

Table 3.1   Summary of the pollutants assessed

Pollutant	Description and effect on human health and the environment	Principal Sources
Oxides of Nitrogen (NOx)	Nitrogen dioxide (NO_2) and nitric oxide (NO) are both collectively referred to as oxides of nitrogen (NO_x). It is NO_2 that is associated with adverse effects on human health. Most atmospheric emissions are in the form of NO which is converted to NO_2 in the atmosphere through reactions with ozone. The oxidising properties of NO_2 theoretically could damage lung tissue, and exposure to very high concentrations of NO_2 can lead to inflammation of lung tissue, affect the ability to fight infection. The greatest impact of NO_2 is on individuals with asthma or other respiratory conditions, but consistent impacts on these individuals is at levels of greater than 564 $\mu g\ m^{-3}$, much higher than typical UK ambient concentrations.	All combustion processes produce NO_x emissions, and the principal source of NO_x is road transport, which accounted for 34% of total UK emissions in 2016. Emissions from power stations contributed a further 22%.
Carbon Monoxide (CO)	The toxicity of CO results in it binding avidly to haemoglobin and thus reducing the oxygen carrying capacity of the blood. In very high doses, the restriction of oxygen to the brain and heart can be fatal. At lower concentrations, CO can affect higher cerebral function, heart function and exercise capacity.	The principal source of CO is emissions from residential sector combustion, accounting for 27% of total UK emissions in 2016, with other stationary combustion responsible for another 27%. Road transport accounted for 18% of UK emissions in 2016.
Particulate Matter (PM)	Particulate matter is the term used to describe all suspended solid matter. Particulate matter with an aerodynamic diameter of less than 10 μm (PM_{10}) is the subject of health concerns because of its ability to penetrate and remain deep within the lungs. The health effects of particles are difficult to assess, and evidence is mainly based on epidemiological studies. Evidence suggests that there may be associations between increased PM_{10} concentrations and increased mortality and morbidity rates, changes in symptoms or lung function, episodes of hospitalisation or doctors consultations. Recent reviews by the World Health Organisation (WHO) and Committee on the Medical Effects of Air Pollutants (COMEAP) have suggested exposure to a finer fraction of particles ($PM_{2.5}$) give a stronger association with the observed health effects. $PM_{2.5}$ typically makes up around two-thirds of PM_{10} emissions and concentrations.	Road transport, industrial processes, small stationary combustion sources and non-road mobile machinery. Other pollutants, including NO_2 and SO_2, have the potential to form secondary particulates which are often smaller than PM_{10}.
Sulphur dioxide (SO₂)	At high concentrations SO_2 is a potent bronchoconstrictor, and asthmatic individuals are more susceptible. It is likely that SO_2 contributes to respiratory symptoms, reduced lung function and rises in hospital admissions. Exposure to high levels of SO_2 over a long period can result in structural changes in the lungs and may enhance sensitisation to allergens.	The principal source of SO_2 is the combustion of fossil fuels containing sulphur and, in the UK, this is primarily through the combustion of coal in power stations, oil refining and solid fuel manufacturing

3.3   Criteria appropriate to the assessment

Air quality assessment levels (AQALs)

As indicated above, there is a large number of sources of standards against which air quality should be assessed, and these often use different terms for the assessment levels, including limit value, air quality standard (AQS), air quality objective (AQO), environmental assessment level (EAL), critical level (CLE), critical

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load (CL) and target. For simplicity, this document follows IAQM/EPUK (2015) is using the term "air quality assessment level (AQAL)", or simply assessment level, to refer to any of these, unless it is useful to be more specific (e.g. to indicate the legal status of the AQAL).

Table 3.2 sets out those AQALs that are relevant to this assessment.

Table 3.2   Air quality assessment levels

Pollutant	Receptors affected	AQS/AQO/EAL	Averaging Period	Value ($\mu g\ m^{-3}$)
NO$_2$	Human	AQS	Annual mean	40
		AQS	1-hour mean, not to be exceeded more than 18 times a year (equivalent to 99.79th percentile)	200
NO$_x$	Ecological	AQS	Annual mean	30
		Target	Daily mean	75
		WHO assessment level	Daily mean	200*
CO	Human	AQS	8-hour mean	10,000
		EAL	1-hour mean	30,000
PM$_{10}$	Human	AQO	Annual mean	40
		AQO	24-hour mean, not to be exceeded more than 35 times a year (equivalent to 90.41th percentile)	50
PM$_{2.5}$	Human	AQO	Annual mean	25
SO$_2$	Human	AQO	1-hour mean, not to be exceeded more than 24 times a year (equivalent to 99.73th percentile)	350
		AQO	24-hour mean, not to be exceeded more than 3 times a year (equivalent to 99.18th percentile)	125
		AQO	15-min mean, not to be exceeded more than 35 times a year (equivalent to 99.9th percentile)	266
SO$_2$	Ecological	AQO	Annual mean	20
Ammonia	Human	EAL	Annual mean	180
		EAL	1-hour mean	2500
Ammonia	Ecological	EAL	Annual mean	1 if lichens or bryophytes are present; otherwise 3

*Where O$_3$ and SO$_2$ are not present above their critical levels.

Critical loads relevant to the assessment

The Air Pollution Information Service (APIS) contains information on applicable critical loads for various habitats and species.

Eutrophication critical loads are given as a range and have units of kg N ha^{-1} y^{-1}. Generally, the lower end of the range should be used as a conservative assessment. The critical loads for acidification are more complicated, in that both the nitrogen and sulphur deposition fluxes must be considered at the same time. Therefore, a critical load function is specified for acidification, via the use of three critical load parameters:

- $CL_{max}S$ — the maximum critical load of sulphur, above which the deposition of sulphur alone would be considered to lead to an exceedance;

- $CL_{min}N$ — a measure of the ability of a system to "consume" deposited nitrogen (e.g. via immobilisation and uptake of the deposited nitrogen); and

- $CL_{max}N$ — the maximum critical load of acidifying nitrogen, above which the deposition of nitrogen alone would be considered to lead to an exceedance.

These three quantities define the critical load function shown in Figure 3.1.

Figure 3.1   Schematic critical load function for acidity
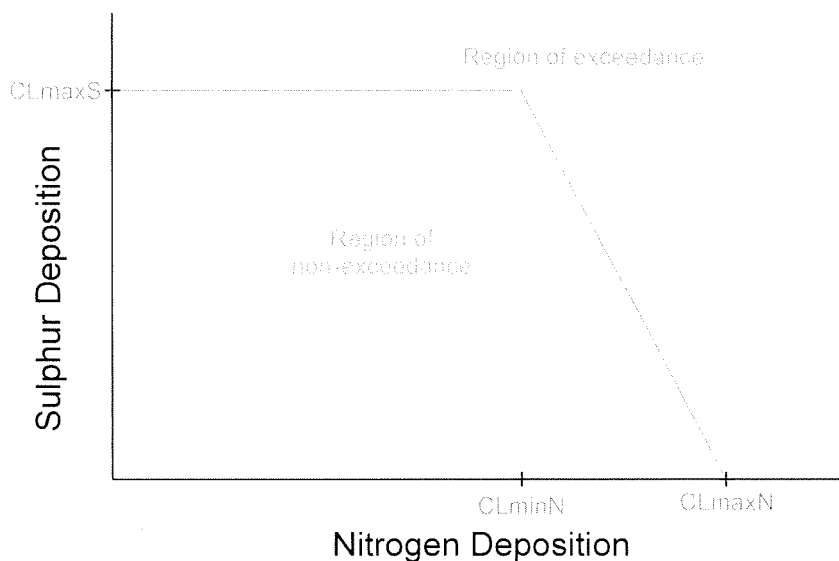
Public exposure

Guidance from the UK Government and Devolved Administrations makes clear that exceedances of the health-based objectives should be assessed at outdoor locations where members of the general public are regularly present over the averaging time of the objective. As in Section 3.1, this also excludes workplaces. Table 3.3 provides an indication of those locations that may or may not be relevant for each averaging period.

Table 3.3   Examples of where the Air Quality Objectives should apply for human receptors

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, care homes etc.	Building facades 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.
8-hour mean	All locations where the annual mean objectives would apply, together with hotels. Gardens of residential properties[1].	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives would apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend one hour or more. Any outdoor locations at which the public may be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.

[1] For gardens, such locations should represent parts of the garden where relevant public exposure is likely, for example where there is a seating or play areas. It is unlikely that relevant public exposure would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.

4. Assessment of impact

This section sets out the results of the dispersion modelling and compares predicted ground level concentrations against the assessment criteria detailed in Section 3. The predicted concentrations resulting from the process (i.e. the process contribution (PC)) are presented along with the total predicted environmental concentrations (PEC), which include the background contribution from sources unrelated to the installation.

Please note that results are given to several decimal places. This is to enable comparison between receptors and between PC and PEC contributions. The number of decimal places quoted should not be taken as providing any indication of the accuracy of the results.

4.1 Meteorological data sensitivity analysis

As described in Section 2.3, results were calculated separately for five different years of meteorological data ('met year'). For each of the receptors and for each pollutant measure, the met year giving the highest concentration was determined, and the corresponding concentration is the one presented here. In other words, each of the individual results are the worst case for that measure.

4.2 Human health effects

Nitrogen dioxide (NO$_2$)

Predicted annual mean NO$_2$ concentrations at relevant receptors (i.e. excluding receptors where there is no relevant public exposure over a year) are given in Table 4.1. Contours of annual mean NO$_2$ PC are given in Figure 4.1.

Table 4.1   Maximum PCs and PECs for annual mean NO$_2$

Receptor	AQAL (µg m^{-3})	PC (µg m^{-3})	PEC (µg m^{-3})	PC (percent of AQAL)	PEC (percent of AQAL)
H2	40	0.55	27.25	1.4%	68.1%
H3	40	0.40	27.10	1.0%	67.8%
H4	40	0.12	26.82	0.3%	67.1%

The maximum annual mean NO$_2$ PEC at any relevant human receptor location is predicted as 27 µg m^{-3} or 68% of the AQAL at receptor H2 (Residential 1). The highest PC is 1 µg m^{-3} or 1% of the AQAL at the same receptor. All concentrations at relevant receptors are well within the legal limit.

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Figure 4.1   NO₂ annual mean process contribution

Bedhampton

Annual mean NO2 PC

Camp Down

Elmleigh Road

Havant

Bedhampton

4 µg m⁻³

2 µg m⁻³

1 µg m⁻³

0 5 µg m⁻³

West Street

Elm Lane

N Street

East Stre

Brockhampton Road

Brockhampton

Forty
Acre Farm

The Old
Coach House

Harts

Langstone
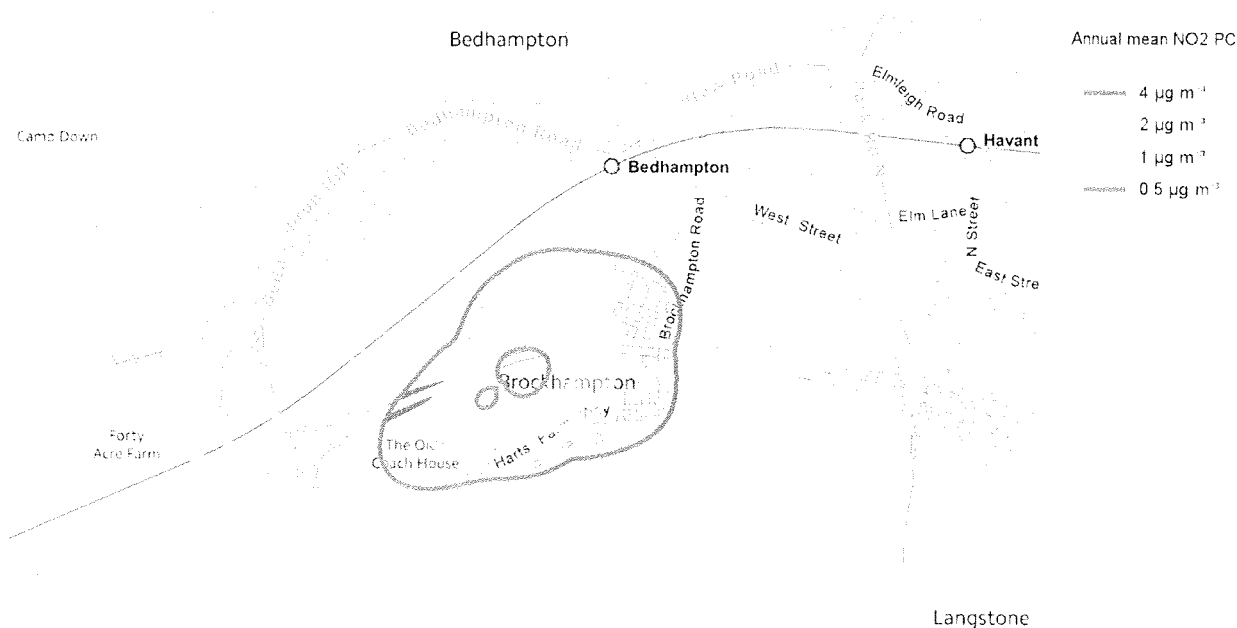
Contains Ordnance Survey data © Crown copyright and database right 2018

Predicted concentrations of the 99.79th percentile 1-hour mean NO₂ are given in Table 4.2, and contours are shown in Figure 4.2. The maximum 99.79th percentile 1-hour mean NO₂ PEC at any relevant human receptor location is predicted as 165 µg m⁻³ or 82% of the AQAL at receptor H2 (Residential 1). All concentrations at relevant receptors are well within the legal limit.

Table 4.2   Maximum PCs and PECs for 99.79ᵗʰ percentile 1-hour mean NO₂

Receptor	AQAL ($\mu g\ m^{-3}$)	PC ($\mu g\ m^{-3}$)	PEC ($\mu g\ m^{-3}$)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	200	111.23	164.63	55.6%	82.3%
H3	200	99.10	152.50	49.6%	76.3%
H4	200	33.66	87.06	16.8%	43.5%

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Figure 4.2   NO₂ 99.79 percentile 1-hour mean process contribution
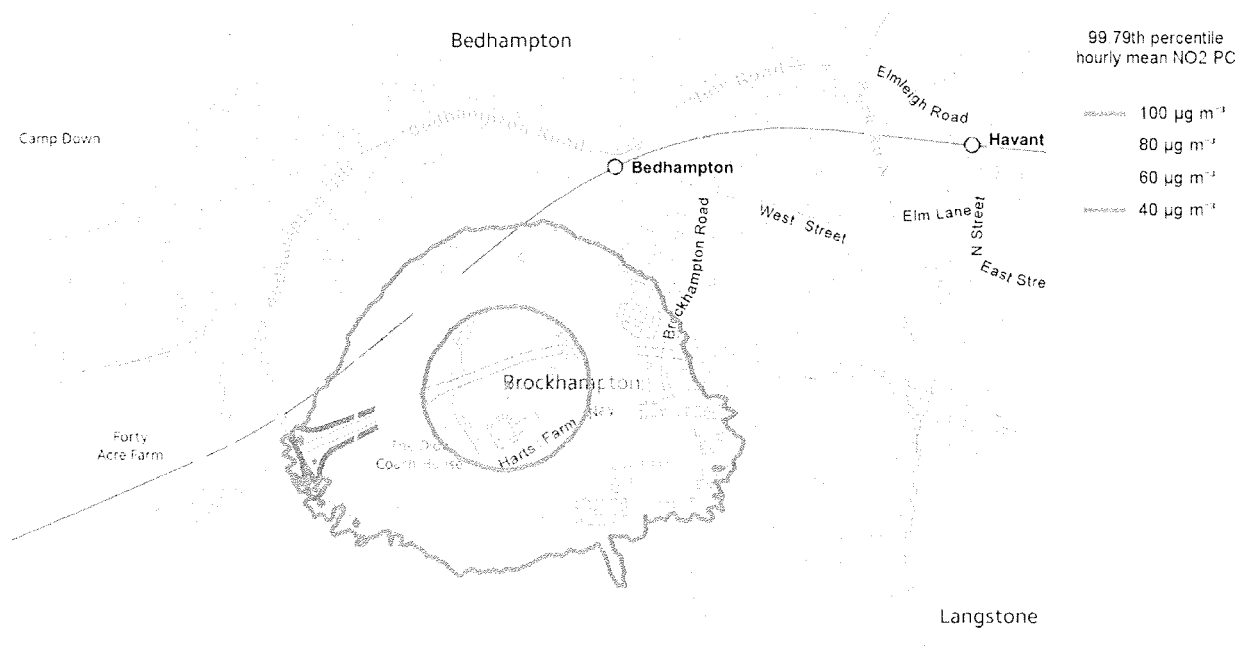
Contains Ordnance Survey data © Crown copyright and database right 2018

Table 4.3 presents the 100th percentile 1-hour mean NO_2 concentrations. It is important to note that there is no statutory limit or other AQAL for 100th percentile 1-hour mean NO_2; this table has been included following guidance from the Environment Agency. Since there is no AQAL, there is no value to assess the PC/PEC against.

Table 4.3   Maximum PCs and PECs for 100th percentile 1-hour mean NO₂

Receptor	AQAL ($\mu g\ m^{-3}$)	PC ($\mu g\ m^{-3}$)	PEC ($\mu g\ m^{-3}$)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	N/A	133.60	187.00	N/A	N/A
H3	N/A	112.14	165.54	N/A	N/A
H4	N/A	51.30	104.70	N/A	N/A

PM$_{10}$

Predicted annual mean and 90.41th percentile daily mean PM_{10} concentrations are given in Table 4.4 and Table 4.5.

The maximum annual mean PM_{10} PEC at any relevant human receptor location is predicted as 16 $\mu g\ m^{-3}$ or 39% of the AQAL at receptor H2 (Residential 1). The maximum 90.41th percentile daily mean PM_{10} PEC at any relevant human receptor location is predicted as 35 $\mu g\ m^{-3}$ or 71% of the AQAL at the same receptor. All concentrations at relevant receptors are within the legal limit.

wood.

Table 4.4   Maximum PCs and PECs for annual mean PM₂.₅

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	40	0.07	15.51	0.2%	38.8%
H3	40	0.05	15.49	0.1%	38.7%
H4	40	0.02	15.49	0.0%	38.7%

Table 4.5   Maximum PCs and PECs for 90.41th percentile daily mean PM₂.₅

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	50	4.53	35.41	9.1%	70.8%
H3	50	3.59	34.47	7.2%	68.9%
H4	50	1.10	32.04	2.2%	64.1%

PM₂.₅

Predicted annual mean PM₂.₅ concentrations at relevant receptors are given in Table 4.5.

The maximum annual mean PM₂.₅ PEC at any relevant human receptor location is predicted as 10 µg m⁻³ or 41% of the AQAL at receptor H2 (Residential 1). All concentrations at relevant receptors are well within the legal limit.

Table 4.6   Maximum PCs and PECs for annual mean PM₂.₅

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	25	0.07	10.29	0.3%	41.2%
H3	25	0.05	10.27	0.2%	41.1%
H4	25	0.02	10.20	0.1%	40.8%

Carbon monoxide (CO)

Predicted maximum 1-hour mean and the maximum rolling 8-hour mean CO concentrations are given in Table 4.7 and Table 4.8.

The maximum 1-hour mean CO PEC at any relevant human receptor location is predicted as 1226 µg m⁻³ or 4% of the AQAL at receptor H2 (Residential 1). The maximum rolling 8-hour mean CO PEC at any relevant human receptor location is predicted as 1159 µg m⁻³ or 12% of the AQS at the same receptor. On this evidence, emissions of CO from the installation are likely to have a negligible impact on human health.

Table 4.7   Maximum PCs and PECs for maximum 1-hour mean CO

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	30,000	440	1226	1.5%	4.1%
H3	30,000	370	1156	1.2%	3.9%
H4	30,000	169	973	0.6%	3.2%

Table 4.8   Maximum PCs and PECs for maximum rolling 8-hour mean CO

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	10,000	373	1159	3.7%	11.6%
H3	10,000	356	1142	3.6%	11.4%
H4	10,000	118	922	1.2%	9.2%

Sulphur dioxide (SO$_2$)

Predicted maximum 99.18th percentile daily mean, 99.73th percentile hourly mean and 99.9th percentile 15-minute mean SO$_2$ concentrations are given in Table 4.9, Table 4.10 and Table 4.11 respectively.

The maximum 99.18th percentile daily mean SO$_2$ PEC at any relevant human receptor location is predicted as 7 µg m^{-3} or 5% of the AQAL at receptor H2 (Residential 1). The maximum 99.73th percentile hourly mean SO$_2$ PEC at any relevant human receptor location is predicted as 7 µg m^{-3} or 2% of the AQAL at the same receptor. The maximum 99.9th percentile 15-minute mean SO$_2$ PEC at any relevant human receptor location is predicted as 7 µg m^{-3} or 3% of the AQAL at the same receptor. All concentrations at relevant receptors are well within the legal limit.

Table 4.9   Maximum PCs and PECs for 99.18th percentile daily mean SO$_2$

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	125	0.36	6.18	0.3%	4.9%
H3	125	0.30	6.12	0.2%	4.9%
H4	125	0.07	6.09	0.1%	4.9%

Table 4.10   Maximum PCs and PECs for 99.73th percentile hourly mean SO$_2$

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	350	0.69	6.51	0.2%	1.9%
H3	350	0.60	6.42	0.2%	1.8%

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Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H4	350	0.20	6.22	0.1%	1.8%

Table 4.11   Maximum PCs and PECs for 99.9th percentile 15-minute mean SO₂*

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	266	0.96	6.78	0.4%	2.5%
H3	266	0.87	6.69	0.3%	2.5%
H4	266	0.31	6.33	0.1%	2.4%

* Calculated using the Environment Agency's suggested method of multiplying the 99.9th percentile hourly mean concentration by 1.34. This gives consistently slightly higher concentrations than using ADMS to output the 15-minute mean concentrations directly.

Ammonia (NH₃)

Predicted annual mean and maximum hourly mean ammonia concentrations are given in Table 4.12 and Table 4.13.

The maximum annual mean ammonia PEC at any relevant human receptor location is predicted as 1.3 µg m⁻³ or 1% of the AQAL at receptor H2 (Residential 1); the PC here is just 0.02 µg m⁻³ or 0.01% of the AQAL. The maximum hourly mean ammonia PEC at any relevant human receptor location is predicted as 14 µg m⁻³ or 1% of the AQAL at the same receptor. All concentrations at relevant receptors are well within the assessment level and there is no risk of any exceedances.

However, it should be remembered that the modelled emission rate was back-calculated to ensure that concentrations at receptors remain with assessment levels. Actual emission rates will be determined by stack monitoring.

Table 4.12   Maximum PCs and PECs for annual mean ammonia

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	180	0.023	1.34	<0.1%	0.7%
H3	180	0.017	1.34	<0.1%	0.7%
H4	180	0.005	1.27	<0.1%	0.7%

Table 4.13   Maximum PCs and PECs for hourly mean ammonia

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H2	2500	11.31	13.95	0.5%	0.6%
H3	2500	9.50	12.14	0.4%	0.5%

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Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)
H4	2500	4.34	6.86	0.2%	0.3%

4.3 Ecological effects

NOₓ concentrations in air

Table 4.14 and Table 4.15 present the assessment of predicted NOₓ concentrations against established critical levels for the ecological receptors considered in this study.

Table 4.14 Critical levels assessment of annual mean NO.

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)	Site type
E1	30	0.04	25.37	0.1%	84.6%	Local
E2	30	0.09	28.57	0.3%	95.2%	Local
E3	30	0.28	25.36	0.9%	84.5%	Major
E4	30	0.14	25.17	0.5%	83.9%	Major
E5	30	0.10	19.24	0.3%	64.1%	Major
E6	30	0.28	25.35	0.9%	84.5%	Major
E7	30	0.28	25.36	0.9%	84.5%	Major
E8	30	0.01	33.66	<0.1%	112.2%	Major

Table 4.15 Critical Levels assessment of daily mean NO.

Receptor	AQAL (µg m⁻³)	PC (µg m⁻³)	PEC (µg m⁻³)	PC (percent of AQAL)	PEC (percent of AQAL)	Site type
E1	200	6.43	57.08	3.2%	28.5%	Local
E2	200	10.24	67.21	5.1%	33.6%	Local
E3	200	31.16	81.30	15.6%	40.7%	Major
E4	200	15.70	65.76	7.8%	32.9%	Major
E5	200	6.22	44.50	3.1%	22.3%	Major
E6	200	30.57	80.71	15.3%	40.4%	Major
E7	200	30.65	80.79	15.3%	40.4%	Major
E8	200	1.55	68.85	0.8%	34.4%	Major

The annual mean NO_x PEC is modelled to exceed the AQAL at the E8 (Portsmouth Harbour Ramsar/SPA) receptor; however this is overwhelmingly due to the existing background concentrations, since the PC here is just 0.01 µg m^{-3} or 0.04%of the AQAL. In fact, the PC is less than 1% of the AQAL at all the modelled receptors. Under Environment Agency guidance, where the PC is less than 1% of the AQAL at major ecological sites (SPAs, SACs, Ramsar sites and SSSIs), or less than 100% of the AQAL at local ecological sites, the impact can be considered insignificant and no further assessment is required. This applies at all modelled receptors.

The daily mean NO_x PEC is below the AQAL at all of the ecological receptors considered. At the local ecological receptors, the PC is up to 5% of the AQAL, so under Environment Agency guidance, the impact can be considered insignificant and no further assessment is required. Of the major ecological sites (SSSIs, SPAs and SACs), the PCs are over 10% of the AQAL at three receptors: E3 (Chichester and Langstone Harbours Ramsar/SPA 1), E6 (Langstone Harbour SSSI) and E7 (Solent Maritime SAC), which is above the Environment Agency criterion for screening out from further assessment. However, it should be noted that these estuary sites are washed by tides twice daily and are primarily designated for fauna rather than plant life.

Using the target of 75 µg m^{-3} as the AQAL means that the PECs at the E3, E6 and E7 receptors are modelled to exceed the AQAL, and the PC at the E4 (Chichester and Langstone Harbours Ramsar/SPA 2) receptor exceeds the 10% of AQAL criterion. However, considering the extremely low sulphur concentrations (see below), this target is not considered to be appropriate.

SO$_2$ concentrations in air

Table 4.16 presents the assessment of predicted SO_2 concentrations against established critical levels for the ecological receptors considered in this study. It has not been possible to confirm whether lichens or bryophytes are present at the local wildlife sites, so it assumed conservatively that they are.

Table 4.16   Critical levels assessment of annual mean SO$_2$

Receptor	AQAL (µg m^{-3})	PC (µg m^{-3})	PEC (µg m^{-3})	PC (percent of AQAL)	PEC (percent of AQAL)	Site type
E1	10	0.0001	3.01	<0.1%	30.1%	Local
E2	10	0.0002	3.47	<0.1%	34.7%	Local
E3	20	0.0006	3.58	<0.1%	17.9%	Major
E4	20	0.0003	2.94	<0.1%	14.7%	Major
E5	20	0.0002	2.79	<0.1%	14.0%	Major
E6	20	0.0006	3.58	<0.1%	17.9%	Major
E7	20	0.0006	3.58	<0.1%	17.9%	Major
E8	20	0.0000	3.03	<0.1%	15.2%	Major

The concentration at all receptors is dominated by the existing background. At the local ecological receptors, the maximum PEC is 3 µg m^{-3} or 35% of the AQAL (assuming the presence of lichens or bryophytes) at the E2 (Farlington Marshes LNR) receptor, where the PC is just 0.0002 µg m^{-3} or 0.002% of the AQAL. At the major ecological receptors (Ramsar, SPA, SAC and SSSI), the greatest PEC is 4 µg m^{-3} or 35% of the AQAL at the E7 (Solent Maritime SAC) receptor, and the greatest PC is 0.0006 µg m^{-3} at the same receptor. Under EA guidance, because the PC at local sites is less than 100% of the AQAL, and the PC at the major ecological sites is less than 1% of the AQAL, all impacts can be considered insignificant and do not require further assessment.

wood.

Ammonia concentrations in air

Table 4.17 presents the assessment of predicted ammonia concentrations against established critical levels for the ecological receptors considered in this study. It has not been possible to confirm whether lichens or bryophytes are present at the local wildlife sites, so it assumed conservatively that they are.

Table 4.17   Critical levels assessment of annual mean ammonia

Receptor	AQAL ($\mu g\ m^{-3}$)	PC ($\mu g\ m^{-3}$)	PEC ($\mu g\ m^{-3}$)	PC (percent of AQAL)	PEC (percent of AQAL)	Site type
E1	1	0.001	1.26	0.1%	126.1%	Local
E2	1	0.003	1.26	0.3%	126.3%	Local
E3	1	0.008	1.33	0.3%	44.3%	Major
E4	1	0.004	1.32	0.1%	44.1%	Major
E5	1	0.003	1.32	0.1%	44.1%	Major
E6	1	0.008	1.33	0.3%	44.3%	Major
E7	1	0.008	1.33	0.3%	44.3%	Major
E8	1	0.000	1.11	<0.1%	37.0%	Major

There are exceedances of the 1 $\mu g\ m^{-3}$ level (but not the 3 $\mu g\ m^{-3}$ level) at all receptors, due to the existing background concentrations, but the additional contribution from the installation is exceedingly small. Of the local environmental receptors, the maximum annual mean ammonia PEC is 1.3 $\mu g\ m^{-3}$ or 126% of the AQAL (assuming lichens or bryophytes are present) at the E2 (Farlington Marshes LNR) receptor, but the PC here is just 0.003 $\mu g\ m^{-3}$ or 0.3% of the AQAL. At the major ecological receptors (SACs, SPAs and SSSIs), the greatest PEC is 44% of the AQAL and the greatest PC is just 0.3% of the AQAL. Under EA guidance, because the PC at local sites is less than 100% of the AQAL, and the PC at the major ecological sites is less than 1% of the AQAL, all impacts can be considered insignificant and do not require further assessment.

However, it should be remembered that the modelled emission rate was back-calculated to ensure that concentrations at receptors remain with assessment levels. Actual emission rates will be determined by stack monitoring.

Nutrient nitrogen deposition

The results for nutrient nitrogen deposition (from emissions of NO_x and ammonia) are shown in Table 4.18. At some of the ecological sites, the PEC exceeds the critical load, but this is overwhelmingly due to the existing background. The PC all the receptors is less than 0.1% of the AQAL. Under Environment Agency guidance, where the PC is less than 1% of the AQAL at major ecological sites (SPAs, SACs, Ramsar sites and SSSIs), or less than 100% of the AQAL at local ecological sites, the impact can be considered insignificant and no further assessment is required. This applies at all modelled receptors.

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Table 4.18   Maximum PCs and PECs for nitrogen deposition

Receptor	AQAL (μg m^{-3})	PC (μg m^{-3})	PEC (μg m^{-3})	PC (percent of AQAL)	PEC (percent of AQAL)	Site type
E1	10	0.02	22.56	0.2%	225.6%	Local
E2	10	0.02	13.88	0.2%	138.8%	Local
E3	20	0.07	14.21	0.4%	71.1%	Major
E4	20	0.04	14.18	0.2%	70.9%	Major
E5	20	0.03	14.17	0.1%	70.8%	Major
E6	20	0.07	14.21	0.4%	71.1%	Major
E7	8	0.07	14.21	0.9%	177.7%	Major
E8	20	0.00	13.02	0.0%	65.1%	Major

Acid deposition

Acidity critical loads for the modelled receptors are given in Table 4.19. Modelled PC and background deposition rates for acidity are given in Table 4.20. A comparison with the critical load function is given in Table 4.21.

Table 4.19   Acid critical loads

Receptor	CLmaxS (keq ha^{-1} y^{-1})	CLminN (keq ha^{-1} y^{-1})	CLmaxN (keq ha^{-1} y^{-1})
E1	1.838	0.357	2.195
E2	0.24	0.321	0.561
E3	0.91	0.438	1.348
E4	0.91	0.438	1.348
E5	0.91	0.438	1.348
E6	0.87	0.223	1.38
E7	0.91	0.438	1.348
E8	N/A	N/A	N/A

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Table 4.20   Acid deposition rates

Receptor	Sulphur PC (keq ha^{-1} y^{-1})	Nitrogen PC (keq ha^{-1} y^{-1})	Sulphur background (keq ha^{-1} y^{-1})	Nitrogen background (keq ha^{-1} y^{-1})	Site type
E1	0.000021	0.0013	0.25	1.61	Local
E2	0.000022	0.0016	0.21	0.99	Local
E3	0.000072	0.0051	0.21	1.01	Major
E4	0.000036	0.0026	0.21	1.01	Major
E5	0.000025	0.0018	0.21	1.01	Major
E6	0.000071	0.0051	0.21	1.01	Major
E7	0.000073	0.0052	0.21	1.01	Major
E8	0.000003	0.0002	0.22	0.93	Major

Table 4.21   Acid deposition: comparison with critical loads

Receptor	Exceedance (keq ha^{-1} y^{-1})			Percent of critical load function			Type
	PC	Background	PEC	PC	Background	PEC	
E1	No exceedance	No exceedance	No exceedance	0.1	84.7	84.8	Local
E2	No exceedance	0.64	0.64	0.3	213.9	214.2	Local
E3	No exceedance	No exceedance	No exceedance	0.4	90.5	90.9	Major
E4	No exceedance	No exceedance	No exceedance	0.2	90.5	90.7	Major
E5	No exceedance	No exceedance	No exceedance	0.1	90.5	90.6	Major
E6	No exceedance	No exceedance	No exceedance	0.4	88.4	88.8	Major
E7	No exceedance	No exceedance	No exceedance	0.4	90.5	90.9	Major
E8	N/A	N/A	N/A	N/A	N/A	N/A	Major

Several receptors are close to or above their critical load for acidity, but this is overwhelmingly due to the existing background. At all receptors, the PC is less than 1% of the AQAL. Under Environment Agency guidance, where the PC is less than 1% of the AQAL at major ecological sites (SPAs, SACs, Ramsar sites and SSSIs), or less than 100% of the AQAL at local ecological sites, the impact can be considered insignificant and no further assessment is required. This applies at all modelled receptors.

5. Conclusions

This assessment has used detailed dispersion modelling to undertake an impact assessment of emissions to air from the Peak Gen power plant in Havant. The pollutants covered by the assessment are:

- Oxides of nitrogen (NO_x and NO_2);

- Particulate matter (PM_{10} and $PM_{2.5}$);

- Carbon monoxide (CO);

- Sulphur dioxide (SO_2);

- Ammonia (NH_3);

- Nitrogen deposition; and

- Acid deposition.

This assessment assumes the engines operate for full, hourly periods to predict both the long-term and short-term impacts of engine emissions. This approach ensures that those meteorological conditions conducive to producing elevated ground level concentrations of pollutants are appropriately considered. However, given that the engines will only run for a maximum of 500 hours per year, additional post-processing of raw modelled output has been undertaken. Consideration has also been given to the fact that the SCR emission abatement system takes about 5 minutes to become effective after a cold start-up.

The impact assessment demonstrates that, under the anticipated operational profile of the plant, exceedances of any air quality assessment level are unlikely at the local receptors identified to protect human health or ecological sites; or, where there are exceedances predicted, these are overwhelmingly due to the existing background and the additional contribution from the installation is negligible.

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