Wressle-2 and Wressle-3

Planning Application for an Extension to the Wressle Wellsite and Associated Pipeline

Wressle Wellsite, Lodge Farm, Clapp Gate, Appleby, North Lincolnshire, DN15 0DB

Air quality assessment of hydrocarbon production operations

Carried out for:

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Carried out by:

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CONTENTS

SUMMARY

Egdon Resources UK Limited currently undertake hydrocarbon production operations from one well at their Wressle wellsite near Scunthorpe. An extension to the current operations is proposed, comprising an extension of the existing Wressle wellsite to construct two well cellars; drill two additional lateral underground boreholes to appraise hydrocarbon resources from the Penistone Flags and Ashover reservoirs; upgrade existing production facilities to include additional fluid storage tanks, separator system, surface pump and associated bunds; install gas processing equipment, construct a 600 m underground gas pipeline and flow gas to the existing National Grid pipeline; and the long term production of oil and gas. Three wells are then expected to be in production, after which the site will be restored. The project duration is expected to be around 15 years.

As part of the planning and permitting process it is necessary to assess the dispersion of releases to atmosphere associated with the proposed site extension, well drilling and testing and subsequent long term oil production to determine their impact on ambient concentrations of important pollutants around the local area. In particular, impact at locations of permanent human habitation and designated and local ecological sites, in the context of attainment of applicable environmental standards, requires assessment.

An Air Quality Dispersion Modelling Assessment accompanied the planning application in 2018 for long term oil production at the Wressle wellsite. The Assessment predicted both short-term and long-term impacts on pollutant concentrations at nearby residential properties and ecological receptors. It concluded that the proposed gas engine and flare will not have a significant impact or effect on local air quality. Both the Council's Environmental Health officer and the Environment Agency raised no objection to the proposed development with regard to its impact on air quality.

The predominant source of pollutant releases during site operations will be from the use of diesel fuel in mobile plant and stationary engines and from the incineration and combustion of produced natural gas. This is largely undertaken in the first two years of the proposed development. Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, particulate matter and sulphur dioxide were therefore considered. The assessment was undertaken using the UK ADMS 6.0 modelling system, with an operating regime considered to provide unlikely worst case conditions for pollutant releases and air quality impact.

Maximum pollutant process contributions from site operations occur within the wellsite boundary. Beyond this location, process contributions reduce significantly with distance. It is not considered that statutory air quality standards would be applicable around the area of maximum impact, or around and just beyond the site boundary, due to the infrequency of human exposure and limited access. The first year's operation, which includes site extension work and well drilling, results in the greatest pollutant releases and air quality impact. Subsequent long term production operations have substantially less impact.

Along the nearby public footpaths, where short term environmental standards might be expected to apply, it is considered that process pollutant contributions are insignificant and unlikely to compromise attainment of these standards.

At neighbouring locations of residential occupation, where long term human exposure might be expected, it is considered that pollutant process contributions from the site operations are insignificant. In all cases the predicted environmental concentration of all pollutants is less than, and in some cases substantially less than, a third of the applicable standard. Bearing in mind the precautionary assumptions made in the assessment, it is considered unlikely that pollutant process contributions from extension and production operations at the Wressle wellsite will pose any risk to, or have any meaningful influence on, the continued attainment of air quality standards at the nearest locations of human exposure.

At the nearest designated and local ecological sites requiring assessment, which are sensitive to nitrogen oxides, sulphur dioxide and nitrogen and acid deposition, process contributions are considered unlikely to pose any threat to, or have any substantial influence on, the attainment of critical levels and critical loads. Process contributions at most sites are insignificant, although at the Broughton Far Wood SSSI contributions to nitrogen oxides and nitrogen and acid deposition, exceed screening criteria in Year 1. It is considered that while the reported impact is likely to be a substantial over estimate of that in practice, an ecological opinion on significance is required. This is covered in the Preliminary Ecological Appraisal that accompanies the planning application.

At the Scunthorpe AQMA process contributions are insignificant and have no meaningful influence on air quality standard attainment within the area.

Necessary assumptions made to undertake the modelling are considered to have the effect of substantially overestimating the process contribution to ambient concentrations. It is considered that the predicted process impact reported herein is a conservative assessment and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

It is likely that the construction activities associated with the development of the wellsite will give rise to dust emissions. It is expected, based on Institute of Air Quality Management methodology, that with adequate mitigation measures in place the risk of dust impact from all proposed development operations will be 'negligible'.

Increases in road traffic brought about by the construction activities and subsequent site operation are assessed to have a neutral impact on air quality based on the guidance within Highways England's (now National Highways) Design Manual for Roads and Bridges.

Operations on site will give rise to releases of greenhouse gases. Based on an assessment of worst case operation it is considered that proposed development lifetime greenhouse gas releases are largely insignificant in relation to the UK's current inventory and future budgets at around 71000 tonnes CO_2 equivalent.

Based upon the outcome of this Air Quality Assessment for the extension of the Wressle wellsite, it is concluded that the proposed development, with appropriate mitigation, is considered to accord with policies DS1, DS11 and M23 of the North Lincolnshire Local Plan with regard to air quality.

1 INTRODUCTION

Egdon UK Limited (Egdon) placed a contract with SOCOTEC UK Limited (SOCOTEC) to undertake an assessment of the impact on local air quality of a proposed expansion in hydrocarbon production operations at their Wressle wellsite near Scunthorpe.

1.1 Scope of study

Egdon currently undertake hydrocarbon production operations at their Wressle wellsite near Scunthorpe. Production of oil is from one well, Wressle-1 (W1), which is stored on site and removed by road. Natural gas flows from the well and is currently disposed of using a combination of incineration, utilising a single flare, and combustion within three microturbines to generate electricity.

Egdon proposes an extension to the current operations involving the extension of the site, drilling of an additional two production wells, Wressle-2 and Wressle-3 (W2 and W3), and upgrading of the oil production facilities. Site electricity will be imported from the grid, while, subject to viability, produced natural gas will be exported to the grid. All three wells are expected to be in production, after which the site will be restored to a state compatible with the surrounding land. The expected project duration is around 15 years.

As part of the planning and permitting process, Egdon have asked that the dispersion of releases to atmosphere associated with the wellsite development be assessed to determine their impact on ambient concentrations of important pollutants around the local area.

The main sources of pollutant releases during site development will be from the use of diesel fuel in on-site stationary engines and construction and transport vehicles and from the short term combustion of produced natural gas by incineration and in a gas engine for electricity generation. During the subsequent long term production phase, releases are minimal. The only significant combustion on site will be from the use of diesel fuel in occasional maintenance plant, although there is the potential for relief natural gas incineration, but only for a short period of less than one hour.

Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, sulphur dioxide and particulate matter were considered. The assessment was undertaken using the UK ADMS 6.0 modelling system with operating scenarios considered to provide worst case conditions for pollutant releases and air quality impact across the proposed development.

The purpose of this study is to determine whether, under what is considered a worst case operating regime, releases to atmosphere are likely to be dispersed adequately in the context of applicable environmental standard attainment.

1.2 General approach

The approach taken comprised the following main stages:

- Determine a suitable modelling tool for the assessment.
- Collect appropriate representative operational data for the plant and vehicles intended for use for input to the model.
- Establish the proposed timeline for operations and their duration and frequency to determine the amount of discharges from each source and the likely timeline for discharge.
- Establish the location of the points of discharge for each source relative to proposed temporary and permanent buildings and structures on the wellsite.
- Establish the locations of any sensitive areas that might be impacted by releases from the wellsite including residential properties, public footpaths and designated and local ecological sites.
- Obtain information on local background concentrations of important pollutants.
- Obtain 5 years' recent meteorological data from a measurement station representative of the wellsite location.

- Model the dispersion of releases from the site operations to determine the process contribution to ambient concentrations of selected pollutants over the local area with particular attention to locations of human exposure and designated and local ecological sites.
- Assess the predicted process contributions and established background concentrations with reference to applicable environmental standards to determine compliance.
- Undertake a sensitivity analysis on the results for other important variable parameters and assess compliance with applicable environmental standards.

Further details of the approach taken and model input information are provided in the following sections.

1.3 Pre-Application Advice

Egdon submitted a request for pre-application advice to North Lincolnshire Council (NLC) in April 2023. Written advice was issued on 19th July 2023. The advice confirmed that the relevant development plan policies in respect of air quality are as follows:

North Lincolnshire Local Plan (2003)

Policy DS1 – General Requirements
Policy DS11 – Polluting Activities
Policy M23 – Oil and Gas Production

The Council's Environmental Protection officer recommended that an air quality assessment should be submitted as part of any forthcoming planning application.

1.4 Structure of the report

This report provides an assessment of the impact of releases from an extension to current hydrocarbon production operations and future enhanced production operations on local air quality near the Wressle wellsite. The approach to the assessment has been described above. The following sections provide a detailed commentary on the assessment and conclusions:

Section 2 Policy context and assessment criteria
Section 3 Modelling methodology
Section 4 Modelling results
Section 5 Conclusions

2 POLICY CONTEXT AND ASSESSMENT CRITERIA

Egdon currently undertake hydrocarbon production operations at their Wressle wellsite near Scunthorpe. Production of oil is from one well (W1), which is stored on site and removed by road. Natural gas flows from the well and is currently disposed of using a combination of incineration, utilising a single flare, and combustion within three microturbines to generate electricity.

Egdon proposes an extension to the current operations involving the extension of the site, drilling of an additional two production wells (W2 and W3) and upgrading of the oil processing facilities. Site electricity will be imported from the grid, while, subject to viability, produced natural gas will be exported to the grid. All three wells are expected to be in production, after which the site will be restored to a state compatible with the surrounding land. The expected project duration is around 15 years.

The wellsite is located within open countryside around 2 km to the north east of Broughton and around 6 km to the east of Scunthorpe. The immediate surrounding land is currently in agricultural use. To the east are large wooded areas, including Rowland Plantation and Far Wood, which both have ecological designations. The nearest residential property is South Cottage which lies around 500m to the west of the wellsite.

2.1 Context of assessment

As part of the planning and permitting application, it is necessary to demonstrate the likely impact of the proposed development and future enhanced production operations at the wellsite on local ambient concentrations of important pollutants. It is in this context that the operations are being examined to determine their additional contribution to the existing concentrations of pollutants and therefore determine compliance with applicable air quality standards and environmental benchmarks.

Local Authorities are required to assess compliance with applicable air quality objectives. Where the objectives are unlikely to be met, the Local Authority is required to declare an Air Quality Management Area (AQMA) and prepare proposals for remedial action to achieve the required objective. The nearest AQMA is the Scunthorpe AQMA, designated for 24 hour mean PM_{10}, which is around 2 km to the east of the wellsite beyond the B1207. Hull No.1, the nearest AQMA designated for annual mean nitrogen, is around 22km to the north east and unlikely to be influenced by releases from the Wressle wellsite.

A survey of planning and permitting applications did not indicated any recently approved, or proposed future developments, with the potential to influence background concentrations of pollutants of interest in the area near the wellsite.

The Environment Agency play an important role in relation to local air quality management by ensuring that processes under their regulatory control do not contribute any significant threat to the attainment of air quality standards. As part of the planning and permitting process it is necessary to demonstrate the impact of site operations on local air quality in the context of the published guidance provided by the Environment Agency[1].

2.2 Local Plan Policies

The following policies are most relevant to the preparation of an Air Quality Assessment in North Lincolnshire. These have been taken into account in preparing this Assessment.

North Lincolnshire Local Plan (2003)

DS1 – General Requirements

Amenity

iii) No unacceptable loss of amenity to neighbouring land uses should result in terms of noise, smell, fumes, dust or other nuisance …;

v) No pollution of water, air or land should result which poses a danger or creates detrimental environmental conditions.

DS11 – Polluting Activities

Planning permission for development … will only be permitted where it can be demonstrated that the levels of potentially polluting emissions, including effluent, leachates, smoke, fumes, gases, dust, steam, smell or noise do not pose a danger by way of toxic release.

M23 – Oil and Gas Production

Proposals for oil and gas production facilities will be permitted, provided that the proposal incorporates environmental protection measures that are adequate to mitigate the impacts arising from a long term or permanent site.

Proposed Submission North Lincolnshire Local Plan

This draft plan was submitted to the Secretary of State for Examination in November 2022. Proposed Main Modifications were published in October 2023. These policies carry some weight at this stage of the new local plan.

MIN6: Mineral Sites

1. Provision to meet the mineral requirements in North Lincolnshire to 2038 will come from sites with planning permission and the following allocations:

    Sites with Planning Permission/Operational Sites

    MIN6 – 14a: Wressle (Oil and Gas)

    4. Where proposals come forward for mineral extraction on the above sites, applications should be supported by a range of assessments that address potential environmental impacts including air quality… dust … All new developments for mineral extraction will be required to demonstrate how any environmental impacts have been mitigated and deliver environmental benefits such as measurable biodiversity net gain.

DM1: General Requirements

Amenity

> 5. Planning permission for development will only be permitted where it can be demonstrated that the levels of potentially polluting emissions, including effluent, leachates, smoke, fumes, gases, dust, steam, smell or noise do not pose a danger by way of toxic release … or create adverse environmental conditions likely to affect nearby developments and adjacent areas.

DM3: Environmental Protection

1. Development proposals as appropriate to their nature and scale should demonstrate that environmental impacts on receptors have been evaluated and appropriate measures have been taken to minimise the risks of adverse impacts to air quality …

Air Quality

2. The Council will seek to ensure that proposals for new development will not have an unacceptable negative impact on air quality and will not further exacerbate air quality in the Scunthorpe Town AQMA or contribute to air pollution in areas which may result in a new AQMA. Applicants will be required to provide an air quality impact assessment to demonstrate this.

8. Where proposals have the potential to release significant odours or where a sensitive use is being proposed near to an existing odorous process, applicants will be required to provide an odour impact assessment which demonstrates that impacts upon amenity can be avoided or properly mitigated and managed by remedial measures or improvements as part of the design of the proposed development. In these cases, planning permission will only be granted where a suitable mitigation scheme of remedial measures or improvements has been agreed that will be obtained via a planning condition and/or legal agreement to overcome any adverse impact upon amenity. Proposals for development adjacent to, or in the vicinity of, existing uses will need to demonstrate that both the ongoing use of the site is not compromised, and that the amenity of occupiers of the new development will be satisfactory with the ongoing use of the existing site.

2.3 Pollutants from wellsite operations

The principal source of pollutant releases to atmosphere will be the operation of stationary and mobile plant and vehicles:

- Stationary diesel engines and generators providing power for site drilling operations
- Non-road mobile plant brought to site for construction and site restoration operations
- The movement of heavy duty vehicles (HDV) for transport operations throughout the proposed development.

All plant will be diesel fuelled and as such pollutant releases will be characteristic of the combustion of diesel fuel.
The main pollutants from the combustion of diesel fuel are oxides of nitrogen, carbon monoxide and fine particulate matter.

In addition to the combustion of diesel fuel, the natural gas produced during current production operations and the proposed well clean up and testing, will be disposed of by incineration, with some combustion within a gas engine for electricity generation. During long term production, volumes permitting, produced natural gas is intended to be exported to the grid. Combustion of natural gas will give rise to the same pollutants as combustion of diesel fuel, although it is not expected that there will be any significant releases of particulate matter.

Oxides of nitrogen are generally considered to comprise primarily of nitrogen monoxide and nitrogen dioxide. While nitrogen oxides from road transport is a major contributor to ground level concentrations, emissions from combustion processes are also significant. Oxides of nitrogen are associated with lung damage and enhanced sensitivity to allergens. Emissions from combustion primarily consist of nitrogen monoxide, although reaction in the atmosphere results in conversion to nitrogen dioxide, which is the primary nitrogen oxide of interest with respect to ambient pollution. The emission of nitrogen oxides and their transformation products can cause a wide range of environmental effects including acidification and eutrophication

Combustion of diesel fuel will generally release some form of particulate matter. Particle size will determine the potential impact. Generally, the finer the particulate, the further it can travel into the human respiratory system. Particle size is defined by effective aerodynamic diameter. Material termed PM_{10} (i.e. all particles with an effective aerodynamic diameter up to 10µm) is seen as significant in this regard. Lower particle sizes (e.g. $PM_{2.5}$) are also considered in some air quality legislation and are the subject of monitoring.

Carbon monoxide is a product of incomplete combustion of the fuel and is therefore related to combustion efficiency. It reacts with other pollutants to form ground level ozone and has implications for neurological health. With incomplete combustion there is also the risk of elevated levels of volatile organic compounds which can give rise to odours and influence ground level ozone formation.

There will also be a release of sulphur dioxide which will be dependent on the sulphur content of the diesel fuel and the produced natural gas.

Based on information provided by Egdon[2], it is considered that fugitive releases of natural gas and organic compounds, from extraction operations and the storage and transfer of produced oil, will be insignificant and as such are not considered in this assessment

This assessment considers the air quality impact of the following substances resulting from the existing and proposed future wellsite operations:

Nitrogen oxides (NO_x, consisting of nitrogen monoxide (NO) and nitrogen dioxide (NO_2))
Sulphur dioxide (SO_2)
Carbon monoxide (CO)
Particulate matter (considered as both $PM_{2.5}$ and PM_{10})
Volatile organic compounds (VOCs – assessed as benzene)

2.4 Environmental Standards

An Air Quality Dispersion Modelling Assessment accompanied the planning application in 2018 for long term oil production at the Wressle wellsite. The Assessment predicted both short-term and long-term impacts on pollutant concentrations at nearby residential properties and ecological receptors. It concluded that the proposed gas engine and flare will not have a significant impact or effect on local air quality. Both the Council's Environmental Health officer and the Environment Agency raised no objection to the proposed development with regard to its impact on air quality.

The predominant source of pollutant releases during site operations will be from the use of diesel fuel in mobile plant and stationary engines and from the incineration and combustion of produced natural gas. This is largely undertaken in the first two years of the Project. Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, particulate matter and sulphur dioxide were therefore considered. The assessment was undertaken using the UK ADMS 6.0 modelling system, with an operating regime considered to provide unlikely worst-case conditions for pollutant releases and air quality impact.

NLC's EH department confirmed its agreement with the conclusions of the report. They agreed that the AQ impacts associated with the construction phase can be adequately controlled via mitigation measures by applying a suitable condition. The Environment Agency raised no objection to the proposed development in respect of air quality. Natural England confirmed that, on the basis that input into the gas engine and flare would be below 20MW, there would be no significant impact on Broughton Far Wood SSSI. And raised no objection. The Council's EH department considered that the risks of an adverse impact upon air quality, either in respect of local residents or sensitive habitats, is very low and that there would be appropriate measures to ensure the protection of air quality. The proposal was judged to accord with policies DS1, DS11 and M23 of the North Lincolnshire Local Plan 2003.

The UK's air quality strategy is based on the European Union (EU) Ambient Air Quality Directive (2008/50/EC, 21 May 2008)[3] and the Fourth Daughter Directive (2004/107/EC, relating to metals and hydrocarbons[4]. These directives specify limit values and target values. Limit values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedances allowed per year, if any, and a date by which it must be achieved. Some pollutants have more than one limit value covering different endpoints or averaging times. Target values are set out in the same way as limit values and are to be attained where possible by taking all necessary measures not entailing disproportionate costs.

The Air Quality (Standards) Regulations 2010[5] transpose into English law the requirements of Directives 2008/50/EC and 2004/107/EC on ambient air quality. Equivalent regulations have been made by the devolved administrations in Scotland, Wales and Northern Ireland. Schedules 2 and 3 of the Regulations specify limit and target values respectively.

Table 2.1 summarises the applicable limit values for the substances considered in this assessment as at 2024.

The limit values below are expressed as concentrations recorded over a specified time period which are considered acceptable in terms of current knowledge of the impact on health and the environment. Limit values are legally binding time averaged limits which must not be exceeded. In the case of target values these are values which are expected to be met by a specified date.

Table 2.1 Air Quality Standard Limit Values and Target Values

Substance	Basis	Concentration
Carbon monoxide	running 8 hour mean across a 24 hour period[c]	10 mg/m^3
Nitrogen dioxide	1 hour mean (99.79 percentile – 18 exceedances per year)	200 µg/m^3
	annual mean	40 µg/m^3
Sulphur dioxide	*15 minute mean (99.90 percentile – 35 exceedances per year*[a]	*266 µg/m^3*
	1 hour mean (99.72 percentile – 24 exceedances per year)	350 µg/m^3
	24 hour mean (99.18 percentile – 3 exceedances per year)	125 µg/m^3
PM_{10}	24 hour mean (90.41 percentile – 35 exceedances per year)	50 µg/m^3
	annual mean	40 µg/m^3
$PM_{2.5}$	annual mean	20 µg/m^3
Benzene	annual mean	5 µg/m^3

a. Target value included in Environment Agency guidance[1].
b. Annual means refer to a calendar year.
c. Running 8 hour mean for each daily period commences at 1700 on the previous day and is updated every hour for the following 24 hours.

Critical levels are specified for sulphur dioxide and nitrogen oxides in relation to the protection of ecological conservation areas as shown in Table 2.2.

Table 2.2 Critical levels for the protection of ecological conservation areas

Substance	Basis	Concentration
Nitrogen oxides (as NO_2)	annual mean	30 µg/m^3
	daily mean[b]	200 µg/m^3
Sulphur dioxide	annual mean[a]	10 µg/m^3

a. refers to the lower limit for sensitive lichen communities & bryophytes and ecosystems where lichens & bryophytes are an important part of the ecosystem's integrity. The upper limit where lichens are not present is 20 µg/m^3.
b. The daily critical level for nitrogen oxides is 75 µg/m^3, although this may be increased[1] to 200 µg/m^3 in the case of detailed assessments where the ozone concentration is below the AOT40 critical level (6000 µg/m^3) and the sulphur dioxide concentration is below the lower critical level of 10 µg/m^3. In this case the AOT 40 for ozone is 2674 µg/m^3 (see Annex C) and the sulphur dioxide concentration is less than 10 µg/m^3 (see Table F.2) across all sites considered. As such a daily critical level of 200 µg/m^3 is adopted.

In addition, for the purposes of assessing the significance of pollutants in the ambient atmosphere, the Environment Agency also publish Environmental Assessment Levels (EALs) for the protection of human health[1].

The EALs relevant to this study are summarised in Table 2.3.

Table 2.3 Environmental Assessment Levels

Substance	Basis	Concentration
Carbon monoxide	hourly mean	30000 µg/m^3
Benzene	24 hour mean	30 µg/m^3
Nitrogen monoxide	hourly mean	4400 µg/m^3
	annual mean	310 µg/m^3

2.4.1 Application of environmental standards

The Air Quality Standards Regulations 2010[5] specify legally binding concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The Regulations define ambient air as;

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

Compliance with limit values for the protection of human health does not need to be assessed (Schedule 1, Part 1) 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;
c) on the carriageway of roads and on the central reservation of roads except where there is normally pedestrian access to the central reservation.

It is therefore considered that compliance with environmental benchmarks should concentrate on areas where members of the general public are present over the entire duration of the concentration averaging period specific to the relevant standard. For the longer averaging periods the standards are considered to apply around the frontage of premises such as residential properties, schools and hospitals. The shorter term limit values (1 hour or 1 day means) apply at these locations and other areas where exposure is likely to be of one hour or more on a regular basis.

In this context this assessment of compliance with environmental benchmarks, in respect of protection of human health is considered at the residential locations near the Wressle wellsite and on nearby public footpaths. The assessment of compliance with critical loads and critical levels with respect to ecological impact is assessed at the designated and local ecological sites required for assessment within Environment Agency guidance[1] (see section 2.5.3).

2.5 Background air quality in Scunthorpe

In considering the overall impact of a proposed development, such as this herein, on local air quality and compliance with environmental benchmarks, it is necessary not only to consider the contribution from the proposed source but also the existing levels of pollutants of interest. Background air quality data for the area around the wellsite are available from Department for Environment Food and Rural Affairs (DEFRA) air quality archive[6]. The archive provides modelled background concentrations of important pollutants for 1km^2 areas for the UK. The latest available background levels for the area within an approximate 2 km radius of the Wressle wellsite (496790 411120) were used for this assessment. Within this area there were 22 points at which background concentrations were available. Table 2.4 summarises the background pollutant concentrations obtained from the air quality archive for the assessment area. The values reported are the mean and maximum of the 22 points for which data were available.

Table 2.4 Modelled background pollutant concentrations from the DEFRA archive

Substance	Averaging basis	Concentration (µg/m^3)	
		Maximum	Mean
Nitrogen dioxide (2022)	annual mean	8.08	7.34
Total nitrogen oxides (2022)	annual mean (as NO_2)	10.73	9.68
Nitrogen monoxide (2022)[a]	annual mean	1.73	1.53
PM_{10} (2022)	annual mean	13.02	11.50
$PM_{2.5}$ (2022)	annual mean	5.82	5.34
Carbon monoxide (2010)	maximum 8 hour rolling mean	1530	1510
Sulphur dioxide (2022)	annual mean	1.71	1.51
Benzene (2022)	annual mean	0.35	0.33

a. calculated based on the difference between total nitrogen oxides and nitrogen dioxide assuming total nitrogen oxides is the sum of nitrogen monoxide and nitrogen dioxide.

North Lincolnshire Council[7] undertakes automatic air quality monitoring at seven locations, although these are over 3 km from the wellsite, the nearest being 3.9 km to the west at Low Santon. Non-automatic monitoring is also undertaken by the Council at 22 sites in and around the outskirts of Scunthorpe. The nearest monitoring station to the wellsite is around 4.8 km south east at Barnard Avenue, Brigg. There are no monitoring stations within the area considered to be influenced by releases from current and proposed future operations at the Wressle wellsite.

It is understood that periodic measurements of background concentrations around the wellsite boundary were undertaken in 2014 and 2015. In view of the distance to the nearest sensitive receptor (South Cottage, 500m to the west) and the potential for boundary background concentrations to be heavily influenced by any site operation, it is considered that the measured backgrounds are unlikely to be representative of those experienced around the footpaths and residential locations neighbouring the Wressle wellsite.

For the purposes of this assessment background concentrations are assumed to be the maximum values from the DEFRA archive across the assessment area. This is considered a precautionary approach which will most likely overestimate the existing background concentrations in the important areas of human exposure.

When considering the combination of estimated process contributions and background concentrations it should be noted that background concentrations are generally available as annual mean values and as such simple addition when considering short term air quality standards may not be appropriate. Guidance from the Environment Agency[1] suggests a simplified method for combining estimated process contributions and background concentrations. For comparison with long term standards the overall concentration is the sum of the process contribution (annual mean) and background concentration (annual mean). For comparison with short term standards the Environment Agency suggest the sum of the process contribution (hourly or daily mean) and twice the background concentration (annual mean). This methodology has been employed in this assessment.

Table 2.5 summarises the pollutant background concentrations adopted for this assessment.

Table 2.5 Background concentrations adopted in the assessment

Substance	Averaging basis	Background concentration	
		µg/m³	% of standard
Air Quality Standard Limit Values and Target Values			
Carbon monoxide	8 hour mean	1530	15.3
Nitrogen dioxide	1 hour mean	16.16[a]	8.1
	annual mean	8.08	20.2
Sulphur dioxide	15 minute mean	4.58[b]	1.7
	1 hour mean	3.42[a]	1.0
	24 hour mean	2.01[c]	1.6
PM_{10}	24 hour mean	15.36[d]	30.7
	annual mean	13.02	32.6
$PM_{2.5}$	annual mean	5.82	29.1
Benzene[e]	annual mean	0.35	7.0
Environmental assessment levels			
Carbon monoxide	hourly mean	2188[f]	7.3
Benzene[e]	24 hour mean	0.21[d]	0.7
Nitrogen monoxide	hourly mean	3.46[a]	<0.1
	annual mean	1.73	0.6

a. One hour mean is determined from annual mean value using a conversion factor of 2.0[1].
b. 15 minute mean is determined from the hourly mean using a conversion factor of 1.34[1].
c. 24 hour mean is determined from the hourly mean using a conversion factor of 0.59[1].
d. 24 hour mean is determined from annual mean value using a conversion factor of 1.18 (a and c above).
e. Volatile organic compounds are assessed against the limit value for benzene in accordance with Environment Agency guidance[1] for situations where the composition of the organic compound release is unknown.
f. One hour mean is determined from 8 hour mean using a conversion factor of 1.43[1].

Background levels specific to the designated and local ecological sites considered are obtained from the Air Pollution Information System (APIS)[8] and are discussed later.

2.6 Assessment criteria

The Environment Agency[1] provides a methodology for assessing the impact and determining the acceptability of emissions to atmosphere on ambient air quality for human health and ecology and for deposition to ground. Two stages of assessment are recommended.

Screening assessment – based on standard dispersion factors the ambient impact of releases to atmosphere may be estimated. The estimates tend to be very conservative since no account is taken of plume rise, meteorological conditions or the locations of the sensitive receptors where impact is to be assessed. The estimates are compared with the assessment criteria discussed in sections 2.5.1 to 2.5.3. Where a release can be demonstrated to be 'insignificant' it may be screened out. Where this is not possible a further detailed assessment is required.

Detailed assessment – based on atmospheric dispersion modelling taking into account the factors which influence dispersion and ambient impact (e.g. meteorology, release conditions, locations of sensitive receptors, etc.). Process contributions and predicted environmental concentrations are compared with the same assessment criteria. Where conditions for excluding the release from further consideration cannot be made, a detailed cost benefit assessment will be necessary.

In this assessment all releases have been assessed using detailed modelling approach only.

The criteria considered in this assessment are described below.

2.6.1 Criteria relevant to human health

The contribution of the process (PC) to the ambient concentration of a given pollutant is considered insignificant and requiring no further assessment, if both of the following conditions are met:

- the long term PC is less than 1% of the long term environmental standard
- the short term PC is less than 10% of the short term environmental standard

If these conditions are not met then the corresponding predicted environmental concentration (PEC, PC + background concentration) should be assessed. The process contribution is considered insignificant and requiring no further assessment, if both of the following conditions are met:

- the short term PC is less than 20% of the short term standard minus twice the long term background concentration
- the long term PEC is less than 70% of the long-term environmental standard

If these conditions are not met then the compliance of the process with Best Available Technique (BAT) will need to be assessed. No further action is necessary if it can be demonstrated that both of the following apply:

- proposed emissions comply with BAT associated emission levels (AELs) or the equivalent requirements where there is no BAT AEL
- the resulting PECs won’t exceed environmental standards

Failure to meet these criteria requires that a cost-benefit analysis be undertaken for consideration by the Environment Agency.

2.6.2 Criteria for deposition to ground

Where any of the substances in Table 2.6 are released it is required that the impact they have when absorbed by soil and leaves (termed ‘deposition’) is assessed.

If the PC to ground for any of these substances is below 1% of the limit it is insignificant and requires no further assessment. Where the PC to ground is 1% of the limit or greater a further assessment will be necessary.

In this case none of the substances in Table 2.6 are considered to be released in a quantity sufficient to merit an assessment for deposition to ground.

Table 2.6 Limits for deposition to ground

Substance	Deposition limit (PC to ground) µg/m^2/day
Arsenic	0.02
Cadmium	0.009
Chromium	1.5
Copper	0.25
Fluoride	2.1
Lead	1.1
Mercury	0.004
Molybdenum	0.016
Nickel	0.11
Selenium	0.012
Zinc	0.48

2.6.3 Criteria relevant to protected conservation areas

Where there are protected conservation areas near the release it is necessary to consider the impact of following pollutants:

- nitrogen oxides (long and short term bases)
- sulphur dioxide (long term basis)
- ammonia (long term basis)
- hydrogen fluoride (long and short term bases)
- nutrient nitrogen and acid deposition

In this case releases of nitrogen oxides and sulphur dioxide are considered, together with their impact in relation to the deposition of nutrient nitrogen and acid.

An assessment is required where the release is within 10 km (15 km if the site is a large electric power station or refinery) of any of the following designated sites:

- special protection area (SPA)
- special area of conservation (SAC)
- Ramsar site (protected wetland of international importance)

or within 2 km of a:

- site of special scientific interest (SSSI)
- local nature site (ancient wood, local wildlife site (LWS) and national or local nature reserve (NNR, LNR))

For some larger (greater than 50 MW) emitters there may be a requirement to extend the assessment to:

- 15km for European sites
- 10km or 15km for SSSIs

The impact of air emissions on protected conservation areas at a distance of 15km should be considered for both:

- natural gas (or fuels with a similarly low sulphur content) fired combustion plants, with more than 500 MW thermal input
- some larger combustion plants using more sulphurous fuels with more than 50 MW thermal input

If the PC at a SPA, SAC, Ramsar or SSSI meets both of the following criteria, it is insignificant and no further assessment is required:

- 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

If these criteria are not met then the corresponding PEC should be assessed. The emission is considered insignificant if:

- the long term PC is greater than 1% and the corresponding PEC is less than 70% of the long term environmental standard,

If either of the following criteria are met, a further more detailed consideration of ecological impact is required:

- the long term PC is greater than 1% and the long term PEC is greater than 70% of the long term environmental standard
- the short term PC is greater than 10% of the short term environmental standard

For local conservation areas releases are considered insignificant where both of the following criteria are met:

- the short term PC is less than 100% of the short term environmental standard
- the long term PC is less than 100% of the long term environmental standard

A failure to meet the above criteria requires a further more detailed consideration of ecological impact.

Environmental standards for conservation areas such as critical levels for ambient air and critical loads for nitrogen and acid deposition are considered specific to the habitat types associated with each conservation site. APIS provides acidity and nitrogen deposition critical loads for designated features within every SAC, SPA or A/SSSI in the UK.

2.6.4 Significance of impact

Environmental Protection UK (EP UK) and the Institute of Air Quality Management (IAQM) have published guidance on the impact of pollutant releases in the context of existing air quality assessment levels[9] (i.e. AAD limit and target values etc.). Their categorisation is shown in Table 2.7.

Table 2.7 Impact descriptor for individual receptors

Long term average concentration at receptor in assessment year	% change in concentration relative to Air Quality Assessment Level (AQAL)			
	1	2-5	6-10	>10
75% or less of AQAL	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Slight	Moderate	Moderate	Substantial
103-109% of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

In this case impact is considered as the change in the concentration of an air pollutant, as experienced by a receptor. This may have an effect on the health of a human receptor, depending on the severity of the impact and a range of other contributing factors. The descriptor in itself is not considered a measure of effect.

IAQM guidance indicates that for any point source some consideration must also be given to the impacts resulting from short term, peak concentrations of those pollutants that can affect health through inhalation. Background concentrations are considered less important in determining the severity of impact for short term concentrations. Short term concentrations in this context are those averaged over periods of an hour or less. These exposures would be regarded as acute and will occur when a plume from an elevated source affects airborne concentrations experienced by a receptor over an hour or less.

Where such peak short term concentrations from an elevated source are in the range 10-20% of the relevant AQA_L, then their magnitude can be described as small, those in the range 20-50% medium and those above 50% as large. These are the maximum concentrations experienced in any year and the severity of this impact can be described as slight, moderate and substantial respectively, without the need to reference background or baseline concentrations. Table 2.8 summarises these descriptors.

Table 2.8 Impact descriptors for short term process contributions

Short term process contribution (% AQA_L)	Magnitude	Severity
11-20	Small	Slight
21-50	Medium	Moderate
>51	Large	Substantial

Background concentrations are not unimportant, but they will, on an annual average basis, be a much smaller quantity than the peak concentration caused by a substantial plume and it is the contribution that is used as a measure of the impact, not the overall concentration at a receptor.

In most cases, the assessment of impact severity for a proposed development will be governed by the long term exposure experienced by receptors and it will not be a necessity to define the significance of effects by reference to short-term impacts. The severity of the impact will be substantial when there is a risk that the relevant AQAL for short-term concentrations is approached through the presence of the new source, taking into account the contribution of other prominent local sources.

3 MODELLING METHODOLOGY

The contributions to ambient concentrations of the selected pollutant releases from wellsite development and production operations have been modelled using the Atmospheric Dispersion Modelling System (ADMS) version 6.0. The use of this modelling tool is accepted by the Environment Agency and UK Local Authorities for regulatory purposes.

ADMS and the United States Environmental Protection Agency's (US EPA) AERMOD modelling systems are the two most widely used air dispersion models for regulatory purposes worldwide. Both are based on broadly similar principles. In this case ADMS 6.0 has been employed for the assessment, although the results have been compared with those obtained from the same modelling using the AERMOD system in order to provide confidence in the assessment findings.

ADMS 6.0 requires a range of information in order to perform the modelling. The primary information required is discussed below and is summarised in Annex B.

All modelling files containing relevant input information (see Annex B) are provided to the Regulatory Authorities, on request, to assist in any required confirmatory assessment of the modelling undertaken herein.

3.1 Assessment area

The area over which the assessment was undertaken is a 3km x 3km area with the Wressle wellsite (496790 411120) located around the centre. Figure 3.1 illustrates the assessment area, location of the site, the surrounding area and nearest residential locations and public footpaths.

Figure 3.2 illustrates the general arrangement of the wellsite and the immediate surrounding area.

A general grid with receptors spaced at 30 m intervals (i.e. 10201 points for a 101 x 101 grid) was used to assess the process contribution to ground level concentrations over the assessment area illustrated in Figure 3.1. The grid was considered at an elevation of 1.5 m. This is intended to represent the typical height of human exposure.

In addition to the receptor grid, 15 receptors (1 to 15 in Figure 3.1) were positioned at residential locations near the wellsite. These receptors were placed at an elevation of 1.5 m, as described in Table E.1, and are intended to correspond to locations of long term human exposure near the wellsite.

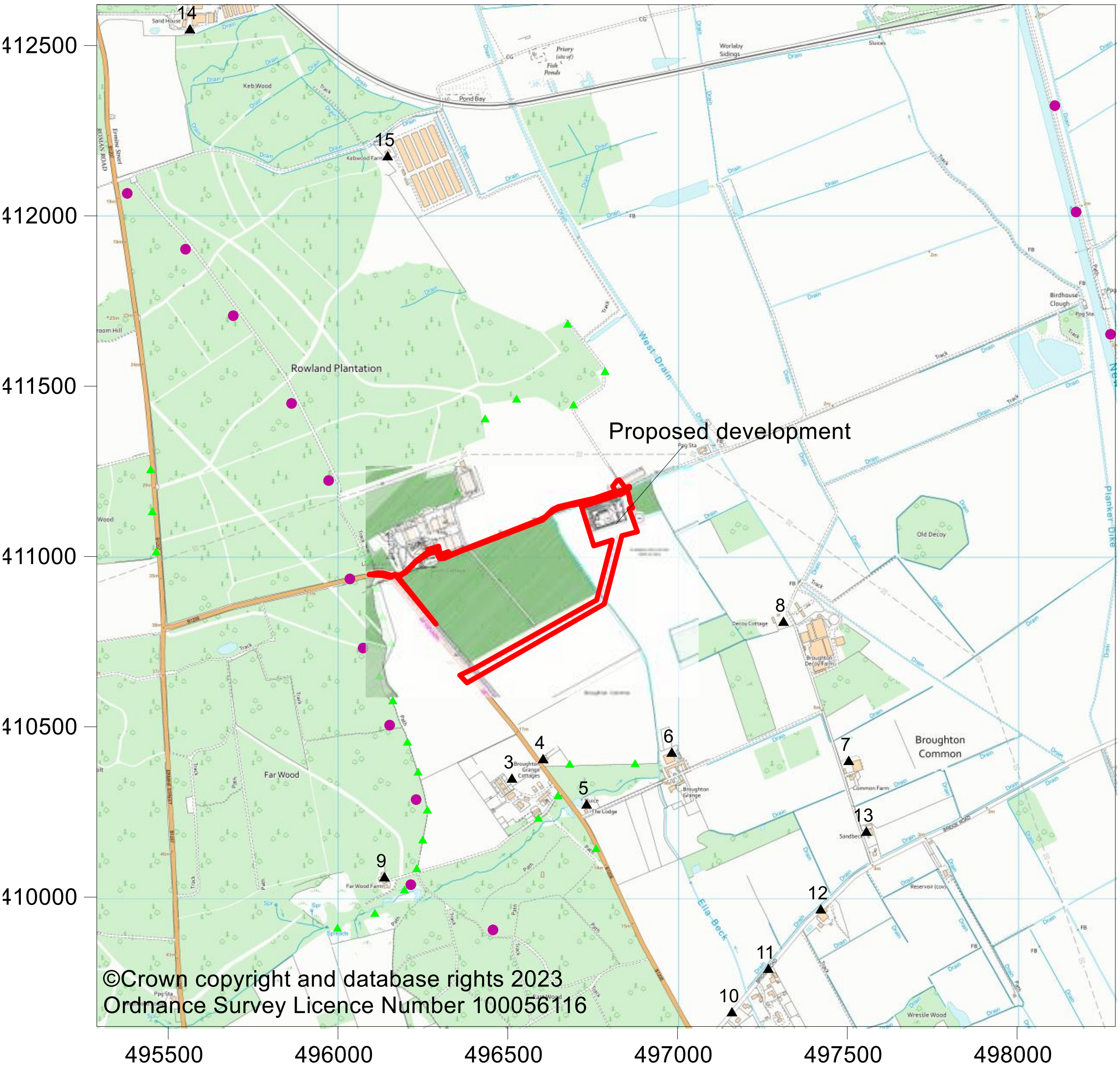
It is also expected that there will be frequent, although of short duration, human exposure along the nearby public footpaths. 14 receptors (16 to 29, purple dots in Figure 3.1) were located along the footpaths closest to the wellsite boundary, in order to assess the likely impact of wellsite releases on air quality along the length of each route. These receptors are described in Table E.1.

In order to determine the likely impact of releases from the wellsite at the nearest AQMA, 4 receptors (30-33) were arranged along the area boundary closest to the wellsite. These receptors are described in Table E.1

20 receptors (78 to 97) were located around the wellsite boundary to give an indication of the maximum off site process contributions. These receptors are also described in Table E.1.

There are a number of tracks in the area which are generally used for farm access and which are not considered to be locations of frequent human exposure where air quality standards for human health would be expected to apply, (as defined in section 2.4.1). These locations are not considered in this assessment.

Figure 3.1 Location of the Wressle wellsite and assessment area

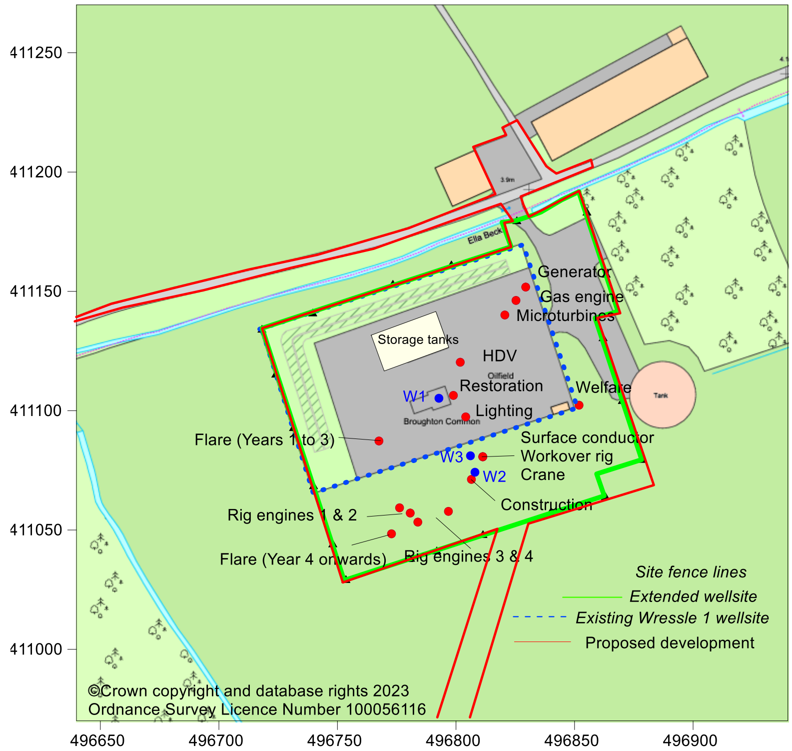


For the purposes of the assessment, the receptors were considered in groups as described below:

1 to 15 Residential locations (see Table E.1 and Figure 3.1)
16 to 29 Footpaths (see Table E.1 and Figure 3.1)
30 to 33 Scunthorpe AQMA (see Table E.1)
34 to 77 Designated and local ecological sites (see Tables 3.1 and E.1)
78 to 97 Site boundary (see Table E.1 and Figure 3.1)

Annex E describes the location of these discrete receptors.

Figure 3.2 Layout of the Wressle wellsite during development and future production



It is also necessary to consider the impact of releases on any local statutory designated sites. Following a review of all sites in the local area, sixteen designated and local ecological sites, met the criteria for assessment (see 2.5.3). Some local sites close to the wellsite were represented by multiple discrete receptors placed along the boundary of the site nearest to the wellsite. Sites further from the wellsite were represented by a single receptor. Some sites overlapped and are represented by the same receptors. The location of these receptors are described in Table 3.1.

Table 3.1 Location of receptors at the designated and local ecological sites

Receptor		Position[a]	Easting (m)	Northing (m)
34-39	Rowland Plantation LWS	340 m N	496694	411446
41-50	Broughton Far Wood SSSI	710 m W	496113	410908
41-50	Far Wood AW	710 m W	496113	410908

51-53	Broughton Alder Wood LWS, SSSI	1.2 km SW	496196	410022
53	Far Wood Farm Meadow LWS	1.4km SW	495999	409910
54-56	Spring Wood AW	1.3 km W	495465	411015
57-61	Broughton East Wood LWS	732 m S	496875	410393
40	Clapgate Pits LWS	710 m W	496092	410994
62	Humber Estuary SPA, SAC, RAMSAR, SSSI	10.0 km N	496721	421220
63-71	Keb Wood LWS	875 m NW	496304	411848
72	New River Ancholme LWS	1.4 km E	498144	411487
73	Weir Dyke LWS	1.6 km NE	498097	412049
74	Broughton West Wood LWS	1.8 km SW	495504	409871
75	Heron Holt LWS	1.4 km W	495476	410746
76	Broughton Pocket Wood LWS	1.9 km S	496604	409206
77	Haverholme Common SNCI	2.0 km NW	495061	412115

a. Location of the edge of the habitat closest to the centre of the Wressle wellsite. In the case of multiple receptors, the receptor closest to the wellsite is described. Details for all receptors are presented in Table E.1.

3.2 Buildings

The presence of buildings close to a discharge flue can have a significant impact on the dispersion of releases. The most significant impact can be the downwash of a plume around a building causing increased concentrations in the immediate area around the building. Buildings can also disturb the wind flow causing a turbulent wake downwind which can also affect dispersion. It is normally considered that buildings within 5 times the height of release or within 5 times the height of the building should be considered in any modelling.

The main structures present on the wellsite are the storage tanks with a similar height to that of the majority of release points (see Tables 3.2 and 3.4). While there are other structures on the site, only the storage tanks are present throughout the proposed development and considered likely to have an influence dispersion.

ADMS 6.0 models buildings as either rectangular or circular structures. In this case the individual tanks are modelled as a single rectangular block. Based on the drawings provided by Egdon[10], the main parameters describing the tanks were estimated as summarised in Table 3.2.

Table 3.2 Parameters describing the Storage Tanks

Structure	Structure centre grid reference		Height (m)	Angle (° from north)	Length (m)	Width (m)
	Easting	Northing				
Storage tanks	496781	411129	4	8	29	16

It is assumed, for the purposes of the assessment, that this is the only structure with the potential to influence dispersion of site releases. A sensitivity analysis was undertaken to determine whether the storage tanks have any significant impact on dispersion as summarised in Table 3.3.

Table 3.3 Sensitivity analysis - Buildings

Main structure (see Table 3.2 and Figure 3.2)	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 15) compared with base case of the storage tanks as the main structure			
	Long term average		Short term average	
	Maximum	Mean	Maximum	Mean
No structure	0.0	0.6	-0.1	0.9

The differences associated with the consideration of building effects are not significant in terms of the overall conclusions of this assessment which are based on maximum impact. It is apparent from the sensitivity analysis that no assessment of building effects provides marginally greater predicted process contributions than inclusion of the storage tanks in the modelling. As such, for the purposes of the assessment, there is no consideration of building effects in the modelling. This is considered a precautionary approach.

Egdon[10] provided details of the wellsite arrangement for each phase of the proposed development, and in particular the locations of the main items of plant proposed for use, as illustrated in Figure 3.2. Table 3.4 describes the release point locations for the discharges considered in this assessment.

Table 3.4 Location of release points

Plant		Easting (m)	Northing (m)	Height of release (m)[a]	Diameter (m)[a]
A	Construction plant	496807	411071	3.0	0.30
B	Lighting towers	496804	411097	3.0	0.15
C	Welfare unit	496852	411102	3.0	0.10
D	Surface conductor	496811	411081	4.0	0.20
E	Generator	496829	411152	4.0	0.30
F1	Rig engine 1	496776	411059	4.0	0.40
F2	Rig engine 2	496781	411057	4.0	0.40
F3	Rig engine 3	496784	411053	4.0	0.40
F4	Rig engine 4	496797	411058	4.0	0.40
G	Workover rig	496811	411081	4.0	0.30
H1	Flare (pre year 4)	496773	411048	9.9	2.91
H2	Flare (post year 4)	496768	411087	9.9	2.91
I	Microturbines 1 to 3	496821	411140	Not operational in proposed development	
J	Gas engine	496825	411146	4.0	0.50
K	Restoration plant	496799	411106	3.0	0.20
L	Crane	496811	411081	3.0	0.20
HDV		496802	411120	3.0	0.10

a. The release height and exhaust flue diameter is either assumed, based on experience, or taken from the equipment specification (see Table G.1). In the case of the lighting towers, HDVs and construction and restoration plant, where there are multiple smaller sources, the release is combined into an assumed single point which represents the average location of operation (see section 3.5).

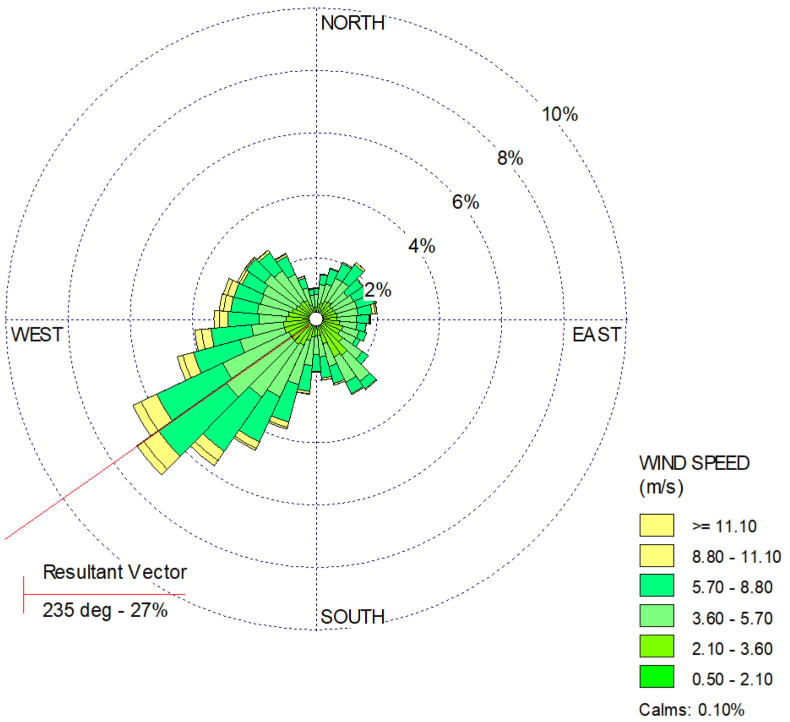
3.3 Meteorology

For this modelling assessment hourly sequential meteorological data from the nearest suitable meteorological station to the area was obtained. The data, provided by the UK Met Office, was from the Normanby Hall station, with supplementary cloud and wind data from the Scampton station, and covered the 5 year period 2018 to 2022. The Normanby Hall station is around 10km south east of the Wressle wellsite at an elevation of 47m, compared with the site elevation of around 7m. Four other measurement stations were also considered as possible sources of meteorological data:

Station	Position	Elevation	Data coverage
Leconfield	33km N	7m	Complete
Scampton	32km S	57m	Complete
Hull Park East	25km NE	2m	Complete (coastal)
Donna Nook No.2	48km SE	8m	Missing cloud and wind (coastal)

Based on advice provided by the Met Office, the proximity of the station, elevation and data coverage, it was considered that data from the Normanby Hall station, supplemented with cloud and wind data from the Scampton station, provided measurements most representative of the conditions at the Wressle wellsite.

Figure 3.3 Composite windrose for the Normanby Hall station (2018 to 2022)



The data included, among other parameters, hourly measurements of wind speed and direction. Figure 3.3 illustrates a composite wind rose for the Normanby station. It may be seen that the wind has significant a south westerly component. Annex D provides a more detailed analysis of the meteorological data used.

3.4 Surface characteristics

The characteristics of the surrounding surfaces and the land use within the assessment area have an important influence in determining turbulent fluxes and hence the stability of the boundary layer and atmospheric dispersion. In ADMS it is necessary to consider the following parameters which describe land use and surface properties:

Surface roughness
Surface albedo
Minimum Monin Obukhov length
Priestley Taylor parameter

3.4.1 Surface roughness

The roughness length represents the aerodynamic effects of surface friction and is physically 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 around 10% of the height of the main surface features. Surface roughness is higher in built up areas than in rural locations.

A range of typical roughness values for common land use types are provided within ADMS:

Land use	Surface roughness (m)
Ice	0.00001
Snow	0.00005
Sea	0.0001
Short grass	0.005
Open grassland	0.02
Root crops	0.1
Agricultural areas	0.2-0.3
Parkland, open suburbia	0.5
Cities, woodland	1.0
Large urban areas	1.5

The Wressle wellsite is located in a rural area on relatively flat agricultural land, with substantial areas of woodland nearby. The nearest residential location is around 500 m to the west. A surface roughness of 0.3m has been selected based on a sensitivity analysis, which considered variations in surface roughness between 0.1 and 1.5m. This resulted in variations in predicted hourly and annual process contributions of nitrogen dioxide over the residential receptors (1 to 15, see Figure 3.1) as summarised in Table 3.5.

Table 3.5 Sensitivity analysis – Surface roughness

Surface roughness (m)	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 15) compared with base case of a surface roughness of 0.5m			
	Long term average		Short term average	
	Maximum	Mean	Maximum	Mean
0.1	9.0	13.6	23.9	33.3
0.3	5.9	6.7	8.7	13.7
0.7	-4.8	-4.4	-8.5	-7.7
0.9	-9.3	-8.8	-15.1	-14.7
1	-11.4	-10.7	-18.6	-17.9
1.5	-20.1	-19.2	-31.3	-30.1

It is considered that a surface roughness of 0.3m is reasonably representative of the area of influence and tends towards a more conservative estimate of the range likely to be most descriptive of the general assessment area (i.e. relatively flat agricultural land in the general direction of the prevailing wind). This selection does not introduce uncertainties which are significant in the context of the conclusions reached in section 4.

3.4.2 Surface albedo

The surface albedo is the ratio of reflected to incident shortwave solar radiation at the surface of the earth and lies in the range 0 to 1. This parameter is dependent upon surface characteristics and varies throughout the year. Surface albedo is higher (higher proportion of reflected radiation) when the ground is snow covered. Based on the recommendations of Oke (1987), ADMS provides default values of 0.6 for snow-covered ground and 0.23 for non-snow covered ground, respectively. In this case a value for surface albedo of 0.23 has been employed.

3.4.3 Monin Obukhov length

The Monin Obukhov length provides a measure of the stability of the atmosphere and allows for the effect of heat production in cities which may not be represented by the meteorological data. In urban areas heat generated from buildings and traffic warms the air above which has the effect of preventing the atmosphere from becoming very stable. Generally the larger the area the greater the effect. In stable conditions the Monin Obukhov length will not fall below a minimum value with the value becoming larger depending on the size of the city. The minimum value of the Monin Obukhov length generally lies between 1 and 200 m, with 1m corresponding to a rural area. ADMS provides the following guidance on minimum Obukhov length:

Population size	Minimum Obukhov length (m)
Large conurbations (>1 million)	100
Cities and large towns	30
Mixed urban/industrial	30
Small towns	10
Rural area	1

In this case the area is considered typical of a rural area. A minimum Monin Obukhov length of 1.0m has been employed. A sensitivity analysis has been undertaken considering minimum Monin Obukhov lengths in the range 1 to 50m. This resulted in variations in predicted hourly and annual process contributions of nitrogen dioxide over the residential receptors (1 to 15, see Figure 3.1) as shown in Table 3.6.

Table 3.6 Sensitivity analysis – Minimum Monin Obukhov length

Minimum Monin Obukhov length (m)	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 15) compared with base case of a minimum Monin Obukhov length of 1m			
	Long term average		Short term average	
	Maximum	Mean	Maximum	Mean
5	-0.8	-1.1	0.0	-1.1
10	-1.2	-1.6	0.0	-1.4

20	-1.3	-1.6	1.3	-0.9
30	1.1	1.3	1.3	4.5
50	0.5	0.3	1.8	2.2

The variations are largely insignificant over the length range considered descriptive of the assessment area and not likely to influence the conclusions reached in section 4. The selected length tends towards a more conservative assessment than might be expected with the use of a greater length. AERMOD does require that the minimum Monin Obukhov length be specified.

3.4.4 Priestley Taylor parameter

The Priestley Taylor parameter represents the surface moisture available for evaporation. 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 Priestley Taylor parameter lies between 0 and 3. Based on suggestions by Holstag and van Ulden, ADMS provides default values of:

Land type	Priestley Taylor parameter
Dry bare earth	0
Dry grassland	0.45
Moist grassland	1

In this case the area is considered representative of moist grassland and a value of 1.0 for the Priestley Taylor parameter has been employed. A sensitivity analysis has been undertaken considering Priestley Taylor parameters in the range 0 to 1.5. This resulted in variations in predicted hourly and annual process contributions of nitrogen dioxide averaged over the residential receptors (1 to 15, see Figure 3.1) as summarised in Table 3.7.

Table 3.7 Sensitivity analysis – Priestley Taylor parameter

Priestley Taylor parameter	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 15) compared with base case of a Priestley Taylor parameter of 1			
	Long term average		Short term average	
	Maximum	Mean	Maximum	Mean
1.5	-0.5	4.0	1.3	8.6
0.5	-2.7	-3.7	0.0	-0.8
0	-5.6	-6.6	-2.2	-1.4

The variations are not significant over the range considered most likely to be descriptive of the area and not likely to influence the conclusions reached in section 4. It is considered that the use of the model default value (for moist grassland) is likely to be most representative of the area.

It may be noted that AERMOD uses the Bowen ratio to describe available surface moisture rather than the Priestley Taylor parameter. The following default values are provided from Paine (1987).

Land use	Bowen ratio (-variation with season)
Water	0.1
Deciduous forest	0.6-2.0
Coniferous forest	0.6-2.0
Swamp	0.2-2.0
Cultivated land	1.0-2.0
Grassland	1.0-2.0
Urban	2.0-4.0
Desert shrubland	5.0-10.0

For the modelling herein, a value of 1.0 was employed for the Bowen ratio.

3.4.5 Terrain

Terrain data was obtained for the assessment area from the Ordnance Survey Land-form Panorama DTM database. There are slight variations in elevation across the main assessment area with the ground rising to the south west at gradient of around 2 to 3% as shown in Figure 3.4. The terrain is largely flat to the east.

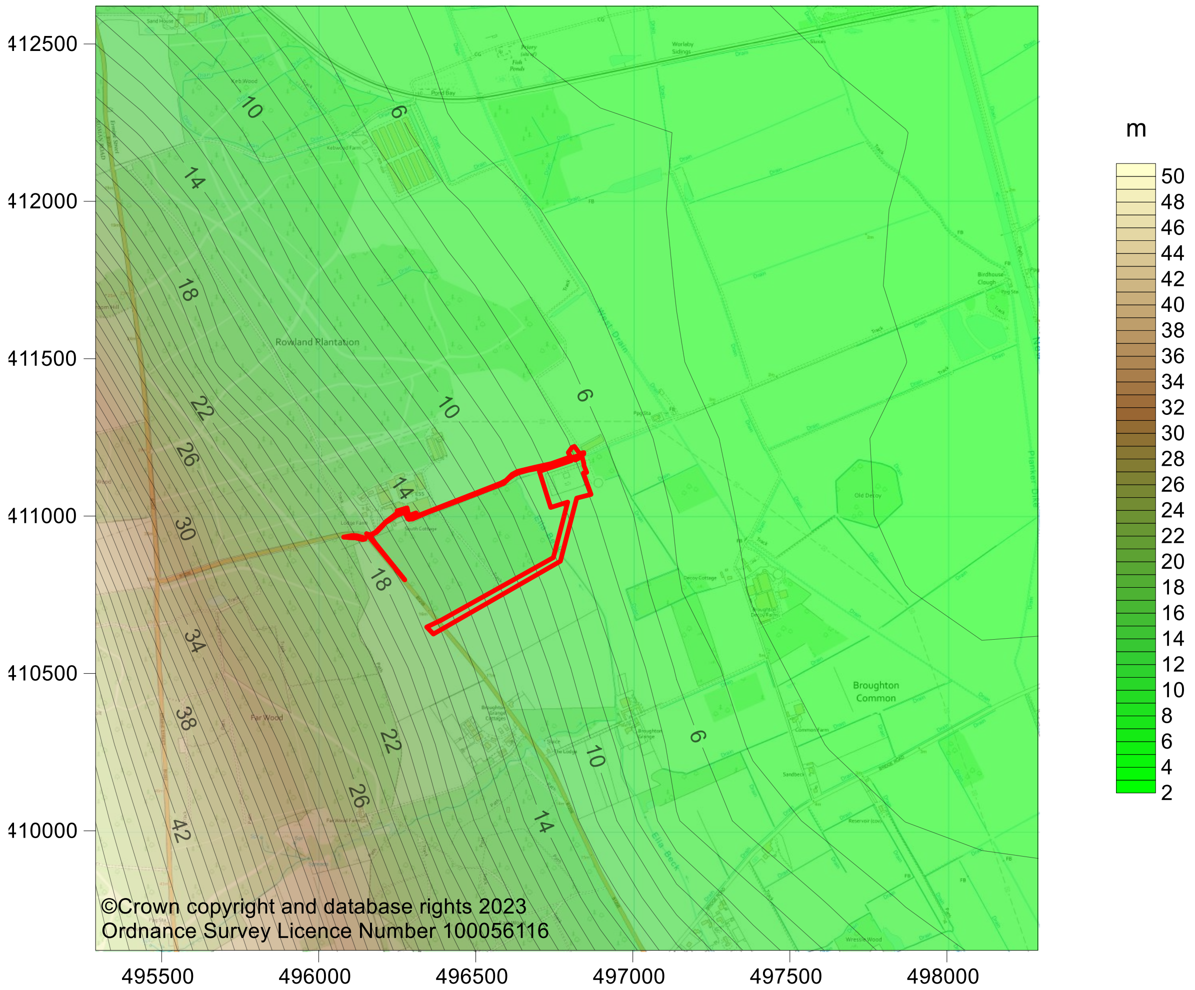
A sensitivity analysis was undertaken to determine the impact of consideration of terrain in the assessment, in contrast to the assumption of a flat assessment area. The sensitivity of the predicted annual and hourly process contributions of nitrogen dioxide across the residential receptors (1 to 15, see Figure 3.1) to consideration of terrain was examined as summarised in Table 3.8.

Table 3.8 Sensitivity analysis – Terrain

Terrain	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 15) compared with base case of an elevated assessment area			
	Long term average		Short term average	
	Maximum	Mean	Maximum	Mean
Flat	-0.5	-4.4	-5.1	-5.0

General guidance suggests that consideration of terrain is not necessary at gradients of less than 5%. In this case, the higher process contributions generally occur when an elevated assessment area is considered, although the differences are unlikely to influence the main conclusions of this assessment. For avoidance of doubt, the assessment is based on an elevated assessment area. This is considered a precautionary approach.

Figure 3.4 Ground elevation within assessment area



3.5 Pollutant releases and conditions

Five sources of pollutant releases are considered in this assessment:

Natural gas fired stationary engine generating electricity
Flare for the incineration of excess produced natural gas
Diesel fired stationary engines associated with temporary mobile plant.
Diesel fuelled construction vehicles used on site
Diesel fuelled HDV vehicle movements on site

Egdon[11] provided details of the incinerator, stationary engines, generators, construction vehicles and HDV movements intended over the various phases of the proposed development. A full listing of the equipment employed and references for the specifications used are provided in Annex G. These are summarised below.

It is noted that the site currently uses three natural gas-fired microturbines for electricity generation. While these are present on site, the proposed development programme does not envisage any operation and as such their releases are not considered further.

3.5.1 Stationary gas engine

A natural gas-fired Jenbacher J612 gas engine with a rated output of 2004kW$_e$[12] may be used for electricity generation. Based on this engine specification, the exhaust gas conditions in Table 3.9 were determined.

Table 3.10 summarises the corresponding pollutant release rates for full load engine operation. Releases of nitrogen oxides are based on compliance with the emission limit value specified for existing engines within the Medium Combustion Plant Directive[13]. The sulphur dioxide release is based on an UK industry standard maximum sulphur content of 50 mgS/m^3 gas and the assumption that all sulphur in the natural gas will be converted to sulphur dioxide upon combustion. Releases of non-methane volatile organic compounds and carbon monoxide are consistent with the average emission factors for natural gas combustion in small plant specified in the European Monitoring and Evaluation Programme/European Environment Agency (EMEP-EEA) guidebook[14]. Methane emissions are based on the emission factor for natural gas fired reciprocating engines in the US EPA's AP42 document[15].

Table 3.9 Exhaust gas conditions

Property		Value
Electrical output[a]	kWe	2004
Efficiency[a]	%	44.0
Thermal input	kW	4556
Fuel lower calorific value[b]	MJ/Nm^3	35.46
Fuel consumption[a]	Nm^3/s	0.128
Stoichiometric flue gas flow rate (wet)[a]	Nm^3/s	1.38
Oxygen content in flue gas[c]	%, dry	10.5
Flue gas volume flow rate (dry)	Nm^3/s	2.08
Flue gas volume flow rate (wet)	Nm^3/s	2.34
Flue gas temperature[a]	ºC	362
Flue gas volume flow rate (actual)[a]	m^3/s	5.85
Flue diameter (internal)[d]	m	0.50
Flue gas velocity	m/s	29.8
Flue gas volume rate at STP and 5% O_2, dry	Nm^3/s	1.48
Flue gas volume rate at STP and 15% O_2, dry	Nm^3/s	4.00

a. Operating parameters from the JMS612 GS NL technical specification[12].
b. Based on natural gas composition in Table 3.11 and combustion calculation.
c. Oxygen content consistent with specified exhaust gas mass flow rate[12].
d. Diameter is assumed based on specfciation[10].

It is assumed that the stationary engine operates at 100% load continuously year round. In practice, it is likely that the engine will have a lower rating and hence a lower air quality impact.

Table 3.10 Pollutant discharge rates

Pollutant		Value
Emission factor		
Nitrogen oxides	$mgNO_2/m^3$ flue gas at reference conditions[d]	500[e]
Carbon monoxide	g/GJ (thermal input)	56
Sulphur dioxide	g/Nm^3 natural gas	0.10
Non methane volatile organic compounds	g/GJ (thermal input)	89
Methane	g/GJ (thermal input)	483
Nitrous oxide[a]	g/GJ (thermal input)	0.5
Release rates[c]		
Nitrogen oxides	gNO_2/s	0.7598
Carbon monoxide	gCO/s	0.2823
Sulphur dioxide	gSO_2/s	0.0128
Volatile organic compounds	gbenzene/s	0.4486
Methane	gCH_4/s	2.435
Nitrous oxide[a]	gN_2O/s	0.0025
Carbon dioxide[b]	gCO_2/s	265

a. Nitrous oxide release is based on an emission factor of $0.5gN_2O/GJ$ (see section 3.5.6).
b. Carbon dioxide release is determined by combustion calculation based on the natural gas composition in Table 3.11.
c. Release rates are determined based on the emission factors in Table 3.10 and engine operating conditions in Table 3.9.
d. Reference conditions are based on a dry gas at STP (Standard Temperature (273K) and (101.3 kPa)) containing 5% oxygen.
e. The emission factor is equivalent to around 190 mg/m^3 expressed at STP in a dry gas containing 15% oxygen.

3.5.2 Flare

Disposal of produced natural gas by incineration will employ a Uniflare UF10 flare stack[16,17]. Egdon estimate a maximum natural gas disposal requirement of 0.5 MMscfd (600 Nm^3/h), consistent with disposal of 10 tonnes/day for production operations on W1. During the testing of W2 and W3, scheduled to last no more than 6 months, it is expected that this requirement will double to around 20 tonnes per day (1.0 MMscfd). For the purposes of this assessment, it is assumed that the flare will operate continuously at a rate of 0.5 MMscfd, except during the testing of W2 and W3 when it will increase to 1.0 MMscfd. This is expected to be a significant overestimate of the disposal rate in practice, given the additional capacity provided by the stationary engine (460 Nm^3/h).

The UF10 flare stack has a capacity of 2500 Nm^3/h and is specified to operate at a temperature of 1000ºC and an excess air level of 200%. Egdon[16] have confirmed that these operating conditions are maintained at the lower throughput considered in this assessment.

The release conditions for the flare have been assessed in Table 3.12, based on the natural gas composition provided by Egdon[18] in Table 3.11.

Table 3.11 Natural gas composition

Parameter		Value
Methane	% v/v	76.6
C_2	% v/v	6.7
C_3	% v/v	3.0
C_4	% v/v	0.4
C_5	% v/v	0.4
C_6+	% v/v	0.4
Nitrogen	% v/v	12.0
Carbon dioxide	% v/v	0.2
Hydrogen sulphide[a]	mg/m^3	5.7

a. The hydrogen sulphide content is consistent with the permitted sulphur content of the produced natural gas.

Table 3.12 Exhaust gas conditions

Property		0.5 MMscfd	1.0 MMscfd
Disposal rate	MMscfd	0.5	1.0
	Nm^3/s	0.164	0.328
Exhaust gas temperature[a]	°C	1000[a]	
Exhaust gas flow rate (actual)[b]	m^3/s	23.4	46.7
Flue diameter[a]	m	2.905	
Velocity	m/s	3.5	7.1
Carbon dioxide release[b]	g/s	338	677

a. Based on flare specification[17].
b. Calculated based on the natural gas composition in Table 3.11.

Pollutant releases are estimated in Table 3.13. Releases are based on the emission factors for industrial flares published by the US EPA in their AP42 document[15] and emission factors from the EMEP-EEA for flaring in oil and gas extraction operations[14].

Table 3.13 Pollutant releases from flare operations

Emission factor source	US EPA AP42[a]	EMEP/EEA 2019[b]
Emission factors		
Total hydrocarbons	0.14 lb/MMBtu	-
Nitrogen oxides (as NO_2)	0.068 lb/MMBtu	1.4 g/kg gas
Carbon monoxide	0.31 lb/MMBtu	6.3 g/kg gas
Non methane volatile organic compounds	-	1.8 g/kg gas
Release rates (g/s per Nm^3/s of gas consumed)		
Non methane volatile organic compounds (as carbon)		1.604
Nitrogen oxides	1.167	1.248
Carbon monoxide	5.320	5.624
Sulphur dioxide[c]	0.011	
Total hydrocarbons (as carbon)	2.403	-

a. AP-42 factors are based on thermal input at the higher heating value.
b. EMEP/EEA factors are based on kg of natural gas burned and a gas density of 0.891 kg/Nm^3.
c. Sulphur dioxide release is based on total oxidation of the sulphur in a gas containing 50mgS/Nm^3.

It is expected that the majority of the release of VOCs will be in the form of methane and lower hydrocarbons, although there will be some releases of higher hydrocarbons. Experience suggests that a significant proportion of the volatile organic compounds emission will be methane and lower hydrocarbons and that that the concentration of higher hydrocarbons (C_6 and above) present in the flue gas will generally be representative of the proportion of higher hydrocarbons in the natural gas[19].For this assessment the volatile organic compound release assessed as benzene is assumed to be equivalent to the non-methane volatile organic compound release. This is considered a significant over estimate of higher hydrocarbons in practice based on the above experience. The higher hydrocarbon (C_{6+}) presence in the produced natural gas is around 1.7% by mass (see Table 3.11).

Where there are corresponding emission factors from the USEPA and EMEP/EEA, the factor providing the greatest release rate is employed. Table 3.14 summarises the pollutant release rates assumed for this assessment.

Table 3.14 Flare stack pollutant release rates assumed for assessment

Property		0.5 MMscfd	1.0 MMscfd
Natural gas disposal rate	Nm^3/s	0.164	0.328
Pollutant release rate			
Nitrogen oxides	gNO_2/s	0.204	0.409
Carbon monoxide	gCO/s	0.920	1.839
Sulphur dioxide	gSO_2/s	0.016	0.033
Benzene (total volatile organic compounds)	gbenzene/s	0.263	0.526

It may be noted that the flare manufacturer[17] indicates significantly lower releases of nitrogen oxides, carbon monoxide and hydrocarbons than determined from the standard emission factors in Table 3.14.

3.5.3 Stationary engines

Table 3.15 summarises the diesel fuelled stationary engines specified for use by Egdon[11] during the proposed development.

The engine specifications generally indicate compliance with either European Union or United States emission standards. The engines are assumed to operate at the emission standards. In addition, it is assumed that the engines will use ultra-low sulphur diesel with a sulphur content of 10 mg/kg (10 ppm).

Based on the claimed emission standards and full load operation, fuel usage and pollutant release rates for each stationary engine have been determined as summarised in Table 3.16.

Table 3.15 Stationary engines and performance

Equipment		Diesel fuel consumption		Power output full load	Emission standard
		l/h	kg/h[a]	kWh	
B	Lighting (4)	6.8	6.0	28.0	EU Stage 3A
C	Welfare unit	2.9	2.5	12.0	EU Stage 3A
D	Surface conductor rig	43.0	37.6	179	EU Stage 3A
E	Generator	84.1	73.5	350	EU Stage 3A
F	Rig engine[d]	344.4	301.0	1420	Measured releases[c]
G	Workover rig	85.1	74.3	354	US Tier 2

a. Based on a fuel density of 0.874 kg/l (at 0°C).
b. Assumes a brake specific fuel consumption of 0.21 kg/kWh, where fuel consumption is not specified.
c. The engine is not certified to an emission standard and the manufacturer's claimed maximum exhaust gas emission concentrations are assumed within the assessment. The emissions relate to operation in low emission mode.
d. The main drilling rig has four identical engines.

Table 3.16 Pollutant release rates for stationary engines

Equipment	Pollutant release rate per unit (g/s)					
	CO	THC[a,b]	NO_x[a,b]	PM	SO_2	CO_2
Lighting (each)	0.0107	0.0011	0.0135	0.0012	0.000008	1.3
Welfare unit	0.0183	0.0019	0.0232	0.0020	0.00001	2.2
Surface conductor rig	0.1740	0.0147	0.1841	0.0099	0.00021	33.4
Generator	0.3400	0.0288	0.3598	0.0194	0.00041	65.4

Rig engine	0.1881	0.0258	1.4421	0.0276	0.00167	267.6
Workover rig	0.3444	0.0466	0.5831	0.0197	0.00041	66.1

a. Total hydrocarbons (THC) are expressed as benzene and nitrogen oxides are expressed as nitrogen dioxide.
b. Where the emission standard quotes a combined value for hydrocarbons and nitrogen oxides, it is assumed that nitrogen oxides comprise 92.6% of the total with the remainder being hydrocarbons[15].
c. A load of 100% is assumed for all engines.

The exhaust gas conditions in Table 3.17 have been estimated and used in the assessment.

Table 3.17 Exhaust gas conditions for stationary engines

Equipment	Height of release (m)	Internal flue diameter (m)	Velocity[b] (m/s)	Temperature[a] (°C)
Lighting[c]	3.0	0.15	0.8	150
Welfare unit	3.0	0.10	3.0	150
Generator	4.0	0.30	18.6	550
Rig engine	4.0	0.40	39.5	455
Surface conductor rig	4.0	0.20	21.4	550
Workover rig	4.0	0.30	18.8	550

a. Based on engine specification with allowance for heat loss.
b. Based on combustion calculations assuming diesel lower heating value of 42.78 MJ/kg.
c. Assumes a single combined release point for all four lighting towers.

It is assumed that all stationary engines operate at full load continuously when operational (see Table G.2).

3.5.4 Construction vehicles

Egdon[11] specified the principal mobile plant that are intended to be employed for the construction and restoration phases of the proposed development as shown in Table 3.18.

It is assumed that all vehicles will operate at the specified emission standard at full load when operational. On this basis the pollutant emission rates for the construction vehicle fleet are estimated in Table 3.19.

Table 3.18 Specification of main construction vehicles

Type		Gross power output (kW)	Fuel consumption (kg/h)[a]	Emission standard
A1 K1	14 t excavator (Hitachi)	78.5	16.5	EU Stage 4
A2 K2	14 t excavator (Cat)	122	25.6	EU Stage 4
A3 K3	14 t excavator (Volvo)	90	18.9	EU Stage 4
A4 K4	Dozer	120	25.2	EU Stage 4
A5 K5	6t dumper	55.4	11.6	EU Stage 3B
A6 K6	9t dumper	55.4	11.6	EU Stage 3B
A7	13t sheeps roller	115	24.2	EU Stage 5
A8	Roller	24.6	5.2	EU Stage 5
A9 K7	12t dumper	108	22.7	EU Stage 4
A10	Concrete pump truck	240	50.4	EURO 6
L	Crane	400	84.0	EU Stage 4

a. Assumes a brake specific fuel consumption of 0.21 kg/kWh.

Table 3.19 Pollutant release rates for construction vehicles

Type	Pollutant release rate per unit (g/s)					
	CO	THC[a]	NO_x[a]	PM	SO_2[c]	CO_2
14 t excavator (Hitachi)	0.109	0.004	0.009	0.001	0.00009	14.7
14 t excavator (Cat)	0.169	0.006	0.014	0.001	0.00014	22.8
14 t excavator (Volvo)	0.125	0.005	0.010	0.001	0.00011	16.8
Dozer	0.167	0.006	0.013	0.001	0.00014	22.4
6t dumper[d]	0.077	0.005	0.067	0.000	0.00006	10.3
9t dumper[d]	0.154	0.011	0.134	0.001	0.00013	20.7
13t sheeps roller[d]	0.319	0.012	0.026	0.001	0.00027	42.9
Roller	0.068	0.003	0.005	0.000	0.00006	9.2
12t dumper	0.150	0.006	0.012	0.001	0.00013	20.2
Concrete pump truck	0.100	0.009	0.027	0.001	0.00028	44.8
Crane	0.389	0.021	0.044	0.003	0.00047	74.7
Total construction phase	1.439	0.067	0.316	0.007	0.00140	224.8
Total restoration phase	0.570	0.022	0.046	0.003	0.00048	76.7

a. Total hydrocarbons are expressed as benzene and nitrogen oxides are expressed as nitrogen dioxide. Where the emission standard quotes a combined value for hydrocarbons and nitrogen oxides it is assumed that nitrogen oxides comprise 92.6% of the total with the remainder being hydrocarbons (based on US EPA AP42 emission factors for uncontrolled emissions from diesel engines -Table 3.3-1)[15].
b. A load of 100% is assumed for all plant.
c. Assumes a diesel sulphur content of 10 mg/kg.
d. The fleet contains two 6t dumpers, 9t dumpers and 13t sheeps foot rollers.

It is assumed that releases from the construction vehicles used in the construction phase can be considered as a single point release (diameter 0.3m) for the purposes of the assessment at a height of 3.0m with a velocity of 29.5 m/s and exhaust temperature of 150ºC. For the smaller fleet of construction vehicles used in the restoration phase a single point release (diameter 0.2m) is considered at a height of 3.0m with a velocity of 22.6 m/s and exhaust temperature of 150ºC. Table H.2 details the construction vehicles used in the construction and restoration phases.

3.5.5 Heavy duty vehicles

Heavy duty vehicles will enter the site and then generally off load, load and leave site. For the purposes of the assessment of releases from these vehicles while on site it is assumed that the vehicle enters the wellsite and then idles for a period of one hour before leaving. This is considered a conservative estimate of releases and it is noted that in practice vehicles will be switched off when not in use.

The emission factors for idling in Table 3.20 have been assumed based on an evaluation of four studies of heavy duty vehicle idling emissions[20,21,22,,23]. These are considered conservative estimates. A factor of 45 gNO_2/h for nitrogen oxides during HDV idling has been used as a guideline by the Greater London Authority[24].

Table 3.20 Emission factors for HDV idling

Parameter		Rahman[20]	DIESELNET[21]	Christopher Frey[22]	Khan[23]	Selected
Nitrogen oxides	g/h	56.9	70.9	89.5		70.9
Nitrous oxide	g/h	0.9				1.1[a]
Carbon monoxide	g/h	95.0	27.8	17.8		27.8
Carbon dioxide	g/h	9108		5931	4660	5296[b]
Particulate matter	g/h	2.6	2.5	1.3		2.6
Total hydrocarbons	g/h		13.6			13.6
Higher hydrocarbons	g/h	13.0		3.5		13.0
Sulphur dioxide	g/h	5.8		0.037	0.029	0.033[b]
Fuel consumption	l/h			2.12	1.67	1.90[b]

a. based on ratio of N_2O to NO_x from Rahman.
b. Mean of values from Christopher Frey and Khan.

Egdon[11] have provided details of maximum daily HDV movements for the various phases of the proposed development (see Table G.3). It is assumed, as a worst case scenario, that HDV movements are maximised based on a 7 day working week to give a pessimistic scenario of HDV movements during each year. The average number of HDVs idling on each working day of the year is determined in Table 3.21.

Table 3.21 Frequency of HDV idling

Year	HDV 2 way movements /year	Mean HDVs idling/working hour in year	Fuel consumption l/working hour
1	2331	0.53	1.01
2	985	0.22	0.43
3, 4, 5, 7 to 10, 12 to 14 (each year)	1797	0.41	0.78
6 & 11 (each year)	1727	0.39	0.75
15	348	0.37	0.71

a. In the determination of idling rate HDVs are assumed to operate for 12 hours on each working day.

Based on the assumed proposed development schedule (see Table G.2), Table 3.22 summarises the expected HDV activity during each year of the proposed development.

Table 3.22 HDV activity in each year of the proposed development

Year	HDVs arriving at site	Total HDV movements (in and out)	AADT
1	2331	4662	12.8
2	985	1970	5.4
3, 4, 5, 7 to 10, 12 to 14 (each year)	1797	3594	9.8
6 & 11 (each year)	1727	3454	9.5
15	348	696	1.9

a. AADT - annual average daily traffic count - based on 365 days per year and the maximum number of two way movements (in and out of site).

Based on the average frequency of HDV idling (Table 3.21) and the selected pollutant emission rates (Table 3.20) the yearly average release rates in Table 3.23 for HDV idling were estimated.

Table 3.23 Pollutant releases from HDV idling

Year	Pollutant release rate in each working hour (g/s)					
	NO_x	CO	PM	VOC	SO_2	CO_2
1	0.010	0.004	0.0004	0.0019	0.000005	0.78
2	0.004	0.002	0.0002	0.0008	0.000002	0.33
3, 4, 5, 7 to 10, 12 to 14 (each year)	0.008	0.003	0.0003	0.0015	0.000004	0.60
6 & 11 (each year)	0.008	0.003	0.0003	0.0015	0.000004	0.58
15	0.007	0.003	0.0003	0.0014	0.000003	0.55
Maximum annual average	0.010	0.004	0.0004	0.0019	0.000005	0.78
Maximum in phase	0.026	0.010	0.0009	0.0049	0.000012	1.92

It is assumed that releases from the HDVs during idling can be considered as a single point release (diameter 0.1m) for the purposes of the assessment at a height of 3.0m with a velocity of 2.3m/s and exhaust temperature of 150°C.

For the purposes of this assessment the maximum hourly HDV pollutant rates in Table 3.23 (based on a 12 hour operational day and the maximum average HDV movements per any individual phase) have been adopted for all years of the proposed development and applied as a continuous release over 24 hours per day, 7 days per week operation. This is a significant overestimate in all phases and will allow sufficient margin should minor changes to the above schedule become necessary.

3.5.6 Other releases

The combustion of diesel fuel and natural gas will also give rise to other releases which are greenhouse gases. It is important that these be considered. In addition to the pollutants above, the inventory of nitrous oxide has also been considered.

For nitrous oxide emission factors of 0.5 gN_20/GJ and $2.1gN_2O/GJ$(heat input) for natural gas and diesel combustion[19] respectively, have been employed.

3.6 Modelling scenarios

ADMS 6.0 has been employed to estimate process contributions to ambient pollutant concentrations based on the general conditions specified above. For the assessment the model has been run using meteorological data for each of five years (2018 to 2022) and has considered five separate years of operation.

The expected programme of work is listed in Table G.2.

In Year 1, the site is extended and new wells W2 and W3 are drilled and tested before being brought into production. During this period, well W1 continues production. Egdon expect that prior to the commencement of construction, all electricity for fixed site operation will be imported. There will there be no requirement to use diesel to fuel the lighting towers (B), welfare units (C) or the generator (D). Produced natural gas will primarily be routed to the gas engine, although there may be some excess requiring disposal by incineration. For the purposes of the assessment a conservative approach is adopted, assuming that the gas engine runs continuously at full load (461 Nm^3/h). During the first half of the year, when only W1 is producing, the flare is assumed to operate at a disposal rate of around 10t/day (590 Nm^3/h). This increases in the second half of the year to 20 t/day (1180 Nm^3/h). All mobile plant used for drilling and construction are assumed to be self-powered using diesel.

In Year 2, the site production facilities will be upgraded and all three wells will be in production. It is intended that the produced natural gas be routed to the grid removing the need for any on site disposal. However, it is recognised that this may take some time following confirmation of viability. For the purposes of the assessment it is assumed that in Year 2 produced natural gas continues to be used in the gas engine operating continuously at full load and the flare operates continuously at a disposal rate of 20 t/day (1180 Nm^3/h). This is likely to be a significant overestimate of the gas disposal requirement as connection to the grid is expected to follow shortly following confirmation of viability.

From Year 3 onwards, it is expected that all produced gas will be exported to the grid. The only requirement for disposal would be in the case of an interruption to gas export and this would be a short term event of less than an hour. For most years of production the site operates without any significant pollutant release with the exception of periods of slickline and workover operations when mobile plant will be diesel fuelled. Egdon do not expect any significant releases from well production or subsequent oil storage and transfer[18].

In Year 15, the wells will be abandoned and the site restored. This will involve the use of mobile plant which will be fully diesel fuelled.

Table 3.24 summarises the equipment usage for the individual years as discussed above. The specification for each item of equipment is presented in Table G.1.

Table 3.24 Equipment usage

Equipment		Year			
		1	2	3 to 14	15
A	Construction plant	1-56	163-365		
B	Lighting towers				1-84
C	Welfare unit				1-84
D	Surface conductor rig	1-56			
E	Generator				1-84
F	Main drilling rig	57-203			
G	Workover rig	204-322		331-365	1-36
H1	Flare (0.5 MMscfd)	1-182			1-36
H1	Flare (1.0 MMscfd)	183-365	1-365		
I	Microturbines	Not operational during the proposed development			
J	Gas engine	1-365	1-365		
K	Restoration plant				37-84
L	Mobile crane	57-203		359-365 325-365 (years 6 & 11)	37-84
HDV		1-365	1-365	1-365	1-84

a. See Tables G.1 and G.2 for equipment description and daily operational hours respectively.

The assessment considers five annual scenarios as discussed above.

It may be noted that long term air quality benchmarks are expressed as a mean over a calendar year. For the purposes of this assessment, it is assumed that the proposed development will start at the beginning of Year 1 and, once commenced, will run continuously with no breaks between phases or within phases and that phases will be of the full duration assumed. These assumptions would be expected to ensure that the proposed development activities which provide the maximum pollutant releases and hence have the maximum air quality impact, are captured and accommodated within a calendar year. As such the assessment represents a worst case for the proposed development both in terms of long term and short term air quality impact.

In practice, it would be expected that there will be breaks between and within various phases of the proposed development. Some phases may be shorter or longer than intended. Nevertheless, it is considered that the proposed development schedule in Table G.2 represents an unlikely worst case which will provide estimates of air quality impact which will be substantially greater than those in practice, particularly in the case of impacts assessed over the long term. Any departures in practice, from the proposed development schedule should not result in changes to air quality impacts which would be any worse than those determined in this assessment. There is, therefore, a reasonable margin of headroom inherent in the conclusions of this assessment.

Sensitivity analyses have been undertaken to look at the impact on air quality of model selection. The US EPA's AERMOD modelling system is a widely used model for determining the dispersion of releases to air and their subsequent ambient impact and is accepted by the Environment Agency and UK Local Authorities for regulatory purposes. To determine the influence of the model selection, part of the assessment was repeated using the AERMOD model.

4 MODELLING RESULTS

ADMS 6.0 has been run for the operating scenarios described in Section 3.6. The results of the modelling are discussed below. In this section results are presented in tabular form, while in Annex A contour plots are provided which illustrate the estimated process contribution to selected ambient pollutant concentrations over the entire assessment area.

The initial part of this assessment is used to determine the air quality impact at the location of maximum concentration in order to identify those pollutants which are clearly insignificant in terms of air quality impact and those which may require further assessment. The second part of the assessment then considers in detail the impact of process contributions of selected pollutants at sensitive locations to determine their significance in the context of applicable air quality standards and critical levels and loads.

4.1 Impact of process releases

Figures A.1 and A.2 illustrate the dispersion of nitrogen dioxide on short term and long term bases respectively, for Year 1 operations. Figures A.3 and A.4 provide the corresponding illustrations for total volatile organic compounds (assessed as benzene). The dispersion patterns are reasonably typical of all pollutants considered. On both long and short term averaging bases, the location of maximum process contribution is within the wellsite boundary. This pattern is typical of low level releases. The maximum off site process contribution occurs at the wellsite's north eastern boundary in the general direction of the prevailing wind. Year 1 provides the highest process contributions for all substances over all years considered. Table 4.1 summarises the maximum process contributions and predicted environmental concentrations at the wellsite boundary for Year 1.

Table 4.1 Maximum process contributions and predicted environmental concentrations – Site boundary

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration	
		μg/m³	% standard	μg/m³	μg/m³	% standard
Carbon monoxide	8 hours	774	7.7	1530	2304	23.0
	1 hour	881	2.9	2188	3069	10.2
Nitrogen dioxide	1 hour	446	223	16.16	462	231
	annual	43.8	110	8.08	51.9	130
Sulphur dioxide	15 min	4.5	1.7	4.58	9.1	3.4
	1 hour	3.8	1.1	3.42	7.2	2.1
	24 hours	2.81	2.2	2.01	4.8	3.9
PM_{10}	24 hours	4.1	8.3	15.36	20	39
	annual	1.4	3.5	13.02	14.4	36
$PM_{2.5}$	annual	1.4	7.0	5.82	7.2	36.1
Benzene	24 hours	98	328	0.21	99	328
	annual	18	350	0.35	18	357
Nitrogen monoxide	1 hour	866	19.7	3.46	870	19.8
	annual	40.9	13.2	1.73	42.7	13.8

For all substances, with the exception of nitrogen dioxide and volatile organic compounds (as benzene), maximum process contributions are within the Environment Agency screening criteria (short term process contributions are less than 20% of the short term environmental standard less the corresponding background and/or the maximum long term predicted environmental concentration is less than 70% of the long term environmental standard) and as such are considered insignificant and requiring no further investigation.

Maximum process contributions of nitrogen dioxide and volatile organic compounds exceed Environment Agency screening criteria and also exceed the respective air quality benchmarks.

Air quality standards with respect to human health are not considered to be applicable on the wellsite or around the wellsite boundary and beyond in the areas most affected by site process contributions. Frequent human exposure, over the periods of the standards, is unlikely in these areas (see section 2.4.1) due to the absence of any residential locations or designated footpaths. Figures A.1 to A.4 include identification of the area within which screening criteria are exceeded. Process contributions beyond this area are not considered significant.

The air quality impacts of these substances are considered in more detail in the following sections at sensitive locations where air quality standards would be expected to apply. These locations include the nearest residential properties and the neighbouring footpaths. Nitrogen dioxide, nitrogen oxides and sulphur dioxide are also considered at designated and local ecological sites where critical levels and loads are applicable.

Table 4.2 compares the process contributions at the site boundary over all operational scenarios considered.

Table 4.2 Maximum process contributions over all operational years – Site boundary

Substance		Year of operation (see Table G.2)			
		1	2	3 to14	15
Carbon monoxide	8 hours	7.7	7.4	4.0	1.3
	1 hour	2.9	2.7	1.5	1.5
Nitrogen dioxide	1 hour	222.9	36.6	48.9	58.1
	annual	109.6	55.9	12.6	28.2
Sulphur dioxide	15 min	1.7	1.5	0.2	0.6
	1 hour	1.1	1.1	0.1	0.4
	24 hours	2.2	2.3	0.2	0.6
PM_{10}	24 hours	8.3	1.8	1.4	8.2
	annual	3.5	0.7	0.7	2.2
$PM_{2.5}$	annual	7.0	1.4	1.4	4.4
Benzene	24 hours	327.7	333.4	93.9	152
	annual	350.0	339.2	21.7	48.6
Nitrogen monoxide	1 hour	19.7	3.3	4.7	2.3
	annual	13.2	6.7	1.5	0.5

It may be seen that for all substances, Year 1 operation results in the highest process contribution. In the following sections the assessment concentrates on Year 1 operation, although the corresponding results from other operational years are presented in Annex E.

4.2 Impact of process releases at locations of human exposure

In order to determine the impact of wellsite releases at locations of frequent human exposure, discrete receptors were located at the residential locations in the vicinity of the Wressle wellsite and along the footpaths to the west and east of the wellsite (see Figure 3.1 and Table E.1). These are considered to be the only locations in the vicinity of the wellsite to which the public normally have access and where human exposure for some or all of the air quality standard averaging periods is likely.

Table 4.3 summarises the maximum process contributions and predicted environmental concentrations at the nearest footpaths during Year 1 operation. In view of the short term presence of members of the public along the footpath, it is considered that only short term environmental standards would be applicable in this area.

Table 4.3 Maximum process contributions and predicted environmental concentrations at footpaths (short term impact)

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration	
		µg/m³	% standard	µg/m³	µg/m³	% standard
Carbon monoxide	8 hours	32.4	0.32	1530	1562	15.6
	1 hour	58.9	0.20	2188	2247	7.5
Nitrogen dioxide	1 hour	22.5	11.2	16.16	38.6	19.3
Sulphur dioxide	15 min	0.30	0.11	4.58	4.9	1.8
	1 hour	0.20	0.06	3.42	3.6	1.0
	24 hours	0.10	0.08	2.01	2.1	1.7
PM_{10}	24 hours	0.12	0.24	15.36	15.5	31.0
Benzene	24 hours	3.0	10.1	0.21	3.3	10.8
Nitrogen monoxide	1 hour	66.0	1.50	3.46	69.5	1.6

The maximum process contributions of the all substances are equivalent to less than less than 20% of their short term environmental standard less the corresponding background, and are therefore considered insignificant.

All maximum short term predicted environmental concentrations are comfortably within the applicable short term environmental standards. It is concluded that process contributions from wellsite operations, at what is considered to be unlikely worst case operating conditions, are insignificant and pose no meaningful threat to environmental standard compliance at the nearby public footpaths.

Table 4.4 summarises the maximum process contributions and predicted environmental concentrations at residential locations near the wellsite. These are considered to be the only locations near the wellsite to which the public normally have access and where human exposure for both the long and short term air quality standard averaging periods is likely.

The maximum short term process contributions of the all substances are less than 20% of their short term environmental standard less the corresponding background and/or the maximum long term predicted environmental concentration is less than 70% of the long term environmental standard. Process contributions of all substances are therefore considered insignificant.

Table 4.4 Maximum process contributions and predicted environmental concentrations – Residential locations

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration	
		µg/m³	% standard	µg/m³	µg/m³	% standard
Carbon monoxide	8 hours	31.7	0.3	1530	1562	15.6
	1 hour	66.2	0.2	2188	2254	7.5
Nitrogen dioxide	1 hour	29.2	14.6	16.16	45.4	22.7
	annual	1.9	4.8	8.08	10.0	25.0
Sulphur dioxide	15 min	0.4	0.1	4.58	5.0	1.9
	1 hour	0.3	0.1	3.42	3.7	1.1
	24 hours	0.2	0.1	2.01	2.2	1.7
PM_{10}	24 hours	0.2	0.4	15.36	15.5	31.1
	annual	0.05	0.1	13.02	13.1	32.7
$PM_{2.5}$	annual	0.05	0.2	5.82	5.9	29.3
Benzene	24 hours	4.9	16.2	0.21	5.1	16.9
	annual	0.5	9.5	0.35	0.8	16.5
Nitrogen monoxide	1 hour	76.1	1.7	3.46	79.5	1.8
	annual	1.8	0.6	1.73	3.5	1.1

In all cases the predicted environmental concentration of all pollutants is less than, and in some cases substantially less than, a third of the applicable standard. Bearing in mind the precautionary assumptions made in the assessment, it is considered unlikely that pollutant process contributions from extension and production operations at the Wressle wellsite will pose any risk to, or have any meaningful influence on, continued attainment of air quality standards at the nearest locations of human exposure.

Tables E.3 and E.4 present maximum process contributions over all four years considered at the local footpaths and residential locations respectively. In all cases, Year 1 operation provides the maximum process contribution.

Based on Environmental Protection UK and the Institute of Air Quality Management classification (section 2.6.4) the maximum impact significance of releases of volatile organic compounds at the most affected sensitive location (Decoy Cottage) is considered to be ‘slight’, falling to ‘negligible’ for all other substances. Table 4.5 summarises the assessment of significance.

Table 4.5 Assessment of impact significance based on IAQM classification

Substance	Maximum process contribution[a]	Predicted environmental concentration[a]	IAQM classification (see Table 2.7)
	% environmental standard		
Nitrogen dioxide	4.8	25	Negligible
Benzene	9.5	17	Slight
Nitrogen monoxide	0.6	1	Negligible

a. Process contributions and predicted environmental concentrations are expressed as a percentage of the applicable long term environmental standard (see Table 4.4) for the most affected residential location.

4.3 Impact of process releases at designated and local ecological sites

Sixteen designated and local ecological sites, requiring assessment based on Environment Agency criteria (see section 2.6.3), were identified near the Wressle wellsite as discussed in section 3.1.

The main substances of interest at these sites are nitrogen oxides, nitrogen dioxide and sulphur dioxide. For the purposes of the assessment of process contributions at these sites, discrete receptors were placed along the boundaries of the sites closest to the wellsite as described in Table 3.1.

The critical loads and levels adopted for use in this assessment have been obtained from the APIS and are summarised in Table F.1 In the selection of critical loads, the minimum for the most sensitive habitat within each site has been selected. The nitrogen critical load is provided as a range and the minimum in that range has been adopted for the assessment. This represents a worse case precautionary approach to the assessment and will most likely result in an overestimate of impact.

The site background concentrations, as obtained from APIS, are summarised in Table F.2. These represent the maximum background concentration across the entire site in each case and as such there will be parts of the site which experience somewhat lower background concentrations. This represents precautionary approach.

The maximum process contributions to concentrations of nitrogen oxides and sulphur dioxide at the designated and local ecological sites are summarised in Table 4.6 for Year 1 operation. Table F.3 presents the detailed determination of these process contributions at each site.

Table 4.6 Maximum process contributions of nitrogen oxides and sulphur dioxide at designated and local ecological sites – Year 1

Site	Nitrogen oxides[a]				Sulphur dioxide	
	Annual mean		Daily mean		Annual mean	
	PC	PEC	PC	PEC	PC	PEC
	% of critical level					
Broughton Far Wood SSSI	6.3	42	17.0	28	0.10	19
Broughton Alder Wood SSSI	2.9	40	7.4	18	0.05	19
Humber Estuary SAC	0.1	107	0.5	33	0.00	39
Spring Wood	2.2	39	6.5	18	0.04	19
Rowland Plantation	15.0	51	38.4	49	0.30	19
Far Wood	6.3	42	17.0	28	0.10	19
Broughton East Wood	5.4	41	15.5	26	0.08	19
Clapgate Pits	5.9	41	17.8	28	0.10	19
Weir Dyke	3.3	40	5.5	16	0.09	19
Far Wood Farm Meadow	2.2	38	6.2	17	0.04	19
Broughton West Wood	1.4	38	3.6	15	0.03	16
Heron Holt	2.3	38	6.7	18	0.04	19
Keb Wood	5.8	41	14.0	25	0.10	19
Broughton Pocket Wood	1.2	37	3.1	14	0.02	17
Haverholme Common	1.4	41	3.6	15	0.02	19
New River Ancholme	3.2	38	5.4	16	0.08	19

a. Total nitrogen oxides are expressed as NO_2.

The maximum long term and short term process contributions of nitrogen oxides and sulphur dioxide are equivalent to less than 1% and 10% respectively, of the applicable critical levels for all sites with a European designation, with the exception of Broughton Far Wood SSSI. Here the process contributions exceed the screening criterion. Maximum long term and short term process contributions of nitrogen oxides and sulphur dioxide are less than 100% of the critical levels for all locally designated sites. As such for all sites, with the exception of the Broughton Far Wood SSSI, process contributions are considered insignificant.

The determination of nitrogen and acid deposition at the designated and local ecological sites is summarised in Table 4.7 for Year 1 operation. Tables F.4 and F.5 present the detailed determination of nitrogen and acid deposition respectively at these sites. The determination was undertaken in accordance with the guidance in AQTAG 06[25] and considered dry deposition only. Guidance indicates that wet deposition over relatively short distances is unlikely to be significant.

Table 4.7 Nitrogen and acid deposition at designated and local ecological sites – Year 1

Site	Nitrogen deposition		Acid deposition	
	PC	PEC	PC	PEC
	% of critical load			
Broughton Far Wood SSSI	3.8	348	3.0	250
Broughton Alder Wood SSSI	Not sensitive			
Humber Estuary SAC	0.1	621	0.01	46
Spring Wood	1.3	341	1.0	246
Rowland Plantation	9.1	353	7.3	254
Far Wood	3.8	348	3.0	250
Broughton East Wood	3.3	348	2.6	249
Clapgate Pits	7.1	410	0.6	34
Weir Dyke	2.0	347	0.2	28
Far Wood Farm Meadow	1.3	346	1.0	248
Broughton West Wood	0.8	341	0.6	200
Heron Holt	1.4	341	1.1	245
Keb Wood	3.5	347	2.8	250
Broughton Pocket Wood	0.7	346	0.5	203
Haverholme Common	0.9	340	0.7	247
New River Ancholme	1.9	347	0.2	28

a. Determination of deposition is based on the deposition velocity for forest terrain[25].
b. The critical load selected is the minimum of the range specified for the most sensitive habitat over the entire site.

The maximum process contributions to nitrogen and acid deposition are equivalent to less than 1% of the applicable critical loads for all sensitive sites with a European designation, with the exception of Broughton Far Wood SSSI. Here process contributions exceed the screening criterion. Process contributions are below 100% of the applicable critical loads at all sites with a local designation, and as such are not considered significant. While there is exceedance of the critical load at most sensitive sites, this is due to existing large background depositions. It is not considered that the process contributions have any significant influence on critical load compliance at these sites.

Table E.5 summarises process contributions of nitrogen oxides, sulphur dioxide and nitrogen and acid deposition at the Broughton Far Wood SSSI for all five operational years considered. Year 1 provides the maximum process contributions in all cases and for all years apart from Year 1, maximum process contributions are within the screening criteria. While it is expected that modelling assumptions will result in a substantial over estimate of impact at the Broughton Far Wood SSSI, it is still considered likely that in, practice, screening criteria may be approached or exceeded. This will be a short episode relative to the proposed development duration and will likely be confined to a part of the site. Nevertheless, an ecological opinion on the significance of process contributions is required in respect of daily mean nitrogen oxide and nitrogen and acid deposition.

4.4 Impact of process releases at the Scunthorpe AQMA

Table 4.8 summarises the maximum process contributions over the nearby AQMA (receptors 30 to 33 in Table E.1) for Year 1 operation. The site has a designation for PM_{10} on a 24 hour mean basis. The maximum contribution to PM_{10} from the proposed development at the Wressle wellsite is well within screening criteria, as are the contributions of all other substances on all other averaging bases. It is therefore not considered that process contributions from the proposed development and subsequent production operations at the Wressle wellsite will have any meaningful influence on air quality standard compliance at the Scunthorpe AQMA.

Table 4.8 Maximum process contributions at the Scunthorpe AQMA – Year 1

Substance	Averaging basis	Maximum process contribution	
		µg/m^3	% standard
Carbon monoxide	8 hours	17.2	0.17
	1 hour	33.0	0.11
Nitrogen dioxide	1 hour	10.9	5.45
	annual	0.3	0.75
Sulphur dioxide	15 min	0.2	0.08
	1 hour	0.1	0.03
	24 hours	0.03	0.02
PM_{10}	24 hours	0.03	0.06
	annual	0.01	0.02
$PM_{2.5}$	annual	0.01	0.04
Benzene	24 hours	1.0	3.43
	annual	0.1	1.30
Nitrogen monoxide	1 hour	30.9	0.70
	annual	0.3	0.09

Table E.6 summarises maximum process contributions at the AQMA for all years considered. In all cases process contributions are less than those in Year 1 and all are within screening criteria.

4.5 Sensitivity analyses

In the assessment of the impact of process contributions the worst case results have been reported. For the assessment, process contributions were modelled for each of 5 years' meteorological data using the ADMS modelling system. A sensitivity analysis was undertaken to determine the influence of meteorological conditions and model selection on the findings of the assessment and hence provide some measure of their robustness.

4.5.1 Meteorological conditions

Table 4.9 summarises the influence of meteorological conditions on maximum process contributions for the discrete receptor groups describing the neighbouring residential locations, the local footpaths and wellsite boundary (see Annex E).

Table 4.9 Influence of meteorological conditions on maximum process contribution

Substance	Averaging basis	Residential	Footpath	Site boundary
		Maximum process contribution (ratio of maximum to minimum year)		
Carbon monoxide	8 hours	1.8	1.8	1.7
	1 hour	1.6	1.7	1.5
Nitrogen dioxide	1 hour	1.3	1.3	1.2
	annual	1.6	1.5	1.6
Sulphur dioxide	15 min	1.2	1.3	1.1
	1 hour	1.2	1.2	1.1
	24 hours	1.5	1.4	1.4
PM_{10}	24 hours	1.9	1.8	1.7
	annual	1.6	1.5	1.6
$PM_{2.5}$	annual	1.6	1.5	1.6
Benzene	24 hours	1.5	1.5	1.4
	annual	1.6	1.3	1.4
Nitrogen monoxide	1 hour	1.2	1.2	1.1
	annual	1.6	1.5	1.6

Annual variations in meteorological conditions, on average, show up to a twofold difference between maximum and minimum process contributions. This assessment is based on the maximum process contribution for all the years considered at each location, and as such will be an over estimation for most years.

4.5.2 Model selection

The main assessment has been undertaken using the ADMS modelling system. The US EPA's AERMOD model is also widely used for regulatory purposes worldwide. To determine how the model used may have influenced the findings of the assessment, the AERMOD model was employed to predict process contributions over the important averaging bases at 2020 meteorological conditions. Table 4.10 presents the comparison between the ADMS and AERMOD model predictions averaged over receptor groups describing the neighbouring residential locations, the local footpaths and site boundary (see Annex E).

Table 4.10 Maximum process contributions (variation with model)

Averaging basis	Maximum process contribution (ratio of ADMS to AERMOD - 2020)		
	Residential	Footpaths	Site boundary
annual	1.1	1.2	1.3
1 hour	1.1	1.1	1.6
24 hour	1.5	1.4	2.0

In general, the AERMOD and ADMS models provide predicted ambient process contributions which are in reasonable agreement for all averaging bases at the receptors considered. There are slight differences between the receptor groups, although on average ADMS provides a marginally higher predicted process contribution across the sensitive residential and footpath receptors for all averaging bases, and around a 50% greater prediction at the site boundary. Bearing in mind the margin available in the assessment of air quality standard compliance and the maximum impact relative to critical loads and levels at the ecological receptors, it is not considered that the differences exhibited due to model selection will have any substantial impact on the conclusions of this assessment.

4.6 Modelling uncertainty

The use of models to predict the dispersion of releases has associated uncertainties. The main uncertainties in this assessment result from:

- The operational load in practice is likely to be lower on most occasions than that modelled in this assessment. The proposed development is modelled based on full load operation of all plant on a continuous 24 hour per day basis for the entire duration of the proposed development phase, except where specifically limited by working hours or Egdon's schedule. This provides what is considered to be a significant over estimate of process releases in practice, particularly for the high energy intensive well drilling phases and for the incineration of produced natural gas during the well clean up and testing phases, where gas volumes are uncertain. It is expected that the duration, frequency and intensity of equipment operation will be substantially lower than that considered in the assessment. As such the process contributions and subsequent ambient impact for all pollutants are likely to be an overestimate of those in practice

- The release rates upon which the assessment is based are consistent with the operation of engines, incinerators and construction vehicles at the regulation or benchmark limits. In addition, heavy duty vehicle idling emissions are considered conservative estimates. In practice, it is likely that pollutant release rates will be somewhat lower, and in some cases substantially lower, than the levels assumed in this assessment. This will result in an overestimate of ambient impact.

- Conversion rates for nitrogen monoxide to nitrogen dioxide of 35% and 70% have been employed as recommended by the Environment Agency[1] for short and long term air quality impacts respectively. These are generally considered quite conservative estimates. Conversion rates over the relatively short distances considered in this assessment are likely to be substantially lower than those assumed. Estimates based on the Janssen relationship[26] indicate a likely overestimate of the significance of process releases (see Annex C and Table E.1) of nitrogen dioxide and associated nitrogen and acid deposition at the designated and local ecological sites.

- In the assessment of particulate matter releases the environmental standards used are those for $PM_{2.5}$ and PM_{10}. A precautionary approach is adopted and it is assumed that when comparing the release with the corresponding standards, all particulate matter is present as either PM_{10} or $PM_{2.5}$ as appropriate.

- Volatile organic compounds are assessed as benzene as required within guidance[1] for situations where the composition of the release is not known. In practice, it is expected that a large proportion of the volatile organic compounds release will be methane or other lower hydrocarbons. This is particularly relevant to volatile organic releases from site equipment such as stationary engines and incinerators. Methane and lower hydrocarbons have significantly higher environmental benchmarks compared with benzene and as such significance of the air quality impact on human health in practice will be substantially less than reported in this assessment.

- The meteorological conditions upon which the assessment was based vary from year to year and influence ambient impact. A sensitivity analysis has shown the differences expected due to changes in meteorological conditions for a five year period. This assessment is based on the year providing the maximum impact for each location and pollutant and as such is likely to be an overestimate for most meteorological years.

- Air quality standards are based on assessment over a calendar year and as such long term process contributions will be dependent on the commencement date of the proposed development. This assessment is based on an unlikely worst case where the proposed development schedule runs continuously without breaks from the beginning of Year 1. As such the assessment most likely represents an overestimate of air quality impact in practice, particularly for process contributions determined on a long term (annual) basis. Departures from the modelled schedule will, in practice, most likely result in a lower air quality impact than that determined herein.

- The model used can influence predictions of ambient impact. In this case a sensitivity analysis of the two most widely used models for regulatory purposes indicated that the conclusions of the assessment were not dependent on the selection of model. The ADMS and AERMOD show generally good agreement and it is not considered that model selection has any significant impact on assessment conclusions, although the ADMS model does tend to provide higher predicted process contributions at sensitive locations compared with AERMOD.

- The necessary assumptions made regarding surface characteristics (section 3.4) can have either a negative or positive impact on modelling outcomes. A sensitivity analysis indicates that variations due to the assumed surface characteristics are unlikely to be significant in terms of the conclusions of the assessment as the potential for any impact is mitigated by the selection of descriptive parameters considered representative of the assessment area.

There are inherent uncertainties associated with the use of air dispersion models to predict the ambient impact of releases. With this in mind the assessment herein has been undertaken using conservative assumptions which tend towards an over estimation of the ambient impact. It is considered that the assessment has taken a precautionary approach and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

4.7 Photochemical ozone creation potential

Some of the pollutants released have the potential to react to form ozone. Ground level ozone is a highly reactive pollutant with a potential to damage human health and vegetation. It is produced by the action of sunlight on volatile organic compounds and oxides of nitrogen. Environment Agency guidance[27], provides a standardised methodology for determination of the photochemical ozone creation potential (POCP) of a release. In the case of the proposed operations it is considered that releases of volatile organic compounds, nitrogen dioxide, sulphur dioxide and carbon monoxide have implications for ozone formation. The total release of each of these over the duration of the proposed development is assessed in Table 4.11 based on operating conditions in section 3.5.

The assumptions made in relation to releases are considered to represent the worst case for the proposed operations. The determination indicates a POCP for the entire proposed development of 2098 tonnes.

Table 4.11 Calculation of POCP related releases

Substance	Release over proposed development (t)				POCP	
	NO_2	CO	SO_2	Benzene		
POCP factor	2.8	2.7	4.8	21.8	tonnes	% of total project releases
Year						
1	116.8	76.5	1.280	29.031	1172.4	55.9
2	33.6	49.0	0.932	23.093	734.4	35.0
3	0.8	0.6	0.001	0.168	7.5	0.4
4	0.8	0.6	0.001	0.168	7.5	0.4
5	0.8	0.6	0.001	0.168	7.5	0.4
6	2.7	2.8	0.003	0.373	23.3	1.1
7	0.8	0.6	0.001	0.168	7.5	0.4
8	0.8	0.6	0.001	0.168	7.5	0.4
9	0.8	0.6	0.001	0.168	7.5	0.4
10	0.8	0.6	0.001	0.168	7.5	0.4
11	2.7	2.8	0.003	0.373	23.3	1.1
12	0.8	0.6	0.001	0.168	7.5	0.4
13	0.8	0.6	0.001	0.168	7.5	0.4
14	0.8	0.6	0.001	0.168	7.5	0.4
15	6.0	8.7	0.057	1.329	69.3	3.3
Total	170	145	2	56	2098	100

4.9 Greenhouse gas releases and climate change

Some of the pollutants released are greenhouse gases and it is required that the impact on global warming be determined. In this case the assessment confines itself to the consideration of direct emissions to air from the proposed plant exhausts. There is no assessment of any indirect emission (i.e. heat or power imported to site for use in operations) or consideration of the subsequent usage of produced oil and natural gas exported from site. Environment Agency guidance[28], provides a standardised methodology for determination of the impact on global warming of a release based on the equivalent annual mass release of carbon dioxide. The global warming potential factors for methane and nitrous oxide use the values specified in the Intergovernmental Panel on Climate Change's 5th Assessment Report[29]. For the purposes of this assessment methane is assumed to comprise both methane and non-methane volatile organic compounds.

In the case of the proposed development, releases of carbon dioxide, methane and nitrous oxide are considered in respect of climate change. The annual release of each of these is assessed in Table 4.12 based on operating conditions in section 3.5 and represents the total release for the proposed development.

Table 4.12 Calculation of greenhouse gas releases

Substance	Release over proposed development (t)			Impact	
	CO_2	CH_4	N_2O	t CO_2 equivalent	% of total project releases
Global warming potential (relative to CO_2, 100 years)	1	28	265		
Year					
1	40506	97.8	0.672	43424	61.1
2	20787	89.8	0.222	23361	32.8
3	106	0.168	0.003	111	0.2
4	106	0.168	0.003	111	0.2
5	106	0.168	0.003	111	0.2
6	531	0.373	0.015	546	0.8
7	106	0.168	0.003	111	0.2
8	106	0.168	0.003	111	0.2
9	106	0.168	0.003	111	0.2
10	106	0.168	0.003	111	0.2
11	531	0.373	0.015	546	0.8
12	106	0.168	0.003	111	0.2
13	106	0.168	0.003	111	0.2
14	106	0.168	0.003	111	0.2
15	2075	1.736	0.038	2134	3.0
Total	65488	192	1	71123	100

The assumptions made in relation to releases are considered to represent the worst case for the proposed operations. The determination indicates an equivalent carbon dioxide release for the proposed development of 71123 tonnes.

4.10 Construction dust

It is likely that the construction activities associated with the wellsite development will give rise to dust emissions, albeit temporary in nature and largely restricted the areas close to the construction site.

The potential for fugitive dust is most likely to arise from the movement of vehicles over the earth, the stripping of soil, excavations and the subsequent storage of excavated materials and transfer of materials to and from lorries. This may be exacerbated by spillages during transportation and handling and also by periods of dry weather and high wind speeds. This is considered in Annex H in accordance with the methodology described in the IAQM's guidance[30]on the assessment of dust from demolition and construction.

It is expected that, with adequate mitigation measures in place, the risk of dust impact from all operations will be 'negligible'.

4.11 Operations traffic

The development of the wellsite and the subsequent operation will have the effect of increasing traffic flow, albeit temporarily, in the area, which in turn will result in additional releases of certain pollutants to air. It is necessary to understand the likely ambient impact of this increase in traffic flow. This is assessed in Annex I using methodology provided by the Highways England[31] and the IAQM[9].

Increases in road traffic brought about by the construction activities and subsequent wellsite operations are assessed to have a neutral impact on air quality based the guidance within Highways England’s Design Manual for Roads and Bridges, the additional contributions to ambient pollutant concentrations from associated road traffic have no influence on the findings of the main air quality assessment for plant releases to air.

5 CONCLUSIONS

Egdon Resources UK Limited currently undertake hydrocarbon production operations from one well at their Wressle wellsite near Scunthorpe. An extension to the current operations is proposed, comprising an extension of the existing Wressle wellsite to construct two well cellars; drill two additional lateral underground boreholes to appraise hydrocarbon resources from the Penistone Flags and Ashover reservoirs; upgrade existing production facilities to include additional fluid storage tanks, separator system, surface pump and associated bunds; install gas processing equipment, construct a 600 m underground gas pipeline and flow gas to the existing National Grid pipeline; and the long term production of oil and gas. Three wells are then expected to be in production, after which the site will be restored. The project duration is expected to be around 15 years.

As part of the planning and permitting process it is necessary to assess the dispersion of releases to atmosphere associated with the proposed site extension, well drilling and testing and subsequent long term oil production to determine their impact on ambient concentrations of important pollutants around the local area. In particular, impact at locations of permanent human habitation and designated and local ecological sites, in the context of attainment of applicable environmental standards, requires assessment.

An Air Quality Dispersion Modelling Assessment accompanied the planning application in 2018 for long term oil production at the Wressle wellsite. The Assessment predicted both short-term and long-term impacts on pollutant concentrations at nearby residential properties and ecological receptors. It concluded that the proposed gas engine and flare will not have a significant impact or effect on local air quality. Both the Council's Environmental Health officer and the Environment Agency raised no objection to the proposed development with regard to its impact on air quality.

The predominant source of pollutant releases during site operations will be from the use of diesel fuel in mobile plant and stationary engines and from the incineration and combustion of produced natural gas. This is largely undertaken in the first two years of the proposed development. Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, particulate matter and sulphur dioxide were therefore considered. The assessment was undertaken using the UK ADMS 6.0 modelling system, with an operating regime considered to provide unlikely worst case conditions for pollutant releases and air quality impact.

Maximum pollutant process contributions from site operations occur within the wellsite boundary. Beyond this location, process contributions reduce significantly with distance. It is not considered that statutory air quality standards would be applicable around the area of maximum impact, or around and just beyond the site boundary, due to the infrequency of human exposure and limited access. The first year's operation, which includes site extension work and well drilling, results in the greatest pollutant releases and air quality impact. Subsequent long term production operations have substantially less impact.

Along the nearby public footpaths, where short term environmental standards might be expected to apply, it is considered that process pollutant contributions are insignificant and unlikely to compromise attainment of these standards.

At neighbouring locations of residential occupation, where long term human exposure might be expected, it is considered that pollutant process contributions from the site operations are insignificant. In all cases the predicted environmental concentration of all pollutants is less than, and in some cases substantially less than, a third of the applicable standard. Bearing in mind the precautionary assumptions made in the assessment, it is considered unlikely that pollutant process contributions from extension and production operations at the Wressle wellsite will pose any risk to, or have any meaningful influence on, the continued attainment of air quality standards at the nearest locations of human exposure.

At the nearest designated and local ecological sites requiring assessment, which are sensitive to nitrogen oxides, sulphur dioxide and nitrogen and acid deposition, process contributions are considered unlikely to pose any threat to, or have any substantial influence on, the attainment of critical levels and critical loads. Process contributions at most sites are insignificant, although at the Broughton Far Wood SSSI contributions to nitrogen oxides and nitrogen and acid deposition, exceed screening criteria in Year 1. It is considered that while the reported impact is likely to be a substantial over estimate of that in practice, an ecological opinion on significance is required. This is covered in the Preliminary Ecological Appraisal that accompanies the planning application.

At the Scunthorpe AQMA process contributions are insignificant and have no meaningful influence on air quality standard attainment within the area.

Necessary assumptions made to undertake the modelling are considered to have the effect of substantially overestimating the process contribution to ambient concentrations. It is considered that the predicted process impact reported herein is a conservative assessment and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

It is likely that the construction activities associated with the development of the wellsite will give rise to dust emissions. It is expected, based on Institute of Air Quality Management methodology, that with adequate mitigation measures in place the risk of dust impact from all proposed development operations will be ‘negligible’.

Increases in road traffic brought about by the construction activities and subsequent site operation are assessed to have a neutral impact on air quality based on the guidance within Highways England’s (now National Highways) Design Manual for Roads and Bridges.

Operations on site will give rise to releases of greenhouse gases. Based on an assessment of worst case operation it is considered that proposed development lifetime greenhouse gas releases are largely insignificant in relation to the UK’s current inventory and future budgets at around 71000 tonnes CO_2 equivalent.

Based upon the outcome of this Air Quality Assessment for the extension of the Wressle wellsite, it is concluded that the proposed development, with appropriate mitigation, is considered to accord with policies DS1, DS11 and M23 of the North Lincolnshire Local Plan with regard to air quality.

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Annex A Dispersion modelling contour plots

The results of the modelling of the impact of pollutant releases from wellsite extension and production operations on local ambient ground level concentrations are presented in tabular form in Section 4. In Annex A typical examples of the long term and short term dispersion patterns for nitrogen dioxide and volatile organic compounds (assessed as benzene), the most significant pollutants, are presented. Contour plots illustrating the process contribution to ground level concentrations of each are provided. The results relate to modelling of Year 1 wellsite operation and meteorological conditions which are considered to provide the maximum process contributions over the entire proposed development. All results are presented as the maximum contribution of the process (excluding existing background concentrations), expressed as a percentage of the applicable air quality benchmark.

The plots are considered over an area of 3km x 3km, which comprises the assessment area, immediate area around the wellsite and the nearest residential neighbours.

For presentational purposes contour plots are limited to minimum values of 1% and 5% of the long and short term environmental standards respectively. Process contribution of less than 1% and 10% of the long term and short term standards respectively, are generally considered insignificant in terms of air quality impact.

The plots also identify the area within which Environment Agency screening criteria are exceeded. Any process contribution beyond this area does not req uire further consideration with regard to human health effects.

The following figures are presented:

Figure 1 Predicted maximum process contributions of nitrogen dioxide
(AQS limit 99.8 percentile of 1 hour means – 2018)

Figure 2 Predicted maximum process contributions of nitrogen dioxide
(AQS limit annual mean - 2020)

Figure 3 Predicted maximum process contributions of volatile organic compounds
(EAL for benzene 24 hour means – 2020)

Figure 4 Predicted maximum process contributions of volatile organic compounds
(AQS limit for benzene annual mean - 2020)

Figure A.1 Predicted maximum process contributions of nitrogen dioxide (AQS limit 99.8 percentile of 1 hour means – 2018)

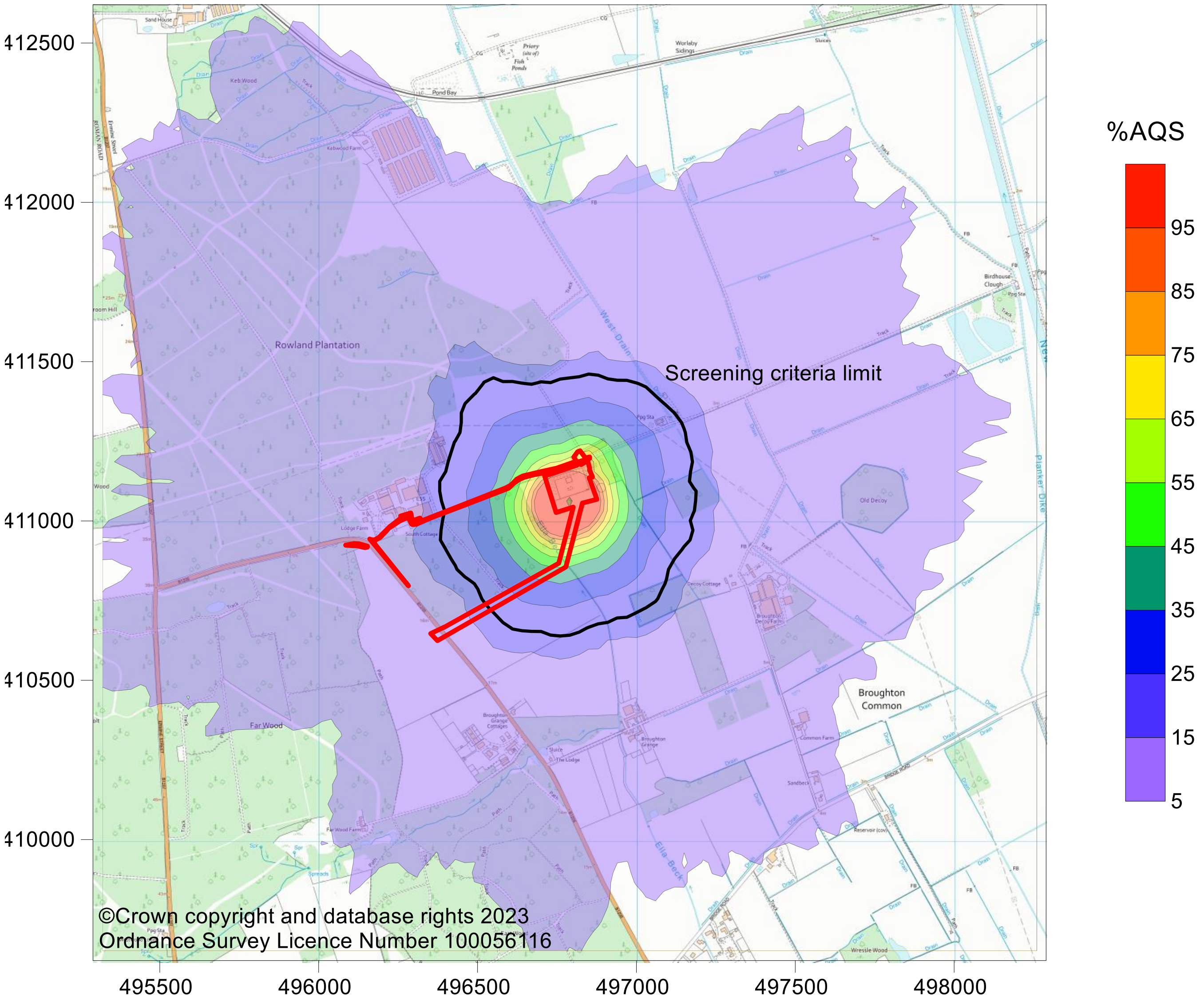


Figure A.2 Predicted maximum process contributions of nitrogen dioxide (AQS limit annual mean - 2020)

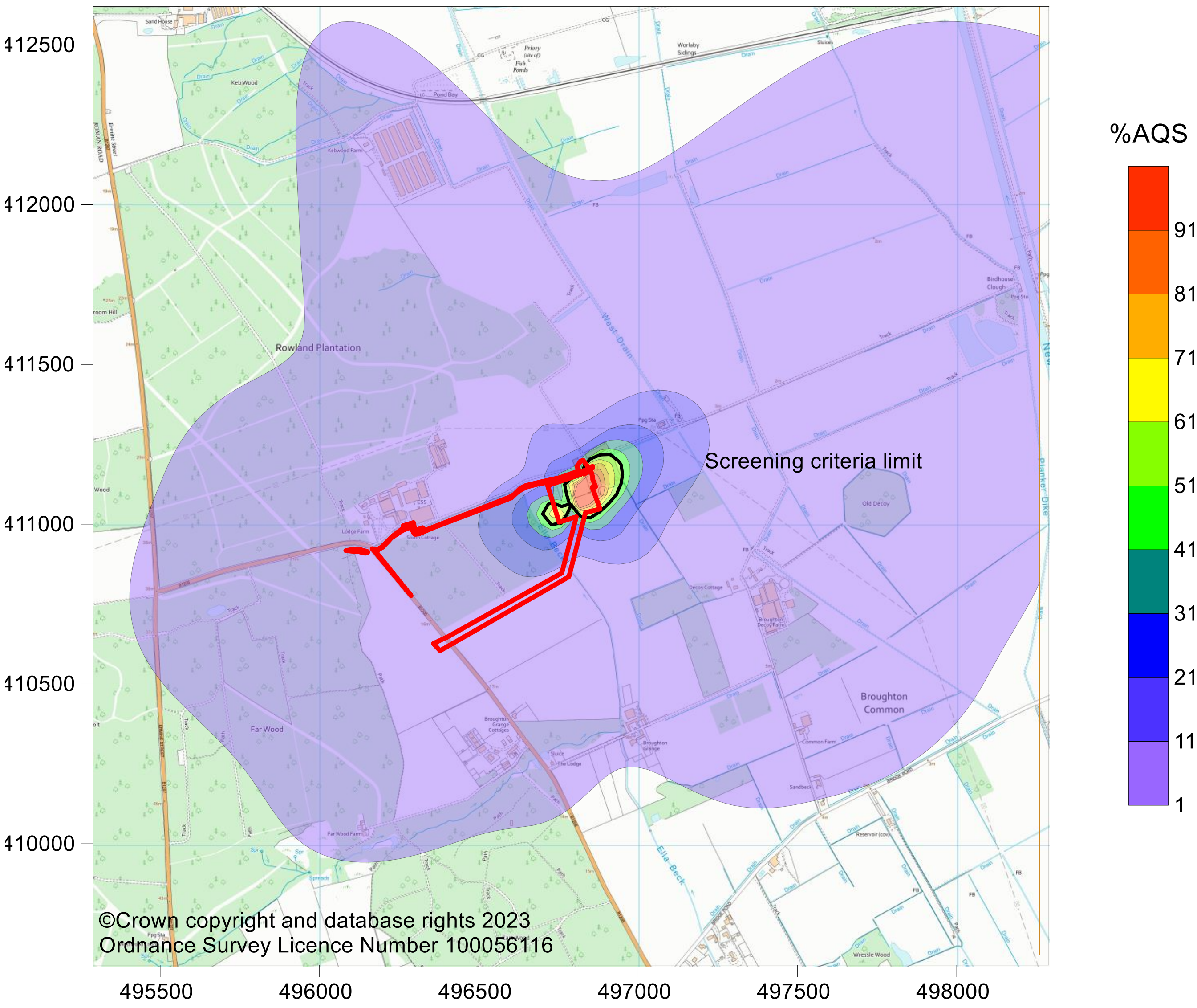


Figure A.3 Predicted maximum process contributions of volatile organic compounds (EAL for benzene 24 hour means – 2020)

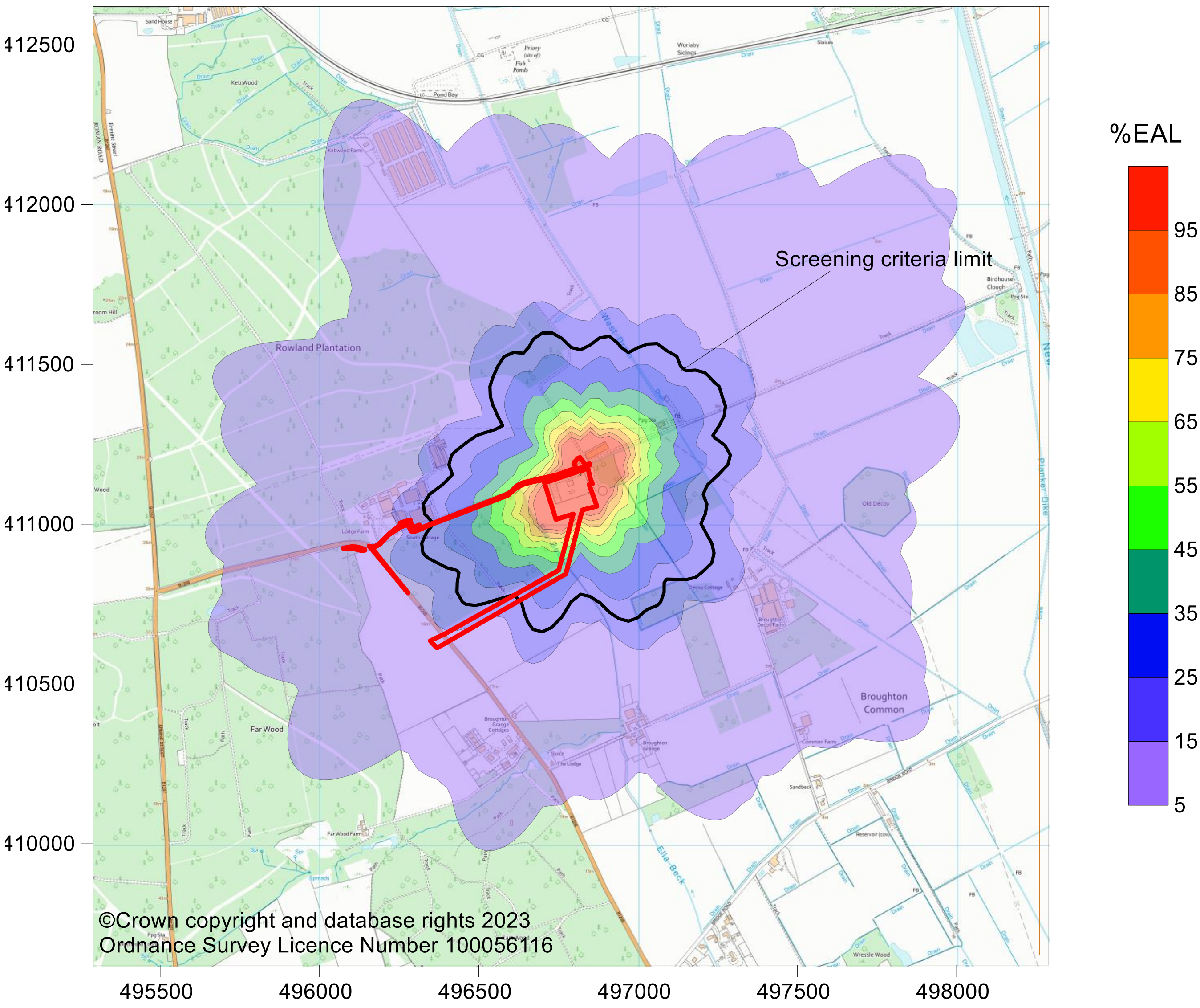
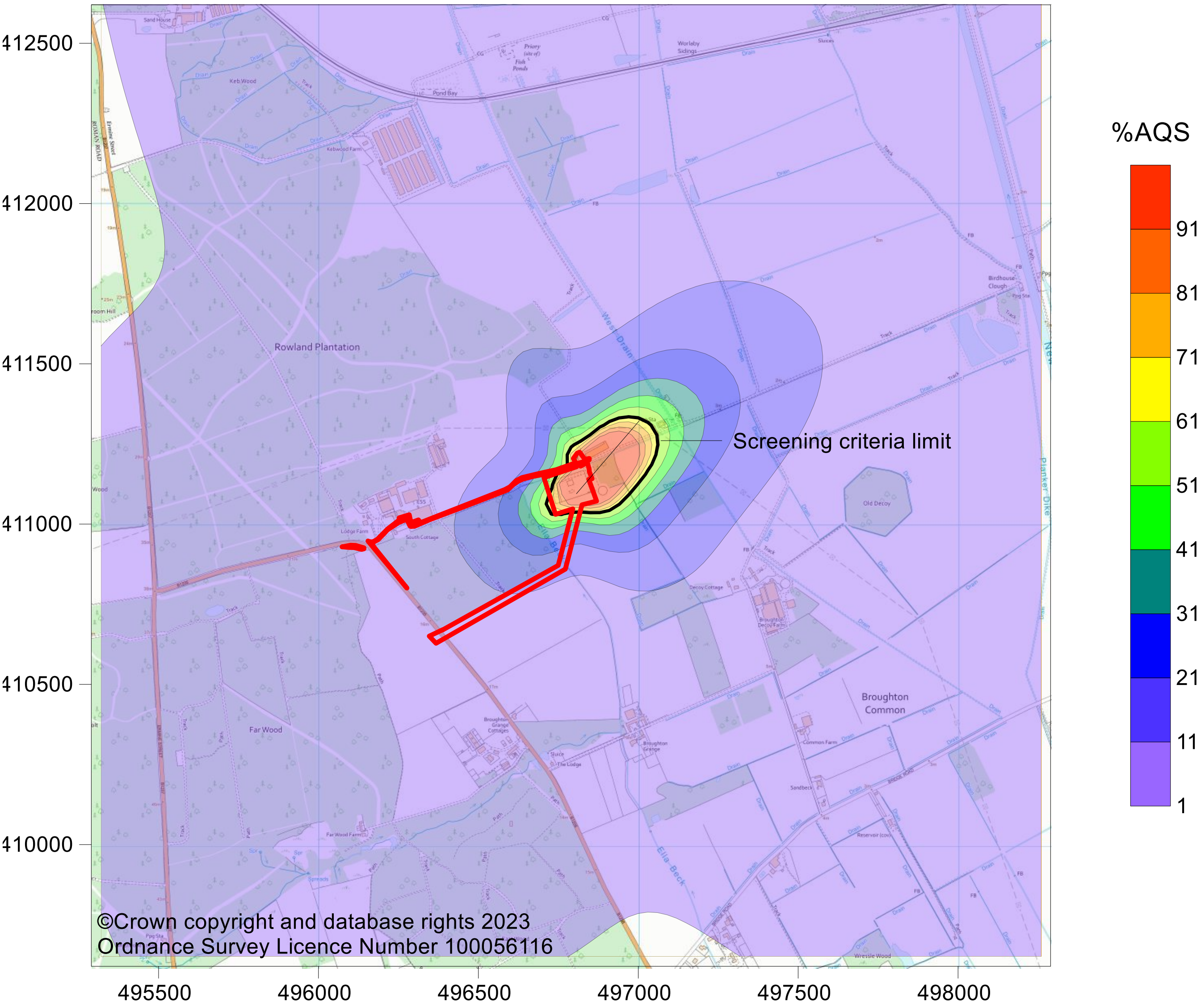


Figure A.4 Predicted maximum process contributions of volatile organic compounds (AQS limit for benzene annual mean - 2020)



ANNEX B Model input data

B.1 Assessment area and surface characteristics

Table B.1 summarises the assessment area considered in the modelling and the values of the parameters describing its surface characteristics. These are described in more detail in sections 3.1 to 3.4.

Table B.1 Assessment area and surface characteristics

Parameter	Value
Assessment area	3000 m x 3000m area with centre 496790 411120
Cartesian receptor grid	101 x 101 receptor grid (total 10201) with receptors spaced at 30m intervals
Discrete receptors	97 receptors - see Table E.1 for description
Meteorological data	Hourly sequential data supplied by the UK Meteorological Office from the Normanby Hall station supplemented with cloud and wind data from the Scampton for the 5 year period 2018 to 2022
Topography	Elevated terrain Ordnance Survey Land-form Panorama DTM for area considered (SE 80 & 82, SK88, TA00 & 02, TF08)
Surface roughness	0.3m
Minimum Monin Obukhov length	1m
Surface albedo	0.23
Priestley Taylor parameter	1.0

The release characteristics of the wellsite sources considered in this assessment are detailed in full in Tables 3.9 to 3.22. Tables B.1 and B.2 summarise the main input data to the model.

Table B.1 Exhaust gas conditions

Plant		Easting (m)	Northing (m)	Height of release (m)	Diameter (m)	Temperature (ºC)	Velocity (m/s)
A	Construction plant	496807	411071	3.0	0.30	150	29.5
B	Lighting towers	496804	411097	3.0	0.15	150	0.8
C	Welfare unit	496852	411102	3.0	0.10	150	3.0
D	Surface conductor	496811	411081	4.0	0.20	550	21.4
E	Generator	496829	411152	4.0	0.30	550	18.6
F1	Rig engine 1	496776	411059	4.0	0.40	455	39.5
F2	Rig engine 2	496781	411057	4.0	0.40	455	39.5
F3	Rig engine 3	496784	411053	4.0	0.40	455	39.5
F4	Rig engine 4	496797	411058	4.0	0.40	455	39.5
G	Workover rig	496811	411081	4.0	0.30	550	18.8
H1	Flare (pre year 4)	496773	411048	9.9	2.91	1000	3.5/7.1
H1	Flare (post year 4)	496768	411087	9.9	2.91	1000	7.1
I	Microturbines 1 to 3	496821	411140	Not operational in proposed development			

Table B.1 continued

Plant		Easting (m)	Northing (m)	Height of release (m)	Diameter (m)	Temperature (°C)	Velocity (m/s)
J	Gas engine	496825	411146	4.0	0.50	362	29.8
K	Restoration plant	496799	411106	3.0	0.20	150	22.6
L	Crane	496811	411081	3.0	0.20	150	22.0
HDV		496802	411120	3.0	0.10	150	2.3

Table B.2 Modelled pollutant releases

		Pollutant release rate (g/s)				
Plant		CO	Benzene	NO_2	PM_{10}	SO_2
A	Construction plant	1.439	0.067	0.316	0.007	0.0014
B	Lighting towers	0.043	0.004	0.054	0.005	0.00003
C	Welfare unit	0.018	0.002	0.023	0.002	0.000014
D	Surface conductor	0.174	0.015	0.184	0.010	0.0002
E	Generator	0.340	0.029	0.360	0.019	0.0004
F1	Rig engine 1	0.188	0.026	1.442	0.028	0.0017
F2	Rig engine 2	0.188	0.026	1.442	0.028	0.0017
F3	Rig engine 3	0.188	0.026	1.442	0.028	0.0017
F4	Rig engine 4	0.188	0.026	1.442	0.028	0.0017
G	Workover rig	0.344	0.047	0.583	0.020	0.0004
H1	Flare – 0.5 MMscfd	0.920	0.263	0.204	0	0.016
H1	Flare – 1.0 MMscfd	1.839	0.526	0.409	0	0.033
I	Microturbines 1 to 3	Not operational during proposed development				
J	Gas engine	0.282	0.449	0.760	0	0.013
K	Restoration plant	0.570	0.022	0.046	0.003	0.0005
L	Crane	0.389	0.021	0.044	0.003	0.0005
HDV		0.010	0.005	0.026	0.001	0.00001

B.2 Model input files

The input data used in the current assessment have been provided under separate cover. Electronic files containing the input data used in the modelling of the maximum process contributions over the entire assessment area of all pollutants considered have been provided as detailed below:

Carbon monoxide	8 hour mean	EDG Year 1 2020.APL
	hourly mean	EDG Year 1 2018.APL
Nitrogen dioxide	1 hour mean	EDG Year 1 2018.APL
	annual mean	EDG Year 1 2020.APL
Sulphur dioxide	15 minute mean	EDG Year 1 2018.APL
	1 hour mean	EDG Year 1 2021.APL
	24 hour mean	EDG Year 1 2018.APL

PM_{10}	24 hour mean	EDG Year 1 2020.APL
	annual mean	EDG Year 1 2022.APL
$PM_{2.5}$	annual mean	EDG Year 1 2022.APL
Benzene	24 hour mean	EDG Year 1 2020.APL
	annual mean	EDG Year 1 2020.APL
Nitrogen monoxide	hourly mean	EDG Year 1 2020.APL
	annual mean	EDG Year 1 2020.APL

B.3 Models used

ADMS	Cambridge Environmental Research Consultants Limited ADMS 6.0: version 6.0.0.1 License: A01-1347-C-AD520-UK (10.10.24)
AERMOD	Lakes Environmental Software AERMOD View: version 12.0.0 (AERMOD version 23132) License: AER0005882 (21.11.24)

ANNEX C Conversion of nitrogen monoxide to nitrogen dioxide

The majority of oxides of nitrogen released will be in the form of nitrogen monoxide. While conversion to nitrogen dioxide will occur in the atmosphere it is unlikely that all of the nitrogen oxides in the flue emission will be in the form of nitrogen dioxide at ground level. It may be noted that for this type of assessment the Environment Agency[1] recommend that conversion rates of 35% and 70% be considered for short and long term air quality impacts respectively. These are considered quite conservative estimates. These conversion rates have been used in this assessment and represent a precautionary approach which will, it is considered, significantly over estimate the process contribution to ground level concentrations of nitrogen dioxide at most locations and as such provide a reasonable margin of headroom which should go some way to offsetting the inevitable uncertainties associated with this type of assessment and the necessary modelling assumptions.

There are methodologies available which enable a more representative estimation of conversion rates at specific locations, largely based on distance from the point of release. Based on a study of Dutch power station plumes, Janssen et al[26] determined an approximate relationship between the conversion of NO to NO_2 and the distance from the point of release as below:

$$\frac{NO_2}{NO_x} = A\left(1 - e^{(-\alpha x)}\right)$$

where A is the ozone parameter describing the oxidation of NO to NO_2 in the presence of ozone and the photolysis of NO_2 by sunlight to reform NO.
α is the wind parameter which expresses conversion rates in respect of downwind distance based on wind speed at plume height and ozone concentration.
x is the downwind distance (km)

The values of A and α depend on ozone concentration, incoming solar radiation and wind speed. Janssen developed empirical values for these based on seasonal measurements of conditions in the Netherlands. It is assumed that a similar relationship is applicable in the UK.

Janssen proposed the following seasonal values for A and α:

Winter (December to February)

Background ozone concentration (ppb)	Wind speed at plume height (m/s)					
	0-5		5-15		>15	
	A	α	A	α	A	α
0-10	0.49	0.05	0.49	0.05	0.49	0.05
10-20	0.74	0.07	0.74	0.07	0.74	0.07
20-30	0.83	0.07	0.83	0.07	0.83	0.10
30-40	0.87	0.07	0.87	0.07	0.87	0.15

Spring/Autumn (March to May and September to November)

Background ozone concentration (ppb)	Wind speed at plume height (m/s)					
	0-5		5-15		>15	
	A	α	A	α	A	α
10-20	0.635	0.10	0.635	0.10	0.635	0.10
20-30	0.74	0.10	0.74	0.10	0.74	0.15
30-40	0.80	0.10	0.80	0.10	0.80	0.25
40-60	0.85	0.10	0.85	0.15	0.85	0.30

Summer (June to August)

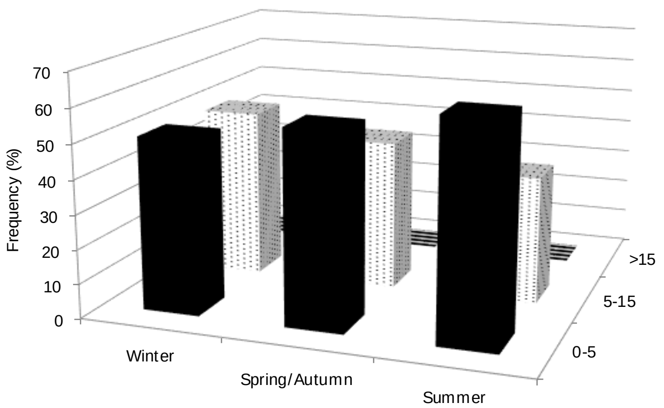
Background ozone concentration (ppb)	Wind speed at plume height (m/s)					
	0-5		5-15		>15	
	A	α	A	α	A	α
20-30	0.67	0.10	0.67	0.10	0.67	0.10
30-40	0.74	0.10	0.74	0.15	0.74	0.25
40-60	0.81	0.15	0.81	0.25	0.81	0.35
60-120	0.88	0.20	0.88	0.35	0.88	0.45
120-200	0.93	0.40	0.93	0.65	0.93	0.80

Janssen indicates that '*the method presented therefore proved to be highly suitable to predict NO_2/NO_x ratios in power plant plumes under widely varying atmospheric conditions'*.

An assessment of the meteorological data for the Normanby Hall station over the period employed in this assessment (2018 to 2022) indicated the following seasonal distribution of wind speed.

Season	Frequency in wind speed category (%)			Mean wind speed (m/s)
	0-5 m/s	5-15 m/s	>15 m/s	
Winter	48.6	51.2	0.2	5.5
Spring/Autumn	59.1	40.9	0.1	4.9
Summer	64.8	35.2	<0.1	4.4

Seasonal wind speed

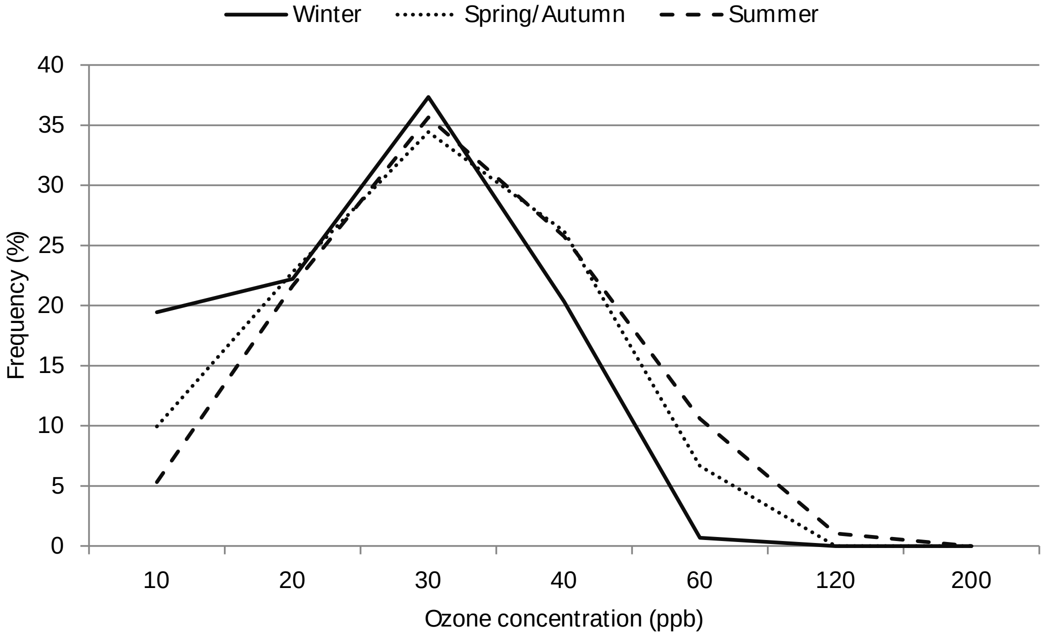


The wind speed is almost exclusively below the 15 m/s category for all seasons, with an overall average of 4.9 m/s.
The nearest automatic station monitoring station which includes measurement of ozone is Hull Freetown (UKA00450) which is located around 22km north east of the Wressle wellsite (509482 429322). An analysis of hourly average data for 2022 indicated the following seasonal concentrations:

Season	Frequency in ozone concentration category (%)	Mean

	0-10	10-20	20-30	30-40	40-60	60-120	120-200	
	ppb							
Winter	19.4	22.2	37.3	20.3	0.7	<0.1	<0.1	20.8
Spring/Autumn	9.9	22.8	34.4	26.2	6.7	<0.1	<0.1	24.6
Summer	5.3	21.6	35.7	25.7	10.6	1.0	<0.1	27.1

Seasonal ozone concentration

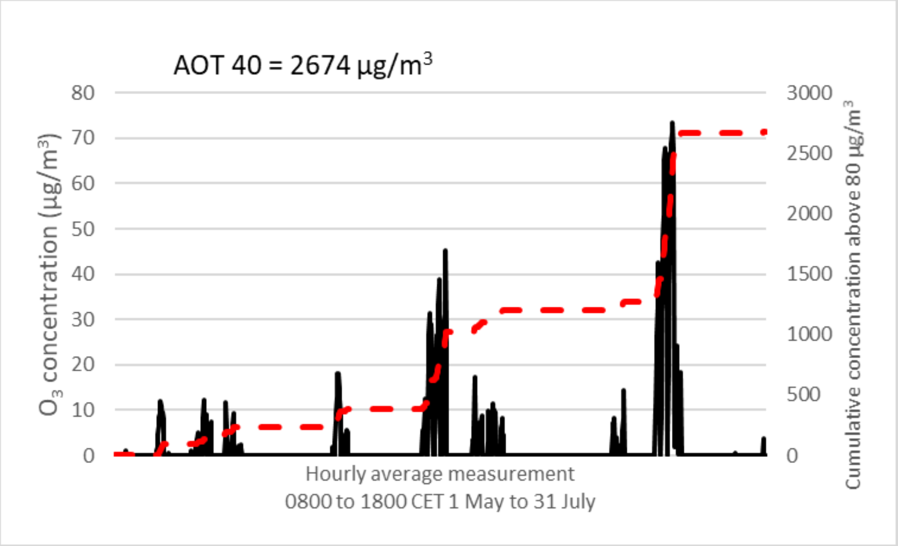


Based the values of wind speed and ozone concentration and Janssen's empirical relationship, it is considered that the following seasonal values for the parameters A and α are appropriate:

Season	Wind speed (m/s)	Ozone concentration (ppb)	A	α
Winter	0-5	20-30	0.83	0.07
Spring/Autumn	0-5	20-30	0.74	0.10
Summer	0-5	20-30	0.67	0.10

The measured ozone concentrations were also examined to determine the AOT 40. This is the sum of the differences of the measured ozone concentrations which are greater than 80µg/m^3 (40 ppb) for the period 0800 to 2000 (Central European Time) over the 1 May to 31 July. The assessment indicated an AOT40 for the data set of 2674µg/m^3 as summarised below.

Ozone AOT 40 assessment (1May to 31 July 2022)



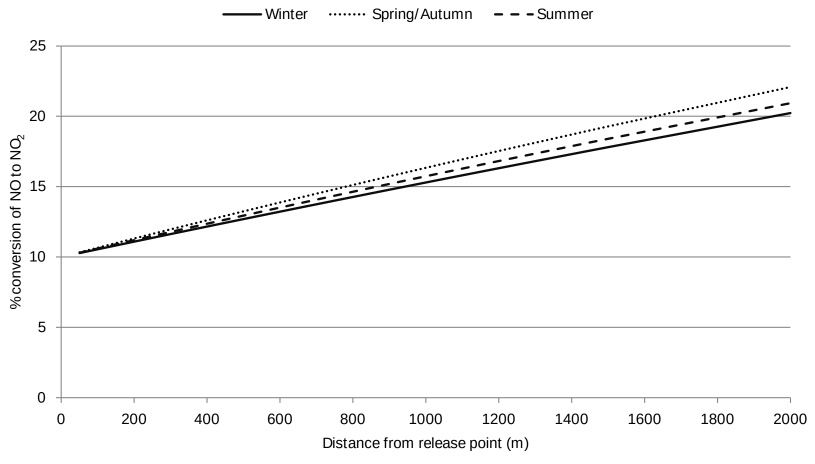
It is likely that a small amount of the nitrogen oxides emitted will be in the form of nitrogen dioxide. For the purposes of this assessment it is assumed that 10% of nitrogen oxides comprise nitrogen dioxide and as such Janssen's relationship for this situation is described by:

$$\frac{NO_2}{NO_x} = y + (1-y)A\left(1-e^{(-\alpha x)}\right)$$

where y is the fraction of nitrogen oxides present as nitrogen dioxide at the point of release.

Based on Janssen's relationship the following seasonal conversion rates are estimated with distance from the source.

Estimated seasonal NO to NO_2 conversion rates



The conversion rates expected for locations within 1 km of the source are less, and in some cases significantly less, than those assumed within the assessment.

ANNEX D Meteorological data

For this modelling assessment hourly sequential meteorological data provided by the UK Met Office from the Normanby Hall station, supplemented with cloud and wind data from the Scampton station, were employed and covered the 5 year period 2018 to 2022. Further details of the data employed are provided in this section.

D.1 Windroses

In section 3.3 a cumulative wind rose for the period 2018 to 2022 is presented. The windroses for each individual year of data used are illustrated below.

Figure D.1 Normanby Hall 2018

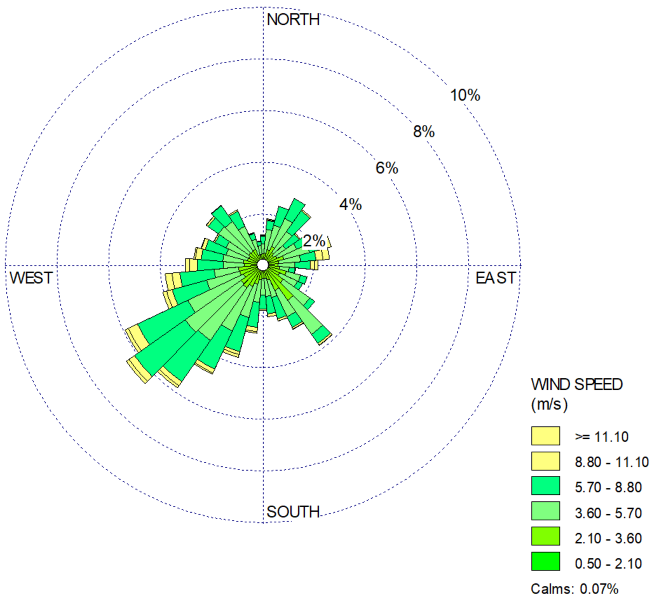


Figure D.2 Normanby Hall 2019

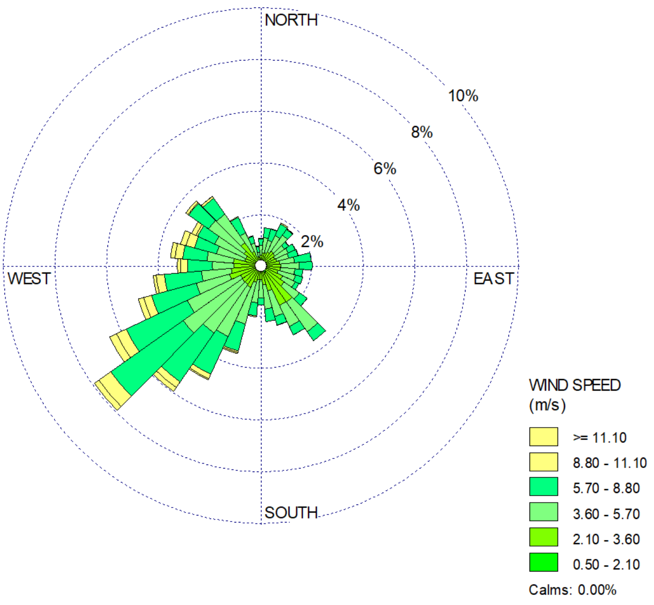


Figure D.3 Normanby Hall 2020

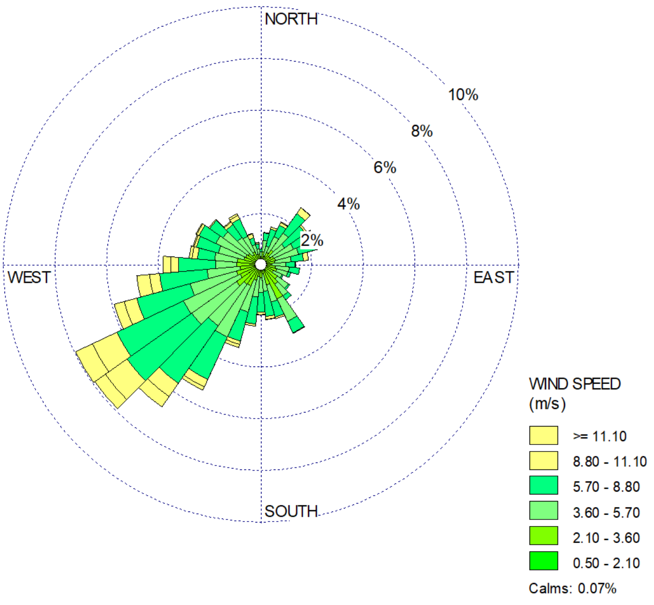


Figure D.4 Normanby Hall 2021

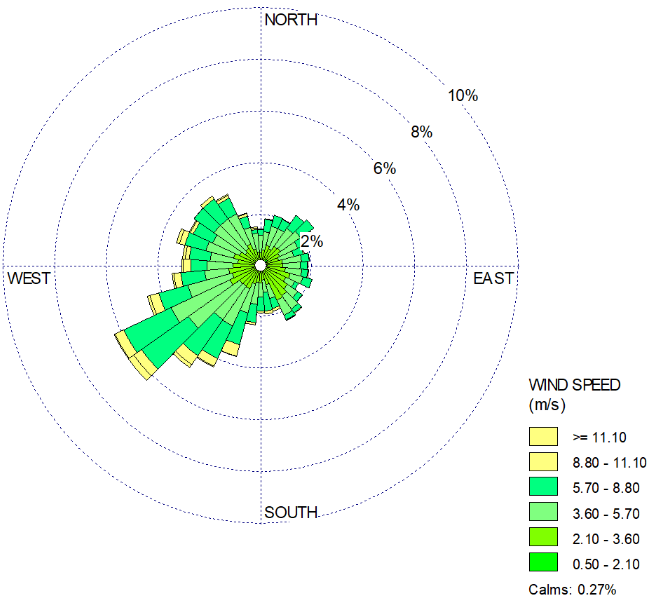
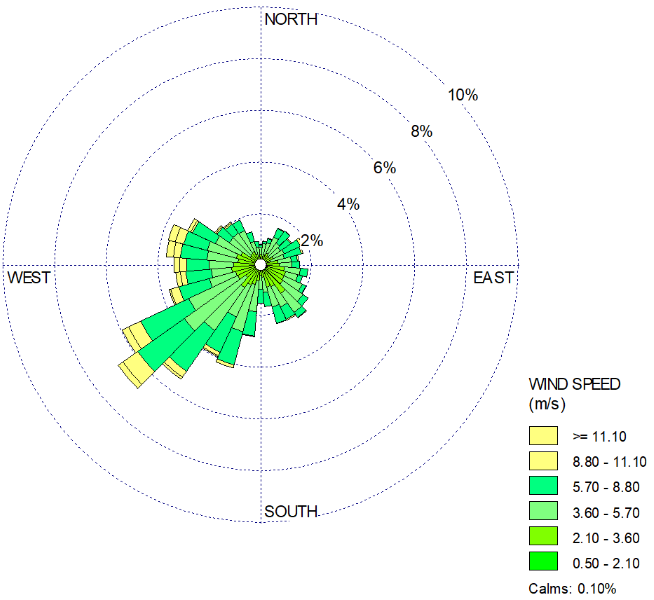


Figure D.5 Normanby Hall 2022



D.2 Data analysis and characteristics

Analyses of the wind direction, wind speed and precipitation are summarised in Tables D.1 and D.2 for the period 2017 to 2021.

Table D.1 Wind speed and direction (2018 to 2022) for Normanby Hall

Wind direction blowing from	Wind speed (m/s)						
	0.3-2.1	2.1-3.6	3.6-5.7	5.7- 8.8	8.8-11.1	> 11.1	Total
	Frequency (% of time)						
N	0.5	1.8	2.6	1.4	0.2	<0.1	6.7
NE	0.6	2.0	3.0	2.2	0.3	<0.1	8.2
E	0.9	2.9	3.1	1.8	0.3	0.1	9.2
SE	0.9	3.8	3.3	1.0	0.1	<0.1	9.2
SE	0.9	2.5	4.4	3.6	0.7	0.1	12.1
SW	0.5	3.4	8.8	7.9	2.5	0.8	24.0
W	0.7	4.2	5.4	5.0	1.9	0.9	18.1
NW	0.5	2.4	4.6	2.7	0.4	0.2	10.7
Calm							1.8

a. Missing data is ignored from the determination of percentage frequency.

Table D.2 Rainfall and wind direction (2018 to 2022) for Normanby Hall

Wind direction Blowing from	Rain fall (mm/h)						
	Dry	0.1-0.3	0.3-0.6	0.6-0.9	0.9-1.2	1.2-1.5	>1.5
	Frequency (% of time)						
N	5.9	0.4	0.2	0.0	0.1	<0.1	0.1
NE	7.4	0.3	0.2	0.0	0.1	<0.1	0.1
E	8.4	0.2	0.2	0.1	0.1	<0.1	0.1
SE	8.2	0.3	0.3	0.1	0.1	<0.1	0.2
SE	10.6	0.6	0.4	0.1	0.1	0.1	0.2
SW	22.2	0.8	0.5	0.1	0.2	0.1	0.2
W	16.9	0.5	0.4	0.1	0.1	<0.1	0.2
NW	9.9	0.4	0.2	<0.1	<0.1	<0.1	0.1
Calm	1.6	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Total	5.9	0.4	0.2	<0.1	0.1	<0.1	0.1

a. Missing data is ignored from the determination of percentage frequency.

The main data characteristics are summarised in Table D.3.

Table D.3 Dataset characteristics (2018 to 2022) for Normanby Hall

No. days data	1795		
No. hours data	43080		
No. calm hours (<0.3 m/s)	788	1.86	%
No. dry hours (<0.1 mm/h)	39988	94.41	%
Mean wind speed (m/s)	4.9		
No. missing records	724	1.71	%
Available records	42356	98.32	%

ANNEX E Discrete receptors

Discrete receptors were used to monitor the process contribution to ambient pollutant concentrations at a range of locations including nearby residential locations and local footpaths as illustrated in Figure 3.1. Details of their location are provided in Table E.1, together with the predicted nitrogen monoxide to nitrogen dioxide conversion rate (see Annex C). All receptors were at an elevation of 1.5m, with the exception of the designated and local ecological sites, which had an elevation of 0m.

The receptors fall into the following groups:

1 to 15 Residential locations (see Figure 3.1)
16 to 29 Footpaths (see Figure 3.1)
30 to 33 Scunthorpe AQMA
34 to 77 Designated and local ecological sites (see Table 3.1)
78 to 97 Site boundary (see Figure 3.1).

Table E.1 Receptor locations

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
1	Lodge Farm	644 m W	496156	411006	16.1
2	South Cottage	563 m W	496246	410976	15.4
3	Broughton Grange Cottages 1	819 m S	496512	410350	17.7
4	Broughton Grange Cottages 2	737 m S	496604	410407	17.0
5	The Lodge	849 m S	496732	410273	18.0
6	Broughton Grange	721 m S	496983	410426	16.8
7	Common Farm	1013 m SE	497504	410401	19.4
8	Decoy Cottage	607 m SE	497312	410810	15.8
9	Far Wood Farm	1245 m SW	496137	410060	21.3
10	Bridge Road 1	1503 m S	497160	409663	23.4
11	Bridge Road 2	1412 m S	497268	409791	22.7
12	Bridge Road 3	1316 m SE	497422	409965	21.9
13	Sandbeck	1202 m SE	497556	410193	21.0
14	Sand House	1883 m NW	495564	412549	26.4
15	Kebwood Farm	1237 m NW	496146	412177	21.3
16	Footpath 152	1699 m NW	495379	412066	25.0
17		1465 m NW	495551	411902	23.1
18		1245 m NW	495692	411707	21.3
19		984 m W	495863	411449	19.1
20		824 m W	495973	411223	17.7
21		778 m W	496035	410934	17.3
22	Footpath 215	815 m SW	496074	410731	17.7
23		886 m SW	496152	410505	18.3
24		1004 m SW	496230	410286	19.3
25		1227 m SW	496215	410037	21.2

Table E.1 continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
26	Footpath 217	1261 m S	496456	409904	21.5
27	Footpath 30	1787 m NE	498111	412324	25.7
28		1646 m NE	498174	412011	24.6
29		1578 m E	498275	411652	24.0
30	AQMA	2004 m NW	494995	412011	27.3
31		1804 m W	494995	411297	25.8
32		1836 m W	494995	410736	26.0
33		2118 m SW	494995	409995	28.1
34	Rowland Plantation LWS	575 m N	496677	411683	15.5
35		424 m N	496787	411544	14.1
36		340 m N	496694	411446	13.3
37		433 m NW	496526	411463	14.2
38		457 m NW	496433	411405	14.4
39		443 m W	496352	411191	14.3
40	Clapgate Pits LWS	710 m W	496092	410994	16.7
41	Broughton Far Wood SSSI & Far Wood AW	710 m W	496113	410908	16.7
42		721 m SW	496132	410824	16.8
43		735 m SW	496158	410746	16.9
44		816 m SW	496122	410650	17.7
45		830 m SW	496162	410578	17.8
46		885 m SW	496205	410456	18.3
47		934 m SW	496236	410368	18.7
48		1011 m SW	496263	410257	19.4
49		1094 m SW	496250	410169	20.1
50		1176 m SW	496232	410085	20.8
51	Broughton Alder Wood SSSI & Far Wood Farm Meadow LWS	1248 m SW	496196	410022	21.4
52		1351 m SW	496109	409954	22.2
53		1446 m SW	495999	409910	23.0
54	Spring Wood AW	1329 m W	495465	411015	22.0
55		1337 m W	495453	411133	22.1
56		1348 m W	495448	411256	22.2
57	Broughton East Wood LWS	732 m S	496875	410393	16.9
58		736 m S	496683	410391	17.0
59		909 m S	496590	410233	18.5
60		833 m S	496648	410299	17.8
61		977 m S	496760	410144	19.1
62	Humber Estuary SSSI RAMSAR SPA SAC	10100 m N	496721	421220	62.0

Table E.1 continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
63	Keb Wood LWS	875 m NW	496304	411848	18.2
64		981 m NW	496122	411839	19.1
65		1067 m NW	496087	411923	19.9
66		1187 m NW	496126	412104	20.9
67		1289 m NW	496078	412195	21.7
68		1307 m NW	496165	412268	21.9
69		1299 m NW	496277	412314	21.8
70		1395 m NW	496128	412348	22.6
71		1570 m NW	495975	412462	24.0
72	New River Ancholme LWS	1403 m E	498144	411487	22.6
73	Weir Dyke LWS	1604 m NE	498097	412049	24.2
74	Broughton West Wood LWS	1793 m SW	495504	409871	25.7
75	Heron Holt LWS	1366 m W	495476	410746	22.3
76	Broughton Pocket Wood LWS	1923 m S	496604	409206	26.7
77	Haverholme Common SNCI	1995 m NW	495061	412115	27.2
78	Site boundary	73 m W	496718	411135	10.7
79		56 m NW	496739	411141	10.5
80		42 m NW	496757	411147	10.4
81		36 m N	496776	411153	10.4
82		42 m N	496798	411161	10.4
83		62 m NE	496827	411170	10.6
84		54 m NE	496834	411152	10.5
85		54 m E	496843	411132	10.5
86		59 m E	496848	411109	10.6
87		52 m SE	496836	411095	10.5
88		38 m SE	496811	411088	10.4
89		39 m S	496788	411081	10.4
90		54 m SW	496764	411073	10.5
91		74 m SW	496740	411065	10.7
92		68 m SW	496737	411077	10.7
93		64 m SW	496732	411094	10.6
94		65 m W	496727	411104	10.6
95		68 m W	496722	411121	10.7
96		52 m NE	496838	411141	10.5
97		57 m E	496847	411117	10.6

a. Position of receptor relative to the centre of the Wressle wellsite.

Table E.2 details the results of the assessment for the discrete receptors. The maximum process contributions for nitrogen dioxide and volatile organic compounds (assessed as benzene), identified as the two largest contributors to air quality impact of the pollutants considered, are provided for each discrete receptor expressed as a proportion of the applicable air quality standard. The values relate to Year 1 of the proposed development, which provided the highest short term and long term process contributions of all years of the proposed development.

Table E2 Maximum process contributions at discrete receptors - Year 1

Receptor		Maximum process contribution (% air quality standard)			
		Nitrogen dioxide		Benzene	
		1 hour	annual	24 hour	annual
1	Lodge Farm	13.6	3.6	14.6	5.7

2	South Cottage	14.6	4.6	16.2	7.1
3	Broughton Grange Cottages 1	9.1	3.0	8.3	4.4
4	Broughton Grange Cottages 2	10.7	3.3	10.2	4.8
5	The Lodge	9.8	2.1	8.2	3.6
6	Broughton Grange	10.9	2.8	12.5	4.8
7	Common Farm	7.4	2.1	8.1	4.3
8	Decoy Cottage	12.6	4.8	15.0	9.5
9	Far Wood Farm	6.6	1.5	4.8	2.3
10	Bridge Road 1	4.8	0.8	4.3	1.6
11	Bridge Road 2	4.9	1.0	4.5	1.9
12	Bridge Road 3	6.2	1.3	4.3	2.5
13	Sandbeck	6.6	1.7	7.2	3.3
14	Sand House	5.0	1.1	4.5	2.1
15	Kebwood Farm	7.6	1.9	7.2	3.8
16	Footpath 152	5.0	1.0	3.4	1.7
17		5.8	1.2	4.1	2.0
18		6.7	1.4	5.0	2.2
19		8.3	1.7	7.1	2.8
20		10.0	2.1	8.5	3.4
21		11.2	2.8	10.1	4.5
22	Footpath 215	10.4	2.5	9.0	3.8
23		8.8	2.1	8.4	3.5
24		8.2	2.1	6.3	3.1
25		6.7	1.6	5.3	2.4
26	Footpath 217	6.2	1.3	4.4	2.1
27	Footpath 30	4.2	1.4	4.1	3.7
28		4.5	1.7	4.6	4.4
29		5.7	1.5	4.7	3.9
30	AQMA	4.5	0.7	2.5	1.2
31		5.4	0.7	3.4	1.2
32		5.2	0.8	3.4	1.3
33		4.1	0.5	1.7	1.0
34	Rowland Plantation LWS	10.6	3.4	15.5	7.4
35		13.5	4.8	22.6	11.3
36		19.4	7.9	31.5	18.0
37		17.6	7.4	23.4	13.8
38		16.2	6.4	22.4	9.5
39		16.9	4.8	19.5	7.5

Table E2 continued

Receptor		Maximum process contribution (% air quality standard)			
		Nitrogen dioxide		Benzene	
		1 hour	annual	24 hour	annual
40	Clapgate Pits LWS	12.8	3.1	12.6	5.0
41	Broughton Far Wood SSSI & Far Wood AW	11.7	3.3	10.8	5.1
42		12.7	3.2	11.8	4.7
43		11.2	2.9	10.3	4.5
44		9.8	2.4	7.9	3.8
45		9.5	2.3	8.7	3.8
46		8.7	2.2	8.4	3.6
47		9.0	2.2	6.9	3.4
48		8.5	2.1	6.6	3.2
49		7.7	1.9	6.1	2.9
50		7.0	1.7	5.6	2.6
51	Broughton Alder Wood SSSI &	6.6	1.5	5.1	2.4
52		6.1	1.3	4.4	2.1
53	Far Wood Farm Meadow LWS	5.6	1.2	4.0	1.8
54	Spring Wood AW	6.6	1.1	4.4	1.9
55		6.9	1.1	4.5	1.8
56		6.5	1.1	4.4	1.8
57	Broughton East Wood LWS	10.5	2.6	9.0	4.4
58		11.8	2.8	10.0	4.4
59		8.6	2.2	7.4	3.4
60		10.2	2.4	8.2	3.7
61		8.6	1.7	7.2	2.9
62	Humber Estuary SSSI RAMSAR SPA SAC	0.5	0.1	0.4	0.1
63	Keb Wood LWS	10.6	3.1	9.8	5.9
64		9.1	2.6	8.7	4.5
65		8.9	2.4	7.4	4.2
66		8.2	2.1	7.5	4.0
67		7.2	1.9	7.0	3.6
68		6.7	1.7	6.4	3.5
69		6.4	1.6	5.9	3.2
70		6.2	1.6	6.0	3.2
71		5.6	1.4	5.8	2.8
72	New River Ancholme LWS	5.9	1.7	5.1	4.2
73	Weir Dyke LWS	4.6	1.7	4.9	4.6
74	Broughton West Wood LWS	5.1	0.7	2.7	1.3
75	Heron Holt LWS	6.4	1.2	4.5	2.0
76	Broughton Pocket Wood LWS	4.5	0.6	2.7	1.1
77	Haverholme Common SNCI	4.4	0.7	2.6	1.3

Table E2 continued

Receptor		Maximum process contribution (% air quality standard)			
		Nitrogen dioxide		Benzene	
		1 hour	annual	24 hour	annual
78	Site boundary	94.2	47.1	124.6	66.2
79		115.9	50.4	113.3	69.9
80		139.5	49.3	187.2	79.0
81		176.4	54.4	272.1	82.6
82		222.9	86.7	182.5	82.8
83		203.9	85.7	175.7	76.1
84		107.9	48.2	148.0	78.5
85		106.2	40.3	144.6	82.2
86		216.8	76.0	155.8	87.6
87		179.5	97.7	135.0	111.5
88		130.2	84.2	133.9	112.0
89		105.9	82.8	143.2	121.8
90		105.6	109.6	177.8	170.8
91		94.3	109.0	252.8	231.3
92		78.4	97.7	327.7	350.0
93		84.3	80.0	320.8	331.5
94		86.9	57.2	291.2	145.9
95		93.6	53.1	209.3	97.8
96		99.1	54.1	239.6	111.0
97		103.2	54.5	151.6	84.7

Tables E.3 to E.6 present the maximum process contributions for operation over all four years considered at the local footpaths, residential locations, most affected nationally designated nature site and the Scunthorpe AQMA..

Table E.3 Maximum process contributions over all operational years - Footpaths

Substance		Maximum process contribution (% air quality standard)			
		Year of operation (see Table G.2)			
		1	2	3 to 14	15
Carbon monoxide	8 hours	0.32	0.30	0.17	0.13
	1 hour	0.20	0.18	0.12	0.12
Nitrogen dioxide	1 hour	11.24	2.33	0.72	1.54
	annual	2.80	0.64	0.09	0.25
Sulphur dioxide	15 min	0.11	0.10	0.01	0.04
	1 hour	0.06	0.05	0.002	0.02
	24 hours	0.08	0.08	0.002	0.02
PM_{10}	24 hours	0.24	0.02	0.01	0.05
	annual	0.07	0.01	0.01	0.02
$PM_{2.5}$	annual	0.14	0.01	0.01	0.03

Table E.3 continued

Substance		Maximum process contribution (% air quality standard)			
		Year of operation (see Table G.2)			
		1	2	3 to 14	15
Benzene	24 hours	10.14	9.52	1.80	3.69
	annual	4.45	4.42	0.17	0.56
Nitrogen monoxide	1 hour	1.50	0.28	0.31	0.44
	annual	0.34	0.08	0.01	0.03

Table E.4 Maximum process contributions over all operational years – Residential locations

Substance		Maximum process contribution (% air quality standard)			
		Year of operation (see Table G.2)			
		1	2	3 to 14	15
Carbon monoxide	8 hours	0.3	0.4	0.2	0.1
	1 hour	0.2	0.2	0.1	0.1
Nitrogen dioxide	1 hour	14.6	2.6	1.7	2.6
	annual	4.8	1.4	0.2	0.5
Sulphur dioxide	15 min	0.14	0.11	0.01	0.06
	1 hour	0.08	0.07	<0.01	0.04
	24 hours	0.13	0.14	<0.01	0.04
PM_{10}	24 hours	0.38	0.04	0.01	0.09
	annual	0.12	0.01	0.01	0.04
$PM_{2.5}$	annual	0.24	0.03	0.02	0.07
Benzene	24 hours	16.2	14.6	2.6	6.1
	annual	9.5	9.1	0.3	1.0
Nitrogen monoxide	1 hour	1.7	0.4	0.4	0.6
	annual	0.6	0.2	0.02	0.1

Table E.5 Maximum process contributions for nitrogen oxides, sulphur dioxide, nitrogen and acid deposition at the Broughton Far Wood SSSI

Substance		Year of operation (see Table G.2)			
		Maximum process contribution (% of critical levels or load)			
		1	2	3 to 14	15
Nitrogen oxides	annual mean	6.3	1.4	0.1	0.4
Nitrogen oxides	daily mean	17.0	3.2	2.3	2.7
Sulphur dioxide	annual mean	0.1	0.1	0.001	0.005
Nitrogen deposition	annual mean	3.8	0.8	0.1	0.2
Acid deposition	annual mean	3.0	0.8	0.1	0.2

Table E.6 Maximum process contributions over all operational years – Scunthorpe AQMA

Substance		Maximum process contribution (% air quality standard)			
		Year of operation (see Table G.2)			
		1	2	3 to 14	15
Carbon monoxide	8 hours	0.17	0.13	0.07	0.16
	1 hour	0.11	0.10	0.04	0.10
Nitrogen dioxide	1 hour	5.45	1.20	0.24	0.53
	annual	0.75	0.20	0.03	0.05
Sulphur dioxide	15 min	0.08	0.06	0.004	0.01
	1 hour	0.03	0.03	<0.001	0.01
	24 hours	0.02	0.02	0.001	0.01
PM_{10}	24 hours	0.06	0.01	0.002	0.002
	annual	0.02	0.002	0.002	0.004
$PM_{2.5}$	annual	0.04	0.004	0.004	0.01
Benzene	24 hours	3.43	3.00	0.78	1.03
	annual	1.30	1.26	0.05	0.11
Nitrogen monoxide	1 hour	0.70	0.17	0.14	0.20
	annual	0.09	0.02	0.004	0.01

ANNEX F Detailed results for designated and local ecological sites

The impact of wellsite process contributions with regard to critical levels for nitrogen oxides and sulphur dioxide and critical loads for nitrogen and acid deposition at designated and local ecological sites is summarised in Section 4.3. Annex F provides the corresponding detailed results.

The critical loads and levels adopted for use in this assessment have been obtained from the APIS and are summarised in Table F.1.

Table F.1 Site relevant critical loads and levels

Site		41-50	51-53	54-56	34-39
		Broughton Far Wood SSSI	Broughton Alder Wood SSSI	Spring Wood AW	Rowland Plantation LWS
Critical levels for nitrogen oxides and sulphur dioxide (see Table 2.2)					
Annual mean NO_x	$\mu gNO_2/m^3$	30			
Daily mean NO_x	$\mu gNO_2/m^3$	200			
Annual mean SO_2	$\mu gSO_2/m^3$	10			
Critical load for nitrogen deposition					
Most sensitive habitat		Calcareous grassland	Lysimachia nemorum woodland	Broadleaved, mixed and yew woodland	Broadleaved, mixed and yew woodland
N deposition CL	kgN/ha/y	10-20	not sensitive	10-15	10-15
Critical loads for acid deposition					
Most sensitive habitat		Broadleaved, mixed and yew woodland	Lysimachia nemorum woodland	Broadleaved, mixed and yew woodland	Broadleaved, mixed and yew woodland
Minimum CLminN	keq	0.285	not sensitive	0.285	0.285
Minimum CLmaxS	keq	0.704		0.704	0.704
Minimum CLmaxN	keq	0.989		0.989	0.989

Table F.1 continued

Site		41-50	57-61	40	62
		Far Wood AW	Broughton East Wood LWS	Clapgate Pits LWS	Humber Estuary SAC
Critical levels for nitrogen oxides and sulphur dioxide (see Table 2.2)					
Annual mean NO_x	$\mu gNO_2/m^3$	30			
Daily mean NO_x	$\mu gNO_2/m^3$	200			
Annual mean SO_2	$\mu gSO_2/m^3$	10			
Critical load for nitrogen deposition					
Most sensitive habitat		Broadleaved, mixed and yew woodland	Broadleaved, mixed and yew woodland	Calcareous grassland	Coastal dune grasses
N deposition CL	kgN/ha/y	10-15	10-15	5-10	5-10
Critical loads for acid deposition					
Most sensitive habitat		Broadleaved, mixed and yew woodland	Broadleaved, mixed and yew woodland	Calcareous grassland	Calcareous grassland
Minimum CLminN	keq	0.285	0.285	0.999	0.856
Minimum CLmaxS	keq	0.704	0.704	4.000	4.000
Minimum CLmaxN	keq	0.989	0.989	4.999	4.856

Table F.1 continued

Site		73	53	74	75
		Weir Dyke LWS	Far Wood Farm Meadow LWS	Broughton West Wood LWS	Heron Holt LWS
Critical levels for nitrogen oxides and sulphur dioxide (see Table 2.2)					
Annual mean NO_x	$\mu gNO_2/m^3$	30			

Daily mean NO_x	$\mu gNO_2/m^3$	200			
Annual mean SO_2	$\mu gSO_2/m^3$	10			
Critical load for nitrogen deposition					
Most sensitive habitat		Broadleaved, mixed and yew woodland			
N deposition CL	kgN/ha/y	10-15	10-15	10-15	10-15
Critical loads for acid deposition					
Most sensitive habitat		Broadleaved, mixed and yew woodland			
Minimum CLminN	keq	0.357	0.285	0.142	0.285
Minimum CLmaxS	keq	8.321	0.704	1.064	0.704
Minimum CLmaxN	keq	8.678	0.989	1.206	0.989

Table F.1 continued

Site		63-71	76	77	72
		Keb Wood LWS	Broughton Pocket Wood LWS	Haverholme Common SINC	New River Ancholme LWS
Critical levels for nitrogen oxides and sulphur dioxide (see Table 2.2)					
Annual mean NO_x	$\mu gNO_2/m^3$	30			
Daily mean NO_x	$\mu gNO_2/m^3$	200			
Annual mean SO_2	$\mu gSO_2/m^3$	10			
Critical load for nitrogen deposition					
Most sensitive habitat		Broadleaved, mixed and yew woodland			
N deposition CL	kgN/ha/y	10-15	10-15	10-15	10-15
Critical loads for acid deposition					
Most sensitive habitat		Broadleaved, mixed and yew woodland			
Minimum CLminN	keq	0.285	0.142	0.285	0.357
Minimum CLmaxS	keq	0.704	1.063	0.703	8.322
Minimum CLmaxN	keq	0.989	1.205	0.988	8.679

a. The critical levels and critical loads are the minimum specified for most sensitive habitat within the site.

The site background concentrations, as obtained from APIS, are summarised in Table F.2. These represent the maximum background concentration across the entire site in each case.

Table F.2 Site relevant background concentrations

Site		41-50	51-53	54-56	34-39
		Broughton Far Wood SSSI	Broughton Alder Wood SSSI	Spring Wood AW	Rowland Plantation LWS
Nitrogen oxides annual mean	$\mu gNO_2/m^3$	10.82	10.97	11.05	10.70
Sulphur dioxide annual mean	$\mu gSO_2/m^3$	1.88	1.88	1.89	1.87
Nitrogen deposition	kgN/ha/y	34.46	34.53	33.98	34.38
Acid deposition	keq/ha y	2.44	2.44	2.42	2.44

Table F.2 continued

Site		41-50	57-61	40	62
		Far Wood AW	Broughton East Wood LWS	Clapgate Pits LWS	Humber Estuary SAC
Nitrogen oxides annual mean	$\mu gNO_2/m^3$	10.63	10.63	10.63	32.10
Sulphur dioxide annual mean	$\mu gSO_2/m^3$	1.88	1.88	1.88	3.88
Nitrogen deposition	kgN/ha/y	34.46	34.46	20.17	31.04
Acid deposition	keq/ha y	2.44	2.44	1.65	2.21

Table F.2 continued

Site		73	53	74	75
		Weir Dyke LWS	Far Wood Farm Meadow LWS	Broughton West Wood LWS	Heron Holt LWS
Nitrogen oxides annual mean	$\mu gNO_2/m^3$	10.92	10.63	10.97	10.82
Sulphur dioxide annual mean	$\mu gSO_2/m^3$	1.85	1.88	1.58	1.87
Nitrogen deposition	kgN/ha/y	34.46	34.46	34.04	34.01
Acid deposition	keq/ha y	2.43	2.44	2.41	2.41

Table F.2 continued

Site		63-71	76	77	72
		Keb Wood LWS	Broughton Pocket Wood LWS	Haverholme Common SINC	New River Ancholme LWS
Nitrogen oxides annual mean	$\mu gNO_2/m^3$	10.70	10.86	11.78	10.33
Sulphur dioxide annual mean	$\mu gSO_2/m^3$	1.89	1.72	1.89	1.87
Nitrogen deposition	kgN/ha/y	34.38	34.53	33.95	34.53
Acid deposition	keq/ha y	2.44	2.44	2.43	2.44

a. Background concentrations are the maximum across the entire site.

The maximum process contributions to concentrations of nitrogen oxides and sulphur dioxide at the designated and local ecological sites are detailed in Table F.3 and are correspond to the summary in Table 4.6.

Table F.3 Maximum process contributions of nitrogen oxides and sulphur dioxide at designated and local ecological sites – Year 1

Site		41-50 Broughton Far Wood SSSI	51-53 Broughton Alder Wood SSSI	54-56 Spring Wood AW	34-39 Rowland Plantation LWS
Nitrogen oxides[a]					
Maximum annual mean PC	$\mu gNO_2/m^3$	1.89	0.88	0.65	4.51
	% CL	6.3	2.9	2.2	15.0
Background concentration	$\mu gNO_2/m^3$	10.82	10.97	11.05	10.7
Maximum annual mean PEC	$\mu gNO_2/m^3$	12.71	11.85	11.70	15.21
	% CL	42	40	39	51
Maximum daily mean PC	$\mu gNO_2/m^3$	33.95	14.71	12.90	76.80
	% CL	17.0	7.4	6.5	38.4
Back ground concentration	$\mu gNO_2/m^3$	21.64	21.94	22.10	21.40
Maximum daily mean PEC	$\mu gNO_2/m^3$	55.59	36.65	35.00	98.20
	% CL	28	18	18	49
Sulphur dioxide					
Maximum annual mean PC	$\mu gSO_2/m^3$	0.0099	0.0046	0.0036	0.0301
	% CL	0.0988	0.0465	0.0360	0.3011
Background concentration	$\mu gSO_2/m^3$	1.88	1.88	1.89	1.87
Maximum annual mean PEC	µgSO2/m3	1.89	1.88	1.89	1.90
	% CL	19	19	19	19

Table F.3 continued

Site		41-50 Far Wood AW	57-61 Broughton East Wood LWS	40 Clapgate Pits LWS	62 Humber Estuary SAC
Nitrogen oxides[a]					
Maximum annual mean PC	$\mu gNO_2/m^3$	1.89	1.63	1.76	0.033
	% CL	6.3	5.4	5.9	0.11
Background concentration	$\mu gNO_2/m^3$	10.82	10.63	10.63	32.1
Maximum annual mean PEC	$\mu gNO_2/m^3$	12.71	12.26	12.39	32.13
	% CL	42	41	41	107
Maximum daily mean PC	$\mu gNO_2/m^3$	33.95	31.01	35.62	1.04
	% CL	17.0	15.5	17.8	0.5
Back ground concentration	$\mu gNO_2/m^3$	21.64	21.26	21.26	64.20
Maximum daily mean PEC	$\mu gNO_2/m^3$	55.59	52.27	56.88	65.24
	% CL	28	26	28	33
Sulphur dioxide					
Maximum annual mean PC	$\mu gSO_2/m^3$	0.0099	0.0083	0.0096	0.0003
	% CL	0.0988	0.0833	0.0957	0.0025
Background concentration	$\mu gSO_2/m^3$	1.88	1.88	1.88	3.88
Maximum annual mean PEC	$\mu gSO_2/m^3$	1.89	1.89	1.89	3.88
	% CL	19	19	19	39

Table F.3 continued

Site		73 Weir Dyke LWS	53 Far Wood Farm Meadow LWS	74 Broughton West Wood LWS	75 Heron Holt LWS
Nitrogen oxides[a]					
Maximum annual mean PC	$\mu gNO_2/m^3$	0.990	0.657	0.421	0.691
	% CL	3.30	2.19	1.40	2.30
Background concentration	$\mu gNO_2/m^3$	10.92	10.82	10.97	10.82
Maximum annual mean PEC	$\mu gNO_2/m^3$	11.91	11.48	11.39	11.51
	% CL	40	38	38	38
Maximum daily mean PC	$\mu gNO_2/m^3$	11.00	12.46	7.18	13.42
	% CL	5.5	6.2	3.6	6.7
Back ground concentration	$\mu gNO_2/m^3$	21.84	21.64	21.94	21.64
Maximum daily mean PEC	$\mu gNO_2/m^3$	32.84	34.10	29.12	35.06
	% CL	16	17	15	18
Sulphur dioxide					
Maximum annual mean PC	$\mu gSO_2/m^3$	0.0086	0.0036	0.0025	0.0039
	% CL	0.0863	0.0359	0.0252	0.0385
Background concentration	$\mu gSO_2/m^3$	1.85	1.88	1.58	1.87
Maximum annual mean PEC	$\mu gSO_2/m^3$	1.86	1.88	1.58	1.87
	% CL	19	19	16	19

Table F.3 continued

Site		63-71 Keb Wood LWS	76 Broughton Pocket Wood LWS	77 Haverholme Common SINC	72 New River Ancholme LWS
Nitrogen oxides[a]					
Maximum annual mean PC	$\mu gNO_2/m^3$	1.745	0.352	0.422	0.957
	% CL	5.82	1.17	1.41	3.19
Background concentration	$\mu gNO_2/m^3$	10.7	10.86	11.78	10.33
Maximum annual mean PEC	$\mu gNO_2/m^3$	12.44	11.21	12.20	11.29
	% CL	41	37	41	38
Maximum daily mean PC	$\mu gNO_2/m^3$	27.96	6.28	7.13	10.72
	% CL	14.0	3.1	3.6	5.4
Back ground concentration	$\mu gNO_2/m^3$	21.40	21.72	23.56	20.66
Maximum daily mean PEC	$\mu gNO_2/m^3$	49.36	28.00	30.69	31.38
	% CL	25	14	15	16
Sulphur dioxide					
Maximum annual mean PC	$\mu gSO_2/m^3$	0.0104	0.0021	0.0024	0.0078
	% CL	0.1042	0.0209	0.0237	0.0784
Background concentration	$\mu gSO_2/m^3$	1.87	1.72	1.89	1.87
Maximum annual mean PEC	$\mu gSO_2/m^3$	1.88	1.72	1.89	1.88
	% CL	19	17	19	19

a. Total nitrogen oxides are expressed as NO_2.

The determination of nitrogen deposition at the designated and local ecological sites is summarised in Table 4.7. Table F.4 provides the corresponding detailed determination.

Table F.4 Nitrogen deposition at designated and local ecological sites – Year 1

Site		41-50 Broughton Far Wood SSSI	51-53 Broughton Alder Wood SSSI	54-56 Spring Wood AW	34-39 Rowland Plantation LWS
Maximum process N	$\mu gNO_2/m^2/s^a$	0.00396	0.00185	0.00137	0.00948

deposition	kgN/ha/y	0.381	0.178	0.131	0.910
	% CL[b]	3.806	not sensitive	1.311	9.100
Background concentration	kN/ha y	34.46	34.53	33.98	34.38
Maximum annual mean PEC	kN/ha y	34.84	34.71	34.11	35.29
	% CL[b]	348	not sensitive	341	353

Table F.4 continued

Site		41-50	57-61	40	62
		Far Wood AW	Broughton East Wood LWS	Clapgate Pits LWS	Humber Estuary SAC
Maximum process N deposition	$\mu gNO_2/m^2/s$[a]	0.00396	0.00342	0.00369	0.00007
	kgN/ha/y	0.381	0.328	0.355	0.007
	% CL[b]	3.806	3.280	7.092	0.133
Background concentration	kN/ha y	34.46	34.46	20.17	31.04
Maximum annual mean PEC	kN/ha y	34.84	34.79	20.52	31.05
	% CL[b]	348	348	410	621

Table F.4 continued

Site		73	53	74	75
		Weir Dyke LWS	Far Wood Farm Meadow LWS	Broughton West Wood LWS	Heron Holt LWS
Maximum process N deposition	$\mu gNO_2/m^2/s$[a]	0.00208	0.00138	0.00088	0.00145
	kgN/ha/y	0.200	0.132	0.085	0.139
	% CL[b]	1.996	1.325	0.849	1.393
Background concentration	kN/ha y	34.46	34.46	34.04	34.01
Maximum annual mean PEC	kN/ha y	34.66	34.59	34.12	34.15
	% CL[b]	347	346	341	341

Table F.4 continued

Site		63-71	76	77	72
		Keb Wood LWS	Broughton Pocket Wood LWS	Haverholme Common SINC	New River Ancholme LWS
Maximum process N deposition	$\mu gNO_2/m^2/s$[a]	0.00366	0.00074	0.00089	0.00201
	kgN/ha/y	0.352	0.071	0.085	0.193
	% CL[b]	3.518	0.709	0.851	1.929
Background concentration	kN/ha y	34.36	34.53	33.95	34.53
Maximum annual mean PEC	kN/ha y	34.71	34.60	34.04	34.72
	% CL[b]	347	346	340	347

a. Determination of deposition is based on the deposition velocity for forest terrain[25].
b. The critical load selected is the minimum of the range specified for the most sensitive habitat over the entire site.

The determination of the process contribution to acid deposition at these sites is summarised in Table 4.7. The detailed determination of acid deposition is presented in Table F.5.

Table F.5 Acid deposition at designated and local ecological sites – Year 1

Site		41-50	51-53	54-56	34-39
		Broughton Far Wood SSSI	Broughton Alder Wood SSSI	Spring Wood AW	Rowland Plantation LWS
Nitrogen acid deposition	$\mu gNO_2/m^2/s$[a]	0.00396	0.00185	0.00137	0.00948
	kgN/ha/y	0.3806	0.1778	0.1311	0.9100
	keq/ha y	0.0272	0.0127	0.0094	0.0650
Sulphur acid deposition	$\mu gSO_2/m^2/s$[a]	0.000237	0.000112	0.000086	0.000723
	keq/ha y	0.00234	0.00110	0.00085	0.00712
Total process acid deposition	keq/ha/y	0.0295	0.0138	0.0102	0.0721
	% CL[b,c]	3.0	not sensitive	1.0	7.3
Total background acid deposition	keq/ha/y	2.44	2.44	2.42	2.44
Maximum annual mean PEC	keq/ha y	2.47	2.45	2.43	2.51
	% CL[b,c]	250	not sensitive	246	254

Table F.5 continued

Site		41-50	57-61	40	62
		Far Wood AW	Broughton East Wood LWS	Clapgate Pits LWS	Humber Estuary SAC
Nitrogen acid deposition	$\mu gNO_2/m^2/s$[a]	0.00396	0.00342	0.00369	0.00007
	kgN/ha/y	0.3806	0.3280	0.3546	0.0067
	keq/ha y	0.0272	0.0234	0.0253	0.0005
Sulphur acid deposition	$\mu gSO_2/m^2/s$[a]	0.000237	0.000200	0.000230	0.000006
	keq/ha y	0.00234	0.00197	0.00226	0.00006
Total process acid deposition	keq/ha/y	0.0295	0.0254	0.0276	0.0005
	% CL[b,c]	3.0	2.6	0.6	0.01

Table F.5 continued

Site		41-50 Far Wood AW	57-61 Broughton East Wood LWS	40 Clapgate Pits LWS	62 Humber Estuary SAC
Total background acid deposition	keq/ha/y	2.44	2.44	1.65	2.21
Maximum annual mean PEC	keq/ha y	2.47	2.47	1.68	2.21
	% CL[b,c]	250	249	34	46

Table F.5 continued

Site		73 Weir Dyke LWS	53 Far Wood Farm Meadow LWS	74 Broughton West Wood LWS	75 Heron Holt LWS
Nitrogen acid deposition	$\mu gNO_2/m^2/s$[a]	0.00208	0.00138	0.00088	0.00145
	kgN/ha/y	0.1996	0.1325	0.0849	0.1393
	keq/ha y	0.0143	0.0095	0.0061	0.0099
Sulphur acid deposition	$\mu gSO_2/m^2/s$[a]	0.000207	0.000086	0.000060	0.000092
	keq/ha y	0.00204	0.00085	0.00060	0.00091
Total process acid deposition	keq/ha/y	0.0163	0.0103	0.0067	0.0109
	% CL[b,c]	0.2	1.0	0.6	1.1
Total background acid deposition	keq/ha/y	2.43	2.44	2.41	2.41
Maximum annual mean PEC	keq/ha y	2.45	2.45	2.42	2.42
	% CL[b,c]	28	248	200	245

Table F.5 continued

Site		63-71 Keb Wood LWS	76 Broughton Pocket Wood LWS	77 Haverholme Common SINC	72 New River Ancholme LWS
Nitrogen acid deposition	$\mu gNO_2/m^2/s$[a]	0.00366	0.00074	0.00089	0.00201
	kgN/ha/y	0.3518	0.0709	0.0851	0.1929
	keq/ha y	0.0251	0.0051	0.0061	0.0138
Sulphur acid deposition	$\mu gSO_2/m^2/s$[a]	0.000250	0.000050	0.000057	0.000188
	keq/ha y	0.00246	0.00050	0.00056	0.00185
Total process acid deposition	keq/ha/y	0.0276	0.0056	0.0066	0.0156
	% CL[b,c]	2.8	0.5	0.7	0.2
Total background acid deposition	keq/ha/y	2.44	2.44	2.43	2.44
Maximum annual mean PEC	keq/ha y	2.47	2.45	2.44	2.46
	% CL[b,c]	250	203	247	28

a. Determination of deposition is based on the deposition velocity for forest terrain[25].
b. Calculations of process contribution and predicted environmental concentrations were used the APIS critical load tool.
c. The critical loads selected are the minimum specified for all habitats over the entire site, where applicable.

ANNEX G Site equipment specification

Details of the equipment specified for use and its operation during the proposed development are provided in Tables G.1 and G2. Table G.3 provides details of the expected HDV movements during the proposed development.

Table G.1 Site equipment specification

Equipment		Type	Description	Reference
A1	Construction plant	14 t excavator	Hitachi ZX130-6 14t excavator, 78.5 kW Isuzu AR-4JJX DOC and SCR, EU Stage 4	Hitachi, ZAXIS utility class excavators (17/08), 2019.
A2	Construction plant	14 t excavator	Caterpillar 323 14t excavator, Caterpillar 7.1 engine, 122 kW, EU Stage 4	Caterpillar 323 product specification, Cat.com
A3	Construction plant	14 t excavator	Volvo EC104EL 14t excavator, Volvo D4J engine, 90 kW, EU Stage 4	Volvo, Brochure for crawler excavator EC140E, 20045714-C, 2017.07.
A4	Construction plant	Dozer	Liebherr PR726 dozer, Liebherr 934 A7, 120 kW, EU Stage 4	Liebherr, PR 726 Litronic, LWT/VM 12227193-0, 5.05.19.
A5	Construction plant	6t dumper	Thwaites MACH 2062 6t dumper, Deutz TD 3.6 L4 engine, 55.4 kW, EU Stage 3B	Thwaites Limited, MACH 2062 6t power swivel, 08/2017
A6	Construction plant	9t dumper (2)	Thwaites MACH 2098 9t dumper, Deutz TD 3.6 L4 engine, 55.4 kW, EU Stage 3B	Thwaites Limited, MACH 2098 9t power swivel, 08/2017
A7	Construction plant	13t sheeps foot roller (2)	Hamm 13i 13t sheeps foot roller, Deutz TCD 4.1 L4, 115 kW, EU Stage 5	Hamm AG, Hamm3i, 12.19, 2737730
A8	Construction plant	Roller (2)	Bomag BW120 roller, Kubota D1803, engine, 24.6 kW, EU Stage 5	Bomag, Technical data, tandem rollers, BW 120 AD-5, 130220 sa04.
A9	Construction plant	12t dumper	Hydrema 912F 12t dumper, Cummins QSB 4.5L, 108 kW, EU Stage 4	Hydrema, 912F series articulated dump trucks, 0855426/02/2018
A10	Construction plant	Concrete pump	Schwing Stetter concrete pump, engine OM470, R6, 240 kW, EU Stage 6	http://www.schwing-stetter.co.uk/Downloads/S20.pdf?t=637436076063436607
B		Lighting Towers (4)	Site light 908, Perkins 403D-11G engine, 8.8 kVA, EU stage 3A	Bruno Generators, Site light 908P specification.
C		Wellfare Unit	Librerty Guard Welfare Unit, 15 kVA generator, assumed to be EU Stage 3A compliant	MHM UK, MG15000 SSK-MV specification
D		Surface Conductor Rig	Junttan PM 20LC surface conductor rig, Cummins QSB6.7 engine, 179 kW, EU stage 3A	Junttan, PM20LC Pile Driving Rig Data sheet, M120LC003, 2 March 2009
E		Generator	Perkins 2206A- E143TAG3 generator, 350 kW, EU Stage 3A	Perkins, PM1880A/12/14.2206A-E13TAG3 engine specification
F		Main drilling rig engines (4)	T-208 WIRTH GH 1500 EG-AC-SV, Caterpillar 3512B, 1360 kWe, manufacturer's emission specification	Caterpillar Electric Power Technical Specification Sheet 3512B, TSS-DM8251-01-GS-EPG-8033726, 7 October 2017

Table G.1 continued

Equipment		Type	Description	Reference
G		Workover rig	Moor 475 workover rig, Detroit Series 60 engine, 354 kW, US Tier 2 compliant.	Detroit Diesel Corp, Detroit engine series 50 and 60 for petroleum applications, 6SA587 304, 2003.
H		Flare	Uniflare UF10 2500	Uniflare Group, Uniflare UF10 range brochure, 2020.
I		Microturbine (3)	Capstone C65 Microturbine (65 kw), assume	C65 Technical Specification, P1222 C65 HPNG, CAP 186, 2022
J		Gas engine	Jenbacher J612, 2MWe	General Electric, Jenbacher JMS612 GS NL, Technical document 27.9.18/A
K1	Restoration plant	14 t excavator	Hitachi ZX130-6 14t excavator, 78.5 kW Isuzu AR-4JJX DOC and SCR, EU Stage 4	Hitachi, ZAXIS utility class excavators (17/08), 2019.
K2		14 t excavator	Caterpillar 323 14t excavator, Caterpillar 7.1 engine, 122 kW, EU Stage 4	Caterpillar 323 product specification, Cat.com
K3		14 t excavator	Volvo EC104EL 14t excavator, Volvo D4J engine, 90 kW, EU Stage 4	Volvo, Brochure for crawler excavator EC140E, 20045714-C, 2017.07.
K4		Dozer	Liebherr PR726 dozer, Liebherr 934 A7, 120 kW, EU Stage 4	Liebherr, PR 726 Litronic, LWT/VM 12227193-0, 5.05.19.
K5		6t dumper	Thwaites MACH 2062 6t dumper, Deutz TD 3.6 L4 engine, 55.4 kW, EU Stage 3B	Thwaites Limited, MACH 2062 6t power swivel, 08/2017
K6		9t dumper (2)	Thwaites MACH 2098 9t dumper, Deutz TD 3.6 L4 engine, 55.4 kW, EU Stage 3B	Thwaites Limited, MACH 2098 9t power swivel, 08/2017
K7		12t dumper	Hydrema 912F 12t dumper, Cummins QSB 4.5L, 108 kW, EU Stage 4	Hydrema, 912F series articulated dump trucks, 0855426/02/2018
L		100 tonne crane	Liebherr 400kW diesel engine assume EU Stage 4	Liebherr-Werk Ehingen GmbH, Mobile and crawler cranes, LTM1100-5.3, 10/2022.

Table G.2 Equipment usage during proposed development phases

Year	Phase	Activity	Duration (days)	Start	End	Days/week	Hours/day	Working days	Equipment in use
1	1A	Site construction works	56	1	56	6	12	48	A,B,C,D,E
	2A	Drilling of W2	73	57	129	7	24	73	B,C,E,F,L
	2B	Drilling of W3	74	130	203	7	24	74	B,C,E,F,L
	3A	Production test on W2	31	204	234	7	24	31	B,C,E,G
	3B	Production test on W3	32	235	266	7	24	32	B,C,E,G
	3C	Proppant Squeeze on W2	10	267	276	7	24	10	B,C,E,G
	3D	Proppant Squeeze on W3	11	277	287	7	24	11	B,C,E,G
	3E	Production test on W2	17	288	304	7	24	17	B,C,E,G
	3F	Production test on W3	18	305	322	7	24	18	B,C,E,G
	4A	Production operations W1	365	1	365	7	24	365	H,J
	4A	Production operations	43	323	365	7	24	43	H,J
2	4A	Production operations	365	366	730	7	24	365	H,J
	4B	Site Civils and enhanced production facilities	203	528	730	6	12	174	A,C,E,H,J
3	4A	Production operations	358	731	1088	7	24	358	
	4C	Slickline operations	7	1089	1095	7	24	7	L
4	4A	Production operations	358	1096	1453	7	24	358	
	4C	Slickline operations	7	1454	1460	7	24	7	L
5	4A	Production operations	358	1461	1818	7	24	358	
	4C	Slickline operations	7	1819	1825	7	24	7	L
6	4A	Production operations	323	1826	2148	7	24	323	
	4C	Slickline operations	7	2149	2155	7	24	7	L
	4D	Workover operations	35	2156	2190	7	24	35	B,C,E,G,L
7	4A	Production operations	358	2191	2548	7	24	358	
	4C	Slickline operations	7	2549	2555	7	24	7	L
8	4A	Production operations	358	2556	2913	7	24	358	
	4C	Slickline operations	7	2914	2920	7	24	7	L
9	4A	Production operations	358	2921	3278	7	24	358	
	4C	Slickline operations	7	3279	3285	7	24	7	L

Table G.2 Equipment usage during proposed development phases

Year	Phase	Activity	Duration (days)	Start	End	Dats/week	Hours/day	Working days	Equipment in use
10	4A	Production operations	358	3286	3643	7	24	358	
	4C	Slickline operations	7	3644	3650	7	24	7	L
11	4A	Production operations	323	3651	3973	7	24	323	
	4C	Slickline operations	7	3974	3980	7	24	7	L
	4D	Workover operations	35	3981	4015	7	24	35	B,C,E,G,L
12	4A	Production operations	358	4016	4373	7	24	358	
	4C	Slickline operations	7	4374	4380	7	24	7	L
13	4A	Production operations	358	4381	4738	7	24	358	
	4C	Slickline operations	7	4739	4745	7	24	7	L
14	4A	Production operations	358	4746	5103	7	24	358	
	4C	Slickline operations	7	5104	5110	7	24	7	L
15	5a	Well abandonment	36	7301	7336	7	24	36	B,C,D,E,H
	5b	Site restoration	48	7337	7384	6	12	42	B,C,D,K,L

Table G.3 HDV movements during proposed development phases

Year	HDVs arriving at site	Total HDV movements (in and out)	AADT
1	2331	4662	12.8
2	985	1970	5.4
3, 4, 7 to 10, 12 to 14 (each year)	1797	3594	9.8
6 & 11 (each year)	1727	3454	9.5
15	348	696	1.9

a. AADT - annual average daily traffic count - based on 365 days per year and the maximum number of two way movements (in and out of site).
b. HDV – a heavy duty vehicle of gross weight greater than 3.5 t.

The highest number of two-way HDV movements over a period of 365 consecutive days is 4662 equivalent to an annual average daily traffic (AADT) count of 13. This occurs during Year 1 of the proposed development.

ANNEX H Construction dust risk assessment

H.1 Introduction

It is likely that the construction activities associated with the proposed development of the wellsite will give rise to dust emissions, albeit temporary in nature and largely restricted the areas close to the wellsite.

The potential for fugitive dust is most likely to arise from the movement of vehicles over the earth, the stripping of soil, excavations and the subsequent storage of excavated materials and transfer of materials to and from lorries. This may be exacerbated by spillages during transportation and handling and also by periods of dry weather and high wind speeds.

The potential for dust impact has been assessed based on the guidance provided by the Institute of Air Quality Management[30]. Four activities considered to have the most significant potential for fugitive release of dust are identified; demolition, earthworks, construction, and track-out. In this case there are no demolition activities associated with the proposed development.

The construction of the extension to Wressle wellsite (phase 1) will take place in in Year 1 and will last around 56 days. During the subsequent well drilling, testing and production phases of the proposed development there will be no appreciable construction work likely to give rise to dust emissions. While there are some civils involved in the enhancement of production facilities in phase 4 (Year 2) this is not expected to result in dust emissions any greater than those in phase 1. The restoration phase of the proposed development (phase 5, Year 15) is of 48 days' duration and utilises substantially fewer construction and heavy duty vehicles compared with the construction phase. It is therefore considered that the construction phase is likely to provide the greatest air quality impact with respect to dust and is representative of the worst case.

H.2 Screening assessment

IAQM guidance indicates that an assessment will normally be required where there is:

• a 'human receptor' within 250 m of the boundary of the site or within 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s).

• an 'ecological receptor' within 50 m of the boundary of the site or 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s).

In this case there are no ecological receptors within 50 m of the wellsite boundary. The nearest site with a statutory ecological designation is a local wildlife site (Rowland Plantation) to the north at a distance of 340 m from the wellsite and 700m from the site entrance at the wellsite. It is not considered necessary to consider ecological receptors within this assessment.

The nearest human receptors are around 470m to the west of the nearest wellsite boundary at South Cottage. The wellsite entrance is considered to be at the end of the access road, which passes South Cottage and is at a distance of 620m. All other residential locations are beyond 500m of the wellsite boundary. On the basis of the screening criteria an assessment of human impact is not required.

It is considered that activities likely to give rise to the greatest release of construction related dust are distant from residential locations, such that significant impact is unlikely. Although an assessment of the impact on human receptors is not required, this has been assessed for completeness.

H.3 Risk of dust impact

H3.1 Potential dust emission magnitude

The potential dust emission magnitude for the earthwork, construction and track-out activities, before any mitigation, are assessed in Tables H.1 to H.4. The assessment generally adopts a conservative approach.

Table H.1 Dust emission magnitude for earthworks activities

Criteria	Effect	Classification
Site area	The area of the entire extended wellsite is around 16,000 m^2. The only area where major construction activities will take place is the intended extension which has an area of 6500m^2.	Medium
Soil type	Moderately dusty soil	Medium
Earth moving vehicles operating	Greater than 10 vehicles operating at any one time (see Tables G.2 and G.3)	Large
Material moved	Expected that around 5000 tonnes of top soil will be removed and around 8000 tonnes of aggregate laid down during the construction of the wellsite extension.	Medium
Presence of bunds	Bunds of less than 4 m height are expected around the wellsite.	Small
Operating times	The major construction phase of the proposed development will last for 56 days and restoration is expected to last for 48 days. The scheduling is as yet unknown.	Small
Overall rating	Conservative estimate of effects.	Medium

The dust emission magnitude for the earthworks associated with the proposed development is considered to be ‘Medium’.

Table H.2 Dust emission magnitude for construction activities

Criteria	Effect	Classification
Building volume	Total building volume is less than 6500 m^3.	Small
Dust potential of construction materials	Largely concrete for drilling pad and MOT type 1 aggregate for site surface (c. 8,000 tonnes).	Small
Concrete batching	Small scale concrete batching is possible	Medium
Sand blasting	No sand blasting is expected.	Small
Overall rating	Conservative estimate of effects.	Medium

Construction activities on the wellsite will involve the levelling of the extension area, excavation of topsoil, creating a containment ditch and extended bunds and the laying of aggregate across the extension area. These activities will be conducted over a relatively short duration estimated at 56 days. While the dust magnitude is classified as 'Medium' this is considered a precautionary assessment.

Table H.3 Dust emission magnitude for track out

Criteria	Effect	Classification
Number of HDV vehicle movements	Less than 20 HDV outward movements expected in any one day (see Table G.3) during the construction and restoration phases.	Small
Surface material	Moderately dusty.	Medium
Length of unpaved road	The site entrance is at the end of an access road off the B1206. There is minimal unpaved surface.	Small
Overall rating	Conservative estimate of effects.	Medium

Access from the wellsite is from the existing access road which joins the B1208. There is minimal unpaved track. While the dust magnitude is conservatively estimated as 'Medium', it is considered that significant impact at the nearest residential locations will be unlikely.

Table H.4 Summary of dust emission magnitude

Activity	Dust emission magnitude
Earthworks	Medium
Construction	Medium
Track-out	Medium

H3.2 Sensitivity of the area

IAQM guidance recommends the assessment of the sensitivity of the area take into account:

- the specific sensitivities of receptors in the area
- the proximity and number of those receptors
- in the case of PM_{10}, the local background concentration
- site specific factors, such as whether there are natural shelters, such as trees, to reduce the risk of wind-blown dust.

It is considered that in terms of both dust soiling and the human health effects of PM_{10} there are a small number of 'high' sensitivity receptors present at around 500m from the nearest location of substantial earthworks associated with the proposed development (i.e. South Cottage and Lodge Farm). All other high sensitivity receptors are beyond 500m from any construction activity associated with the proposed development.

IAQM guidance for trackout sensitivity indicates that receptor distances should be measured from the side of the roads used by construction traffic. Without site specific mitigation, trackout may occur from roads up to 500 m from large sites, 200 m from medium sites and 50 m from small sites, as measured from the site exit. The impact declines with distance from the site, and it is only necessary to consider trackout impacts up to 50m from the edge of the road.

The site entrance is assumed to be the site boundary at the end of the existing access road off the B1208. The nearest residential location to the main route for HDVs is South Cottage, which is some 620m from the site entrance, adjacent to the access road. All other residential locations are beyond 650m of the site entrance.

There are areas of woodland (Rowland Plantation) between the wellsite and the nearest residential properties which might provide a significant natural barrier to wind blown dust emissions, dependent on wind direction.

The sensitivity of the area for the site activities is estimated in Table H.5.

Table H.5 Assessment of sensitivity of area

Potential impact	Condition	Earthworks	Construction	Trackout
Dust soiling	Receptor sensitivity	High	High	High
	Number of receptors	1-10	1-10	1-10
	Distance from site (m)	500	500	620
	Sensitivity of area	Low	Low	Low
Human health	Receptor sensitivity	High	High	High
	Number of receptors	1-10	1-10	1-10
	Distance from site (m)	500	500	620
	PM_{10} background concentration ($\mu g/m^3$)	<24	<24	<24
	Sensitivity of area	Low	Low	Low

3.3 Risk of impact

The risk of impact for human health and dust soiling is estimated by considering the magnitude of the effect (Table H.4) and the sensitivity of the receiving area (Table H.5), as summarised in Table H.6.

Table H.6 Assessment of risk of impact

Potential impact	Earthworks	Construction	Trackout
Dust soiling	Low	Low	Low
Human health	Low	Low	Low
Ecology	Negligible		

H.4 Conclusions and mitigation measures

The impact on human health is considered 'low' based on the distance between the wellsite and access road and the nearest residential locations, the small number of receptors at that distance and the generally low background concentration of PM_{10}.

The risk of dust soiling is considered to be 'low' based on the location of residential properties relative to the site and the small number of receptors.

The assessment indicates that due to the distance between the wellsite and the nearest designated and local ecological sites, the risk of impact on ecological receptors is 'negligible'.

This assessment is made without any mitigation measures being considered.

Mitigation measures, adhering to industry best practice, specific to the control of dust during construction have been incorporated into the design of the development. The following measures will further reduce the dust impact risk determined in this assessment:

- A construction environmental management plan (CEMP), incorporating best practices, will be employed during the construction phase.
- Material deliveries and stock piles on site will be sheeted to prevent windblown dust releases.
- Loads entering and leaving the site will be sheeted, where appropriate, to prevent windblown dust releases.
- In dry periods, a bowser will be available to dampen any dry and dusty road surfaces to minimise entrainment of dust.
- Vehicle wheel washing facilities will be available to minimise the transfer of site dust on to the road network.

It is expected that, with these mitigation measures in place and bearing in mind the conservative approach to the assessment before mitigation, the risk of dust impact from all operations will reduce to 'negligible' for all activities and for all impacts.

ANNEX I Air quality impact of construction and operations traffic

I.1 Introduction

The development of the site and subsequent operation will have the effect of increasing traffic flow in the area, which in turn will result in additional releases of certain pollutants to air. It is necessary to assess the likely ambient impact of this increase in traffic flow.

Assessment methodology, based on the Design Manual for Roads and Bridges (DMRB) published by Highways England[31] (now National Highways) has been used to determine significance and impact of additional off-site traffic movements during the main phases of the proposed development. The impact of on-site vehicle movements is considered within the main air quality assessment.

I.2 Expected traffic flows

The wellsite is accessed by a private road from the B1208, via the B1207 and M180.

Table I.1 summarises the expected maximum heavy duty vehicle (HDV) movements for the duration of the proposed development.

Table I.1 HDV movements over the proposed development

Year	HDVs arriving at site	Total HDV movements (in and out)	AADT
1	2331	4662	12.8
2	985	1970	5.4
3, 4, 5, 7 to 10, 12 to 14 (each year)	1797	3594	9.8
6 & 11 (each year)	1727	3454	9.5
15	348	696	1.9

The highest number of two-way HDV movements over a period of 365 consecutive days is 4662 equivalent to an annual average daily traffic (AADT) count of 12.8. This occurs in Year 1 of the proposed development.

In addition to HDV movements it is expected that there will be no more than 100 movements of passenger cars and light goods vehicles (less than 3.5 t gross weight) during each day of the proposed development.

I.3 Assessment criteria

The DRMB provides guidance on the screening out of changes with the objective of determining whether a proposed development is likely to have a significant impact in terms of air quality. It is first necessary to identify any affected roads in the vicinity using the criteria in Table I.2.

Table I.2 Screening assessment for affected roads

Criterion	Assessment
Road alignment will change by 5 m or more	Not applicable
Daily traffic flows will change by 1,000 AADT or more	No – see Table I.1
Heavy duty vehicle flows will change by 200 AADT or more	No – see Table I.1
Daily average speed will change by 10 km/h or more	Unlikely
Peak hour speed will change by 20 km/h or more	Unlikely

In this case none of the proposed routes to and from the Wressle wellsite is classed as an affected road. The DMRB specifies that if none of the roads in the relevant network meet any of the traffic/alignment criteria, then the impact of the scheme can be considered to be neutral in terms of local air quality and no further work is needed.

The IAQM[7] also provide guidance on the need for an air quality assessment based on indicative criteria related to the change in traffic flow brought about by a development as summarised in Table I.3.

Table I.3 IAQM indicative criteria for traffic change significance

The development will	Indicative criteria to proceed to an air quality assessment
Cause a significant change in Light Duty Vehicle (LDV) traffic flows on local roads with relevant receptors. (LDV = cars and small vans of <3.5 t gross weight)	A change of LDV flows of: - more than 100 AADT within or adjacent to an AQMA - more than 500 AADT elsewhere
Cause a significant change in Heavy Duty Vehicle (HDV) flows on local roads with relevant receptors. (HDV = goods vehicles + buses >3.5t gross vehicle weight)	A change of HDV flows of - more than 25 AADT within or adjacent to an AQMA - more than 100 AADT elsewhere

There are no air quality management areas adjacent to any of the proposed routes into or out of the wellsite. Expected increases in average vehicle movements over the duration of the fall well below the IAQM criteria for an air quality assessment, with AADT for HDVs of 12.8.

On this basis, it is determined that an air quality assessment for the change in traffic brought about by the proposed development is not required.

I.4 Conclusions

Increases in road traffic brought about by the construction activities and subsequent site operation are assessed to have a neutral impact on air quality based on Highways England guidance. The additional contributions to ambient pollutant concentrations from associated road traffic have no influence on the findings of the main air quality assessment for plant releases to air.

END OF REPORT

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