Rathlin Energy (UK) Limited

Air quality assessment of a wellsite development

West Newton A wellsite

Carried out for:

Rathlin Energy (UK) Limited

Carried out by:

SOCOTEC UK Limited

Unit D
Bankside Trade Park
Cirencester
Gloucestershire
GL7 1YT

Date	17 January 2023
Report No.	LSO221240
Issue	1

ISSUE HISTORY

Issue	Date	Approved	
221240,1	17 January 2023	N Ford	N Ford
First issue			

CONTENTS

SUMMARY

Rathlin Energy (UK) Limited propose to develop a wellsite, known as West Newton A, on land off Fosham Road near West Newton. The aim is to undertake an appraisal and potential further drilling of two existing wells and to drill and appraise a further six wells. Following successful appraisal, the wells would be brought into production. The current programme envisages well abandonment and site restoration following a production period of 20 years, with a total project duration of around 22 years.

As part of the planning and permitting process it is necessary to assess the dispersion of releases to atmosphere associated with the proposed operations to determine their impact on ambient concentrations of important pollutants around the local area. In particular, impact at locations of permanent human habitation and sensitive nature conservation sites in the context of attainment of applicable environmental standards requires assessment.

The main sources of pollutant releases during site operations will be from the use of diesel fuel in on-site stationary engines and construction and transport vehicles and from the combustion of produced natural gas by incineration and in gas engines for electricity generation. Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, sulphur dioxide and particulate matter were considered. The assessment was undertaken using the UK ADMS 5.2 modelling system with operating scenarios considered to provide realistic, but conservative, conditions for pollutant releases and air quality impact across the Project. This operating schedule also assumes that electricity produced on site would, where possible, be used to power stationary engines and displace the use of diesel fuel. Any surplus electricity would be exported.

Maximum pollutant process contributions from the 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.

At neighbouring locations of residential occupation, where long term human exposure might be expected, it is considered that pollutant process contributions over the duration of the project are insignificant and pose no meaningful threat to continued attainment of environmental standards.

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

At the nearest conservation sites requiring assessment, which are sensitive to nitrogen and acid deposition, maximum process contributions are considered are largely insignificant and unlikely to pose any threat to, or have any substantial influence on, the attainment of critical levels and critical loads. The Ecological Impact Assessment has concluded that the potential effects of nitrogen oxides, nitrogen deposition and acid deposition upon the Hornsea Mere and Greater Wash SPAs and Lambwath Meadows SSSI are not significant.

In combination effects, taking into account other recent or future proposed developments, largely have no impact on the conclusions of the assessment of the West Newton A development alone for human health or ecology. While in combination process contributions of nitrogen oxides and sulphur dioxide result in increases in acid deposition at the Greater Wash SPA and Lambwath Meadows SSSI leading to exceedance of screening criteria, it is considered that, in practice the conclusions of the modelling of the proposed West Newton A project alone would not materially

change when in-combination effects are considered. The Ecological Impact Assessment has concluded that the potential effects of air quality changes upon the Greater Wash SPA and Lambwath Meadows SSSI are not significant.

Necessary assumptions made to undertake the modelling are considered to have the effect of 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 project 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 Highway's Agency guidance.

Operations on site will give rise to releases of greenhouse gases. Based on a realistic, but precautionary, assessment of operation it is considered that Project lifetime greenhouse gas releases are largely insignificant in relation to the UK's current inventory and future budgets.

1 INTRODUCTION

Rathlin Energy (UK) Limited (Rathlin) placed a contract with SOCOTEC UK Limited (SOCOTEC) to undertake an assessment of the impact on local air quality of a proposed wellsite development near West Newton in the East Riding of Yorkshire.

1.1 Scope of study

Rathlin propose to develop an existing wellsite, known as West Newton A, on land off Fosham Road near West Newton. The aim is to undertake an appraisal and possible further drilling of two existing wells (WNA-1 and WNA-2) and to drill and appraise a further six wells (WNA-3 to WNA-8). Following successful appraisal, the wells would be brought into production. The current programme envisages a period of up to 6 years where the wells are drilled and appraised. Once viability is confirmed, the wells will be brought into production. Produced oil will be transported off site, while associated natural gas will be used to fuel gas engines to produce electricity for site use and export to the grid. The production phase is expected to be of around 20 years' duration. At the end of the production phase the wells will be plugged and the site restored. The full programme is expected to be of around 22 years' duration.

As part of the planning and permitting process Rathlin have asked that the dispersion of releases to atmosphere associated with the proposed operations at the West Newton A wellsite be assessed to determine their impact on ambient concentrations of important pollutants around the local area.

The main sources of pollutant releases during site operations will be from the use of diesel fuel in on-site stationary engines, construction and transport vehicles during the initial construction, final restoration and drilling phases of the project and from the on-site combustion of produced natural gas by incineration during the well clean up and testing phases and in gas engines during the production phase. The main pollutants of concern from the combustion of diesel fuel are nitrogen oxides, carbon monoxide, volatile organic compounds, sulphur dioxide and particulate matter. Combustion of natural gas will result in similar pollutant releases. The purpose of this study is to determine whether, under the proposed operating regime, releases to atmosphere are likely to be dispersed adequately in the context of applicable environmental standard attainment.

A previous assessment (LSO210229,3, dated 28 May 2022) looked at an unlikely worst case operating scenario and while finding acceptable air quality outcomes for human health, indicated a slight exceedance of critical loads at a nearby conservation site. The Environment Agency subsequently issued a Schedule 5 Notice (EPR/BB3001FT/V005, 18 November 2022) requesting that the air quality impact assessment be revised and resubmitted as process contributions to nutrient nitrogen and acid deposition at the Lambwath Meadows site of special scientific interest could not be screened out. The specific requirement was:

'The incorrect background data figures on UK Air Pollution Information System (APIS), also appear to have been used, but even with this correction we have calculated there is still a small exceedance >1% of the PC critical load figure. We also recognise the high background level also. The report and subsequent ecological report submitted on 02/09/22 (extract below) both conclude the impact is negligible, but there is no supporting data to confirm this statement. Please can you either provide more data to quantify the impacts on the SSSI to assist with our consultation with Natural England or provide revised more accurate modelling which includes actual operations compared to current worst case calculations assuming full load, 24hr a day operations in order to shown there is no significant impact. The ecological report submitted to us on 02/09/2022, also concludes a slight exceedance but doesn't explain further any impacts.'

In order to address this requirement, Rathlin Energy have provided a more realistic project schedule and equipment loading. The project schedule is less intense and the required equipment loading is more representative of normal working practice, although the approach is still considered precautionary providing a conservative assessment of air quality impact for both human health and ecology.

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 and nature conservation areas.
- 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 sensitive nature conservation 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 Structure of the report

This report provides an assessment of the impact of releases from proposed wellsite development operations on local air quality in the vicinity of the West Newton A wellsite. The approach to the assessment has been described above. The following sections provide a detailed commentary on the assessment and conclusions:

Section 2 Air quality standards and assessment criteria
Section 3 The model methodology employed and important input data
Section 4 The results of the assessment including sensitivity analyses
Section 5 Conclusions of the assessment

2 POLICY CONTEXT AND ASSESSMENT CRITERIA

Rathlin Energy (UK) Limited propose to extend an existing wellsite and drill and appraise up to six wells for subsequent petroleum and natural gas production. Following completion of production, the wellsite will be restored.

The proposed wellsite and associated access track is located within open countryside in the East Riding of Yorkshire and within the Parish of Aldbrough. The site already has two wells which have been drilled. The northern boundary is adjacent to Fosham Road. The site is located within an agricultural field and is accessed via a junction off Fosham Road. The nearest residential property is Caley Cottage which is around 490m to the east of the wellsite boundary. There are a number of local wildlife sites at around 800m to the south west of the site. The nearest site with a national ecological designation is the Lambwath Meadows site of special scientific interest which is around 1km to the north east.

2.1 Context of assessment

As part of the planning and permitting application, it is necessary to demonstrate the likely impact of proposed operations on local ambient concentrations of important pollutants. It is in this context that the proposed operations are being examined to determine their additional contribution to the existing concentrations of important 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. There are no declared AQMAs in the vicinity of the West Newton A wellsite. The nearest AQMA is around 15 km to the south west in Hull (Hull AQMA No.1(A)).

A survey of planning and permitting applications indicated one development with the potential to influence background concentrations of pollutants of interest in this case. The recently (2016) permitted Tansterne biomass power plant is within 2 km of the wellsite. The influence of this activity on local background pollutant concentrations is considered within this assessment.

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 Pollutants from site 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 project.

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.

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.

In addition to the combustion of diesel fuel, the natural gas produced during well clean up and testing will be disposed of by incineration. If natural gas is produced during production it will be used in gas engines to generate electricity. 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.

Fugitive releases of natural gas, principally methane, are considered unlikely to be significant. Leakages from the wells and associated transport pipework on the wellsite are likely to be minimal and will be subject to best practices for loss prevention. Nevertheless, the assessment does consider fugitive releases during production, at rates considered typical of worldwide oil and gas industry operations, and the implications for odour nuisance due to the potential release of sulphurous compounds (e.g. hydrogen sulphide and mercaptans).

There is also the potential for cold venting of produced natural gas during well lifting operations. This is intended to be infrequent and of a relatively short duration (up to 45 minutes before the gas is incinerated for disposal). While significant impact is not considered likely, for completeness an assessment of the short term air quality impact for methane, volatile organic compounds and sulphurous compounds is considered, together with the implications for odour nuisance.

This assessment considers the air quality impact of the following pollutants resulting from the proposed 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)
Methane (CH_4)
Hydrogen sulphide (H_2S)
Mercaptans (assessed as methyl mercaptan (CH_4S))

2.3 Environmental Standards

The UK's air quality strategy is based on meeting obligations within the European Union (EU) Ambient Air Quality Directive (2008/50/EC, 21 May 2008)[2] and the Fourth Daughter Directive (2004/107/EC, relating to metals and hydrocarbons)[3]. These directives specify limit values and target values. Limit values are set for individual pollutants which consist 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[4] 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 pollutants considered in this assessment as at 2023.

The limit values below are expressed as concentrations recorded over a specified time period which are considered to be 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 Standards Limit Values and Target Values

Substance	Basis (averaging time and exceedance allowance)	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 (averaging time)	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 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 3188 µg/m^3 (see Annex C) and the sulphur dioxide concentration is less than 10 µg/m^3 (see Table 4.5) and 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 (averaging time)	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
Hydrogen sulphide	hourly mean	150 µg/m^3
	annual mean	140 µg/m^3
Methyl mercaptan[a]	hourly mean	300 µg/m^3
	annual mean	10 µg/m^3
Methane[a]	hourly mean	214171 µg/m^3
	annual mean	7140 µg/m^3

a. The annual mean EALs for methane and methyl mercaptans are based on 8 hour time weighted average workplace exposure limits of 1000 ppm (NIOSH[5]) and 0.5 ppm (EH40/2005[7], methanethiol) respectively, converted to long term and short term EALs based on the methodology specified in *H1, Annex F[6] and the Health and Safety Executive's EH40/2005[7]*.

The EAL for methane is considered applicable in the assessment of the group of lower aliphatic hydrocarbon gases (C_1 to C_6). This is considered a precautionary approach, as equivalent EALs for the remainder of the group (ethane, propane, butane, pentane and hexane) are considerably higher than that for methane.

2.3.1 Application of environmental standards

The Air Quality Standards Regulations 2010[4] 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 value (1 hour or 1 day means) applies 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 nearest residential locations in the vicinity of the West Newton A wellsite and on the public footpaths in the vicinity of the wellsite. The assessment of compliance with critical loads and critical levels with respect to ecological impact is assessed at the conservation sites required for assessment within Environment Agency guidance[1] (see section 2.5.3).

2.4 Background air quality in West Newton

In considering the overall impact of a project, 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 DEFRA's air quality archive (http://uk-air.defra.gov.uk/data/pcm-data). The archive provides estimated 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 West Newton A wellsite (519327 439140) 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 points for which data were available.

Table 2.4 Background pollutant concentrations from the DEFRA archive

Substance	Averaging basis	Concentration (µg/m^3)	
		Maximum	Mean
Nitrogen dioxide (2019)	annual mean	8.99	8.41
Total nitrogen oxides (2019)	annual mean (as NO_2)	11.79	10.97
Nitrogen monoxide (2019)[a]	annual mean	1.83	1.67
PM_{10} (2019)	annual mean	16.10	15.79
$PM_{2.5}$ (2019)	annual mean	8.81	8.64
Carbon monoxide (2010)	maximum 8 hour rolling mean	1470	1460
Sulphur dioxide (2019)	annual mean	1.36	1.28
Benzene (2019)	annual mean	0.36	0.35

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.

The annual mean background concentration of methane employed in this assessment (1356 µg/m^3, 1.9 ppm) is based on the Northern Hemisphere average[8] and is slightly higher than the background measurements reported by the Environment Agency for 2001-2003 (1278 µg/m^3)[9].

East Riding of Yorkshire Council[10] undertakes non-automatic air quality monitoring, although the nearest stations are around 10 km from the West Newton A wellsite around Hornsea. No automatic monitoring is undertaken by the Council. It is considered that there are no monitoring stations within the area considered to be influenced by releases from proposed operations at the West Newton A wellsite.

Periodic measurements of background concentrations are undertaken by Rathlin around the West Newton A wellsite boundary. These measurements are undertaken at locations on the wellsite boundary. In view of the distance to the nearest sensitive receptors, the likely attenuation of concentrations with distance 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 local footpaths and nearby residential locations neighbouring the West Newton A 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 that will most likely overestimate the existing background concentrations in the sensitive areas of human exposure around the West Newton area.

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	1470	14.7
Nitrogen dioxide	1 hour mean	17.98[a]	9.0
	annual mean	8.99	22.5
Sulphur dioxide	15 minute mean	3.64[b]	1.4
	1 hour mean	2.72[a]	0.8
	24 hour mean	1.60[c]	1.3
PM_{10}	24 hour mean	19.00[d]	38.0
	annual mean	16.10	40.3
$PM_{2.5}$	annual mean	8.81	44.1
Benzene[e]	annual mean	0.36	7.2
Environmental assessment levels			
Carbon monoxide	hourly mean	2102[f]	7.0
Benzene[e]	24 hour mean	0.42[d]	1.4
Nitrogen monoxide	hourly mean	3.66[a]	0.1
	annual mean	1.83	0.6
Methane[g]	hourly mean	2712[a]	1.3
	annual mean	1356	19.0

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].
f. One hour mean is determined from 8 hour mean using a conversion factor of 1.43[1].
g. Lower hydrocarbons (methane, ethane, propane, butane, pentane and hexane) are assessed against the limit for methane.

Background levels specific to the protected conservation areas considered (e.g. Lambwath Meadows site of special scientific interest) are obtained from the Air Pollution Information System (APIS - www.apis.ac.uk) and are discussed later.

2.5 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 nature conservation areas 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 from the wellsite have been assessed using detailed modelling approach only.

The criteria considered in this assessment are described below.

2.5.1 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.

2.5.2 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.

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

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.

2.5.3 Criteria relevant to protected conservation areas

Where there are protected conservation areas in the vicinity of 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 extended the assessment to:

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

The impact of air emissions on protected conservation areas should up to 15km for both of:

- 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

Extended impact screening distances for larger plant will need to be agreed with the Environment Agency at pre-application.

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 to be 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 to be 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.

2.5.4 Significance of impact on human health

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[11] (i.e. AQS 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 are exposures that 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 operations have been modelled using the Atmospheric Dispersion Modelling System (ADMS) version 5.2. 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 5.2 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 5.2 requires a range of information in order to perform the modelling. The primary information required is discussed below and summarised in Annex B.

All modelling files containing relevant input information (see Annex B) are provided to the Regulatory Authorities 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 2km x 2 km area with the West Newton A wellsite (519327 439140) located approximately at the centre. Figure 3.1 illustrates the assessment area, location of the site, the surrounding area and nearby residential locations and public footpaths.

A general grid with receptors spaced at 20 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 3.2. The grid was considered at an elevation of 1.5 m. This is intended to represent the typical height of human exposure.

Figure 3.3 illustrates the general proposed layout for the wellsite and the immediate surrounding area.

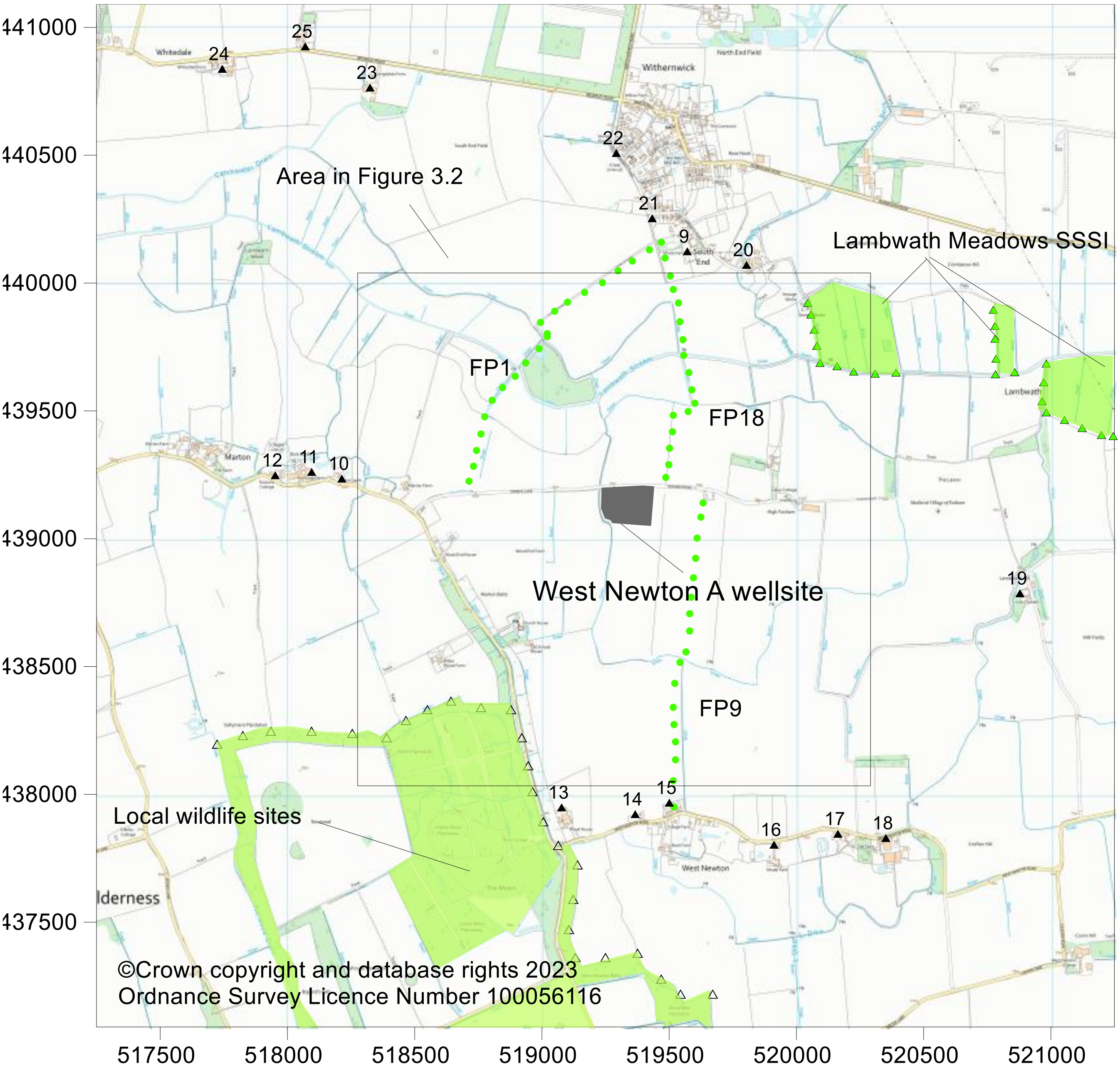
In addition to the receptor grid, 25 receptors (1 to 8 in Figure 3.2 and 9 to 25 in Figure 3.1) were positioned at residential locations in the vicinity of the wellsite. These receptors were placed at an elevation of 1.5 m as described in Table G.1 and are intended to correspond to the nearest locations of long term human exposure in the vicinity of the wellsite.

It is also expected that there will be frequent, although of short duration, human exposure along the nearby public footpaths. 54 receptors (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 G.1.

55 receptors were located around the wellsite boundary to give an indication of the maximum off site process contributions. These receptors are described in Table G.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 2.3.1). These locations are not considered in this assessment.

Figure 3.1 Location of the West Newton A wellsite



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

1 to 25	Residential locations (see Figure 3.1 and Table G.1)
26 to 79	Footpaths (see Figure 3.1 and Table G.1)
80 to 134	Site boundary (see Table G.1)
135 to 184	Conservation sites (see Figure 3.1 and Table 3.1)

Annex G describes the location of these discrete receptors.

Figure 3.2 Modelling assessment area

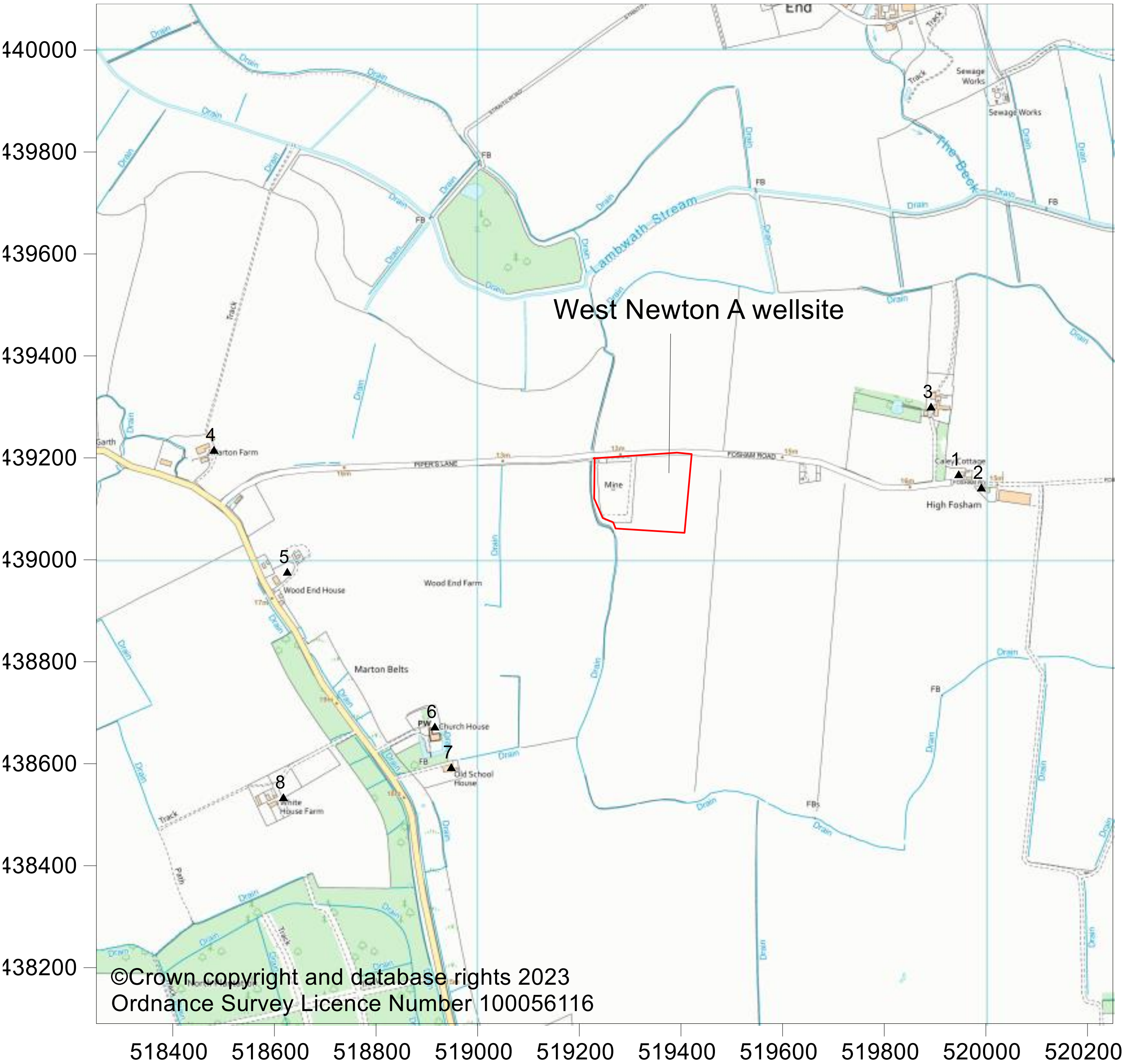
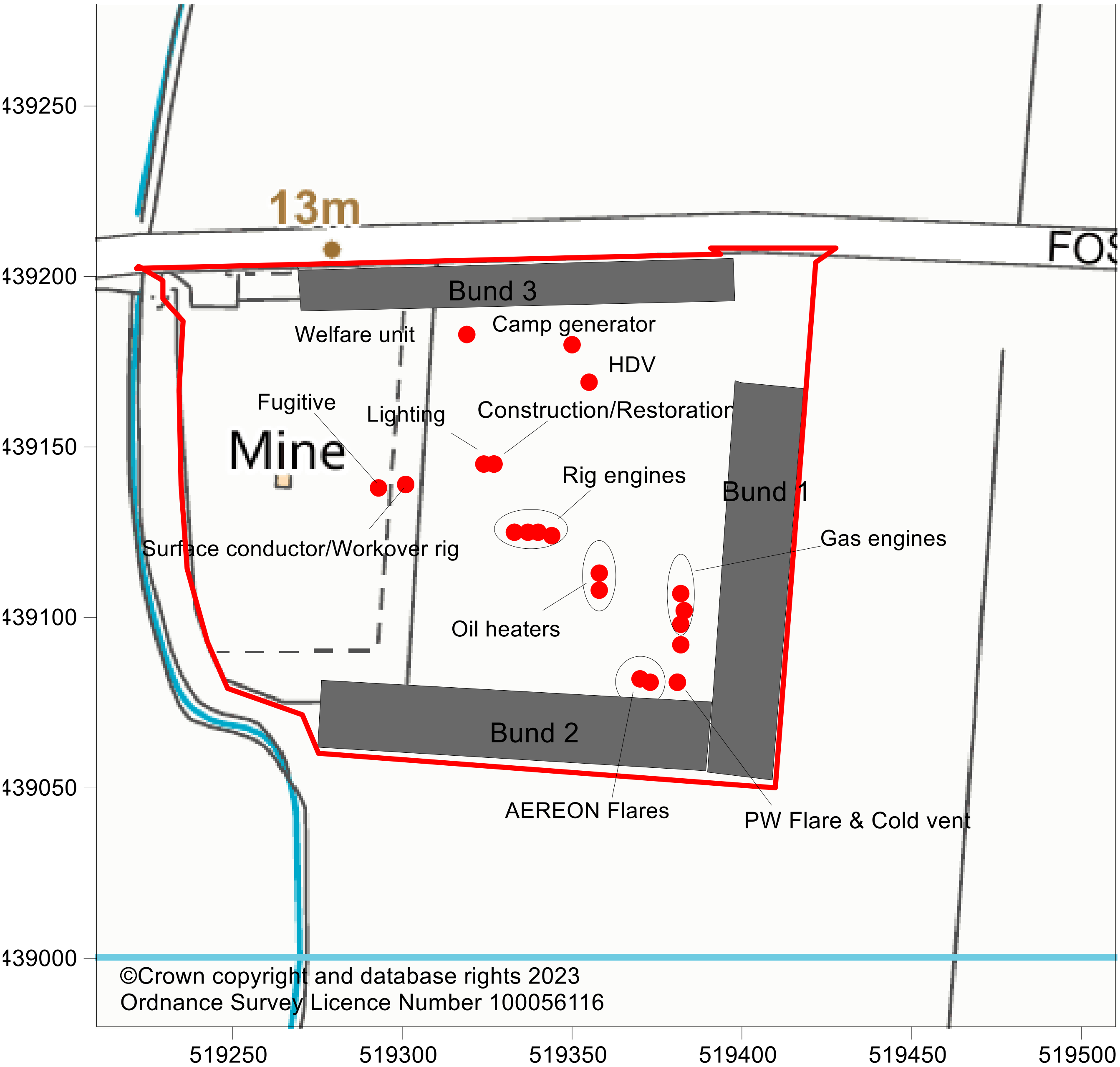


Figure 3.3 Layout of the West Newton A wellsite



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, three sites with a European or national designation were identified, together with five local wildlife sites, which met the criteria for assessment (see 2.5.3). Two sites with a European designation, which were relatively distant from the wellsite were each described by a single receptor located at the edge of the site closest to the wellsite boundary. For the Lambwath Meadows SSSI and the five local wildlife sites which were within 1 km of the well site, multiple receptors were located around the boundaries of the sites closest to the wellsite. All ecological receptors are described in Table 3.1 and Table G.1.

Table 3.1 Location of receptors at the nature conservation sites

Receptor		Position[a]	Easting (m)	Northing (m)
135	Hornsea Mere SPA	7.1 km N	517874	446072
136	Greater Wash SPA	5.5 km NE	524149	441802
137-159	Lambwath Meadows SSSI	1.0 km NE[b]	520093	439687
160-184[c]	Wycliffe North Plantation LWS The Moors LWS Mill Avenue LWS Burton Constable Parkland LWS Sallymere Plantation LWS	0.9 km SW[b]	518879	438332

a. Location of the edge of the habitat closest to the West Newton A wellsite boundary.
b. The receptor described is the closest to the wellsite boundary of all receptors describing the site.
c. The five local wildlife sites are considered together, described by 25 receptors.

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 significant structures present on the wellsite for all or a major part of the project will be the site boundary bunds, while there will be a range of other temporary and permanent structures on the site, it is expected that these structures will have the most influence on dispersion due to their size and proximity to the more significant points of release to atmosphere and their relatively long term presence.

ADMS 5.2 models buildings as either rectangular or circular structures. In this case the three bunds considered were modelled as rectangular blocks. Based on the drawings provided by Rathlin[12] the main parameters describing these structures were estimated as described in Table 3.2.

Table 3.2 Parameters describing major site structures

Structure	Structure centre grid reference		Height (m)	Angle (° from north)	Length (m)	Width (m)
	Easting	Northing				
Bund 1	519403	439112	3	95	20	116
Bund 2	519340	439069	3	95	115	19
Bund 3	519333	439199	3	85	129	13

It is assumed, for the purposes of the assessment, that these structures are present throughout the project duration and are the only structures influencing dispersion.

A sensitivity analysis was undertaken to determine the effect of the selection of the structure that has most influence on dispersion.

Main structure (see Table 3.2 and Figure 3.3)	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 25) compared with base case of Bund 1 as the main structure			
	Short term average		Long term average	
	Maximum	Mean	Maximum	Mean
Bund 2	5.3	19.1	1.7	8.1
Bund 3	2.6	19.1	1.5	6.3
No structure	-4.6	20.7	-1.4	9.7

The differences associated with the selection of the main structure are not considered to be significant in terms of the overall conclusions of this assessment which are based on maximum impact. It is apparent from the sensitivity analysis that consideration of Bund 2 as the main building provides marginally greater maximum long term and short term predicted process contributions than Bund 1, Bund 3 or no consideration of building effects. As such, for the purposes of the assessment, Bund 2 is used as the main building influencing dispersion in the modelling. This is considered a precautionary approach.

Releases to atmosphere will occur throughout the site depending on the placement of the major items of equipment and the movement of site vehicles such as construction equipment and heavy-duty vehicles (HDV) entering and leaving the site. For the purposes of this assessment a simplifying approach has been taken for minor emitters by treating each of these as a group represented as a single point source located at a position which is generally representative of that group. For the construction and restoration equipment and HDVs the release point is representative of their expected site movements, while the positioning of the source groups containing portable lighting towers and the welfare unit is based on an assessment of their proposed locations. Fugitive releases, while likely around the site, are considered to be located close to the well heads. The major emitters (see Table 3.3), which comprise the stationary engines and flares are each treated as individual sources and are located as indicated in site plans provided by Rathlin[12].

Figure 3.3 illustrates the assumed position of each release point. Table 3.3 describes the release point locations for the grouped sources and the major emitters.

Table 3.3 Location of release points

Item	Equipment	Height of release (m)	Easting (m)	Northing (m)
LIGHT	Lighting towers	1.5	519324	439145
WELFARE	Welfare unit with generator	3.5	519319	439183
CAMP	Camp generator	4.0	519350	439180
SURFACE	Surface conductor rig	4.0	519301	439139
WORKOVER	Workover rig	4.0	519301	439139
RIGENGINE1	Drilling rig generator	4.0	519333	439125
RIGENGINE2	Drilling rig generator	4.0	519337	439125
RIGENGINE3	Drilling rig generator	4.0	519340	439125
RIGENGINE4	Drilling rig generator	4.0	519344	439124
CONSTRUCTION	Non road mobile construction plant	3.0	519327	439145
RESTORATION	Non road mobile restoration plant	3.0	519327	439145

Table 3.3 continued

Item	Equipment	Height of release (m)	Easting (m)	Northing (m)
OILHEATER1	Oil heater	3.5	519358	439113
OILHEATER2	Oil heater	3.5	519358	439108
CEB350	CEB350 incineration system for disposal of produced natural gas during well appraisal	5.5	519372	439084
CEB1200	CEB1200 incineration system for disposal of produced natural gas during well appraisal	7.3	519373	439081
CEB4500	CEB4500 incineration system for disposal of produced natural gas during well appraisal	6.3	519370	439082
PWFLARE	Flare for disposal of produced natural gas during well clean up operations	12.2	519381	439081
HDV	Heavy duty vehicles entering and leaving the wellsite	3.0	519355	439169
GASENGINE1	Natural gas fired generators used for disposal of produced natural gas during oil production	6.0	519382	439107
GASENGINE2			519383	439102
GASENGINE3			519382	439098
GASENGINE4			519382	439092
FUGITIVEP	Fugitive releases associated with the well production process	1.0	519293	439138
COLDVENT	Temporary cold venting of natural gas during well lifting	12.2	519381	439081

a. Release heights and positions are estimated from site drawings provided by Rathlin[12].

3.3 Meteorology

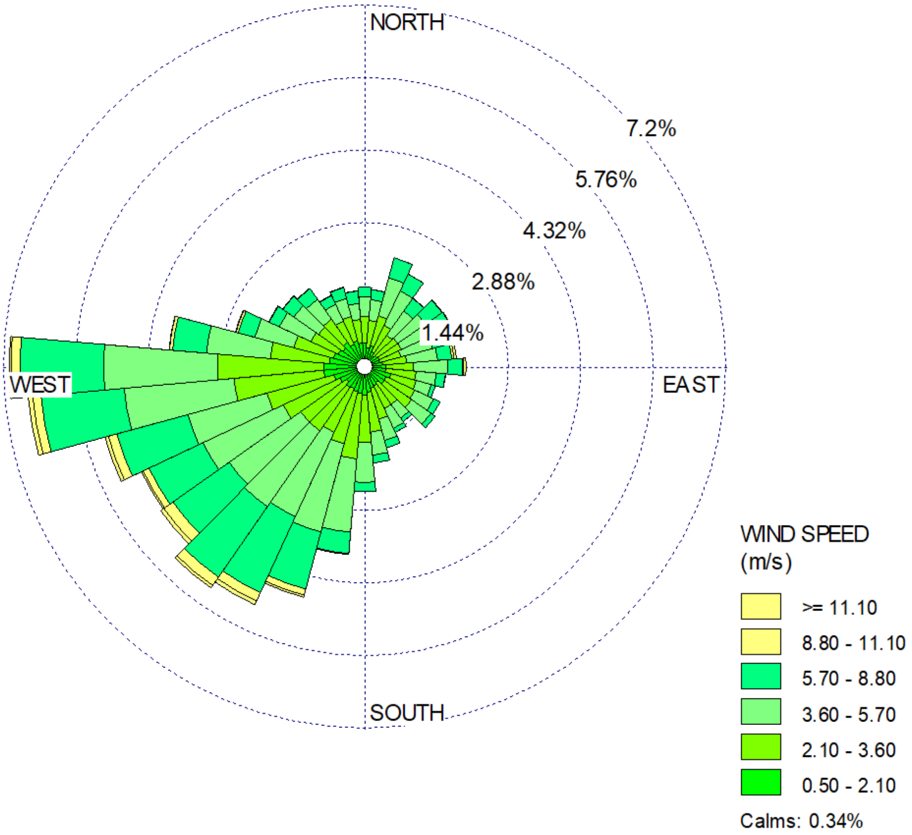
For this modelling assessment hourly sequential meteorological data from the nearest suitable meteorological station to the area was obtained. The data, provided by the UK Met Office, was from the Leconfield station and covered the 5 year period 2016 to 2020. The Leconfield station is around 19 km northwest of the West Newton A well site at an elevation of 7m, compared with the site elevation of around 15m. The UK Meteorological Office also suggested the Hull Park East station as a possible source of meteorological data:

Station	Position	Elevation	Data coverage
Hull Park East	11 km SW	2 m	Missing cloud and wind data

Based on advice provided by the Met Office, the proximity of the station, elevation and data coverage, it was considered that data from the Leconfield station provided measurements most representative of the conditions at West Newton.

The data included, among other parameters, hourly measurements of wind speed and direction. Figure 3.4 illustrates a composite wind rose for the Leconfield station. It may be seen that the wind has significant westerly and south westerly components. Annex D provides a more detailed analysis of the meteorological data used.

Figure 3.4 Composite windrose for the Leconfield station (2016 to 2020)



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 approximately 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 West Newton A wellsite is located in a rural area on relatively flat agricultural land. The nearest residential location is around 490m to the east. A surface roughness of 0.2m has been selected. A sensitivity analysis has been undertaken considering variations in surface roughness of between 0.1 and 0.6m. This resulted in the following variations in predicted hourly and annual process contributions of nitrogen dioxide over the residential receptors (1 to 25, see Figures 3.1 and 3.2):

Surface roughness (m)	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 25) compared with a base case surface roughness of 0.2m			
	Short term average		Long term average	
	Maximum	Mean	Maximum	Mean
0.1	5.1	27.3	5.8	13.3
0.3	-5.7	9.4	-5.6	-1.0
0.4	-9.9	0.7	-10.4	-6.6
0.5	-11.8	-6.0	-14.1	-11.0
0.6	-12.4	-8.1	-16.5	-18.7

It is considered that the base case surface roughness of 0.2m used in the sensitivity analysis above 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). 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 to be 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 30m. This resulted in the following variations in predicted hourly and annual process contributions of nitrogen dioxide over the residential receptors (1 to 25, see Figures 3.1 and 3.2):

Minimum Monin Obukhov length (m)	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 25) compared with a base case minimum Monin Obukhov length of 1m			
	Short term average		Long term average	
	Maximum	Mean	Maximum	Mean
5	-2.0	10.6	-4.1	0.4
10	-2.0	7.1	-6.4	-2.6
15	-2.0	6.4	-7.4	-4.0
20	-2.0	6.5	-8.1	-4.8
30	-0.9	14.8	-3.7	0.1

The variations (in maximum process contributions) 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 not 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 the following variations in predicted hourly and annual process contributions of nitrogen dioxide averaged over the residential receptors (1 to 25, see Figures 3.1 and 3.2).

Priestley Taylor parameter	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 25) compared with a base case Priestley Taylor parameter of 1			
	Short term average		Long term average	
	Maximum	Mean	Maximum	Mean
1.5	10.0	29.9	5.9	16.2
0.5	5.3	16.7	-1.4	2.7
0	5.3	14.9	-3.6	-1.0

The variations (in maximum process contributions) are largely insignificant 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).

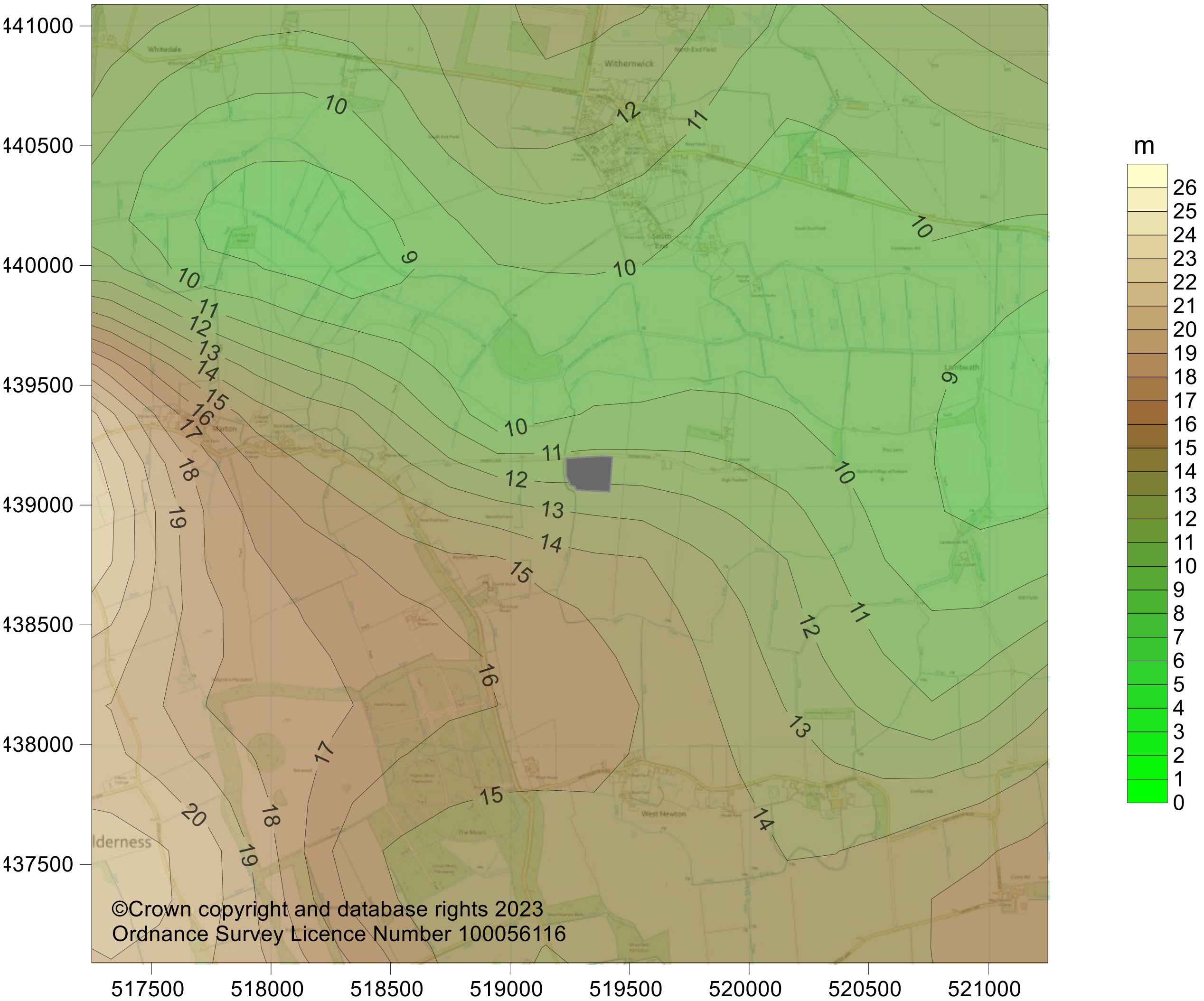
Land use	Bowen ratio (-variation with season)
Water	0.1
Deciduous forest	0.6-2.0
Coniferous forest	0.6-2.0
Swamp	0.2-2.0
Cultivated land	1.0-2.0
Grassland	1.0-2.0
Urban	2.0-4.0
Desert shrubland	5.0-10.0

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 data base. There are slight variations in elevation, predominantly rising east to west across the main assessment area, with a gradient of up to 1% as shown in Figure 3.5.

Figure 3.5 Ground elevation within assessment area



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 25, see Figures 3.1 and 3.2) to consideration of terrain was examined as below.

Terrain	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 25) compared with a base case of an elevated assessment area			
	Short term average		Long term average	
	Maximum	Mean	Maximum	Mean
Flat	2.0	-15.0	0.6	-4.4

General guidance suggests that consideration of terrain is not necessary at gradients of less than 5%. In this case the higher maximum long term process contributions generally occur when flat terrain is considered. For avoidance of doubt the assessment is based on a flat assessment area. This is considered a precautionary approach.

3.5 Pollutant releases and conditions

Seven general sources of pollutant releases are considered in this assessment:

Diesel fired stationary engines
Construction vehicles used on site
HDV vehicle movements on site
Incineration of produced natural gas
Combustion of natural gas in gas-fired generators
Fugitive releases of natural gas
Cold venting of produced natural gas

Rathlin[12] provided details of the incinerators, stationary engines, generators, construction vehicles and HDV movements intended over the various phases of the development project. A full listing of the equipment employed and references for the specifications used are provided in Annex H. These are summarised below.

3.5.1 Stationary engines

Table 3.4 summarises the diesel fuelled stationary engines specified for use by Rathlin[12] during the project.

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 an average 70% load, fuel usage, power output and pollutant release rates for each stationary engine have been determined as summarised in Table 3.5.

Table 3.4 Stationary engines and performance

Equipment		Diesel fuel consumption		Power output full load	Average load	Power output average load[b]	Emission standard
		l/h	kg/h[a]	kWh	%	kWh	
a	Lighting (4)	4.5	3.9	6.7	70	4.7	EU Stage 3A
b	Welfare unit	2.0	1.8	12.0	70	8.4	EU Stage 3A
m	Surface conductor rig	30.1	26.3	179	70	125	EU Stage 3A
t	Workover rig	59.5	52.0	354	70	248	US Tier 2
n	Camp generator	58.9	51.5	350	70	245	EU Stage 3A
o	Rig engines (4)	201.8	176.4	1200	70	840	Measured releases[c]
u	Oil heaters (2)[d]	59.4	52.0	732 kW (input)	70	512 kW (input)	AP42 1.3

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 oil heaters can be fired on either diesel or natural gas. Natural gas is the normal fuel, although diesel firing generates the greater pollutant releases and is assumed as a worse case in this assessment.

Table 3.5 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	0.0287	0.0029	0.0363	0.0031	0.00002	3.5
Welfare unit	0.0128	0.0013	0.0162	0.0014	0.00001	1.6
Camp generator	0.2380	0.0201	0.2519	0.0136	0.00029	45.8
Rig engine	0.1866	0.0490	1.0499	0.0187	0.00098	156.9
Surface conductor rig	0.1218	0.0103	0.1289	0.0070	0.00015	23.4
Workover rig	0.2406	0.0325	0.4073	0.0137	0.00029	46.2
Oil heater (each burner)	0.0082	0.0004	0.0329	0.0033	0.00024	38.4

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[13].
c. A load of 70% is assumed for all engines and heaters.

The exhaust gas conditions in Table 3.6 have been estimated and used in the assessment.

Table 3.6 Exhaust gas conditions for stationary engines

Equipment	Height of release (m)	Internal flue diameter (m)	Velocity[b] (m/s)	Temperature[a] (°C)
Lighting[c]	1.5	0.15	0.7	150
Welfare unit	3.5	0.10	2.1	150
Camp generator	4.0	0.30	13.0	550
Rig engine	4.0	0.40	19.6	455
Surface conductor rig	4.0	0.20	15.0	550
Workover rig	4.0	0.30	13.2	550
Oil heater (each burner)	3.5	0.38	3.1	150

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 and heaters operate at 70% load continuously when operational (see Table H.2).

3.5.2 Construction vehicles

Rathlin[12] specified the principal mobile plant that are intended to be employed for the construction phase of the project as shown in Table 3.7.

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 3.8.

Table 3.7 Specification of main construction vehicles

Type		Gross power output (kW)	Fuel consumption (kg/h)[a]	Emission standard
c	14 t excavator (Hitachi)	78.5	16.5	EU Stage 4
d	14 t excavator (Cat)	122	25.6	EU Stage 4
e	14 t excavator (Volvo)	90	18.9	EU Stage 4
f	Dozer	120	25.2	EU Stage 4
g	6t dumper	55.4	11.6	EU Stage 3B
h	9t dumper	55.4	11.6	EU Stage 3B
I	13t sheeps roller	115	24.2	EU Stage 5
j	Roller	24.6	5.2	EU Stage 5
k	12t dumper	108	22.7	EU Stage 4
l	Concrete pump truck	240	50.4	EURO 6

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

Table 3.8 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	0.077	0.005	0.067	0.000	0.00006	10.3
9t dumper	0.154	0.011	0.134	0.001	0.00013	20.7
13t sheeps roller	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	0.333	0.013	0.027	0.002	0.00028	44.8
Total construction phase	1.339	0.058	0.289	0.006	0.00140	224.8
Total restoration phase	0.951	0.044	0.258	0.005	0.00080	127.9

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)[13].
b. A load of 100% is assumed for all plant.
c. Assumes a diesel sulphur content of 10 mg/kg.

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 150°C. 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 37.7 m/s and exhaust temperature of 150°C. Table H.2 details the construction vehicles used in the construction and restoration phases.

3.5.3 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 to be 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 3.9 have been assumed based on an evaluation of four studies of heavy duty vehicle idling emissions[14, 15, 16, 17]. 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[18].

Table 3.9 Emission factors for HDV idling

Parameter		Rahman[14]	DIESELNET[15]	Christopher Frey[16]	Khan[17]	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.

Rathlin[12] have provided details of maximum daily HDV movements for the various phases of the project (see Table H.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 project year. The average number of HDVs idling on each working day of a project year is determined in Table 3.10.

Table 3.10 Frequency of HDV idling

Year	HDV 2 way movements /year	Mean HDVs idling/working hour in year	Fuel consumption l/working hour
1	5092	1.4	2.6
2	5970	1.6	3.0
3	9210	2.5	4.7
4	8480	2.3	4.3
5	10770	2.9	5.4
6	10660	2.8	5.4
7 to 20	10285 (each year)	2.7	5.2
21	1320	0.4	0.7
22	1560	0.4	0.8

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

Based on the assumed project schedule (see Table 3.23), Table 3.11 summarises the expected HDV activity during each year of the project.

Table 3.11 HDV activity in each project year

Year	HDVs arriving at site	Total HDV movements (in and out)	AADT
1	5092	10184	27.9
2	5970	11940	32.7
3	9210	18420	50.5
4	8480	16960	46.5
5	10770	21540	59.0
6	10660	21320	58.4
7 to 20	10285	20570	56.4
21	1320	2640	7.2
22	1560	3120	8.5

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 3.10) and the selected pollutant emission rates (Table 3.9) the yearly average release rates in Table 3.12 for HDV idling were estimated.

Table 3.12 Pollutant releases from HDV idling

Project year	Pollutant release rate in each working hour (g/s)					
	NO_x	CO	PM	VOC	SO_2	CO_2
1	0.0267	0.0105	0.0010	0.0051	0.000012	2.0
2	0.0313	0.0123	0.0011	0.0060	0.000015	2.3
3	0.0483	0.0189	0.0018	0.0093	0.000022	3.6
4	0.0445	0.0174	0.0016	0.0085	0.000021	3.3
5	0.0484	0.0190	0.0018	0.0093	0.000023	3.6
6	0.0479	0.0188	0.0018	0.0092	0.000022	3.6
7 to 20	0.0462	0.0181	0.0017	0.0089	0.000022	3.5
21	0.0150	0.0059	0.0006	0.0029	0.000007	1.1
22	0.0328	0.0129	0.0012	0.0063	0.000015	2.5
Maximum	0.048	0.019	0.002	0.009	0.000023	3.6

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 5.3m/s and exhaust temperature of 150ºC.

For the purposes of this assessment the maximum hourly HDV pollutant rates in Table 3.12 (based on a 12 hour operational day and the maximum annual average HDV movements per day) have been adopted for all years of the project 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.

3.5.4 Incinerators

Disposal of produced natural gas during well clean up and well testing will be by incineration. Rathlin[12] have specified three potential combustion systems for use during well testing depending on the disposal requirements. All units are enclosed combustion systems manufactured by AEREON and offer a range of disposal rates up to 3.9 MMscfd (see Table H.1). In addition, during the well clean up a PW Well Services shrouded ground flare will be used with a maximum disposal capacity of 2.5 MMscfd (0.77 Nm^3/s). This system will be employed to dispose of any produced gas during well clean up and well lifting operations.

Rathlin[12] have indicated a maximum natural gas disposal budget for the entire project of 330 MMscf. Based on the expected duration of each phase, a worst case assumption that the disposal budget will be exhausted and 24 hour per day continuous incineration operation, the average disposal requirements for the various project years have been determined as summarised in Table 3.13.

Table 3.13 Annual natural gas disposal budget for well testing

Year	Activity	Duration (days)	Disposal budget (MMscf)	Average disposal rate (MMscf/day)
1	Appraisal testing of wells WNA-1 & WNA-2 in 1c and 1f	60	20	0.33
2	Treatment and clean up of WNA-3 & WNA-4 in 3b and 4b	60	20	0.33
3	Appraisal testing of wells WNA-3 & WNA-4 in 3c and 4c	120	120	1.00
4	Treatment and clean up of WNA-5 & WNA-6 in 5b and 6b	60	20	0.33
	Appraisal testing of wells WNA-5 & WNA-6 in 5c and 6c	90	120	0.75
5	Treatment and clean up of WNA-7 & WNA-8 in 7b and 8b	60	15	0.25
6	Appraisal testing of wells WNA-7 & WNA-8 in 7c and 8c	60	15	0.25

For the purposes of this assessment it is assumed that during the periods of testing, the appropriate flare will operate continuously at the average disposal rate in Table 3.13. During all well clean up phases it is assumed that the PW system will operate continuously at the average disposal rate.

The release conditions for the incinerator options have been assessed in Table 3.15, based on the latest natural gas composition provided by Rathlin[12] in Table 3.14.

Table 3.14 Natural gas composition

Parameter		Value
Methane	% v/v	88.49
C_2	% v/v	4.78
C_3	% v/v	1.28
C_4	% v/v	0.51
C_5	% v/v	0.25
C_6	% v/v	0.18
C_{7+}	% v/v	0.21
Nitrogen	% v/v	2.88
Carbon dioxide	% v/v	1.41
Hydrogen sulphide[a]	% v/v	0.01
Mercaptans[a]	% v/v	0.015
Total sulphur[a]	mg/Nm^3	214

a. The estimation of total sulphur content assumes that all mercaptans are present as methanethiol (CH_4S) and is based on the maximum measurement during well gas sampling in 2021[31].

Pollutant releases are estimated in Table 3.16. Releases are based on the emission factors for industrial flares published by the US EPA in their AP42 document[13] and emission factors from the European Monitoring and Evaluation Programme/European Environment Agency (EMEP-EEA) for flaring in oil and gas extraction operations[19].

Table 3.15 Exhaust gas conditions (for each incineration unit at maximum disposal rate)

Flare		AEREON enclosed combustion system			PW Flare
		CEB350	CEB1200	CEB4500	
Disposal rate	MMscfd	0.297	0.988	3.85	2.5
	Nm^3/s	0.09	0.31	1.19	0.77
Exhaust gas temperature[b]	ºC	1093	1093	1093	1000
Exhaust gas flow rate (actual)[a,c]	m^3/s	8.9	29.6	115.3	69.8
Flue diameter	m	1.1	1.08	3.27[d]	2.0
Velocity	m/s	9.4	11.6	13.7	22.2
Carbon dioxide release[e]	g/s	197	655	2552	1657

a. Based on a combustion efficiency of 100%.
b. Mid point of operating temperature range from flare specification.
c. Assumes an excess air level of 83%, equivalent to an oxygen content in the exhaust gas of 10% by volume, dry basis, with a flue gas volume of 19.3 Nm^3/Nm^3 natural gas consumed.
d. Effective diameter based on a rectangular exhaust (2.8m x 3.0m).
e. Determined from gas composition and gas disposal rate.

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_7 and above) present in the flue gas will generally be representative of the proportion of higher hydrocarbons in the natural gas[20]. 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 to be a significant over estimate of higher hydrocarbons in practice based on the above experience. The higher hydrocarbon

(C_{7+}) presence in the produced natural gas is around 1.2% by mass (compared with a total non-methane VOC content of 15.5% by mass (see Table 3.14)).

Table 3.16 Pollutant releases from incineration 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)	-	1.479
Nitrogen oxides	1.215	1.150
Carbon monoxide	5.538	5.175
Sulphur dioxide[c]	0.428	
Total hydrocarbons (as carbon)	2.501	-

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 0.821 kg/Nm^3.
c. Sulphur dioxide release is based on total oxidation of the sulphur content of the natural gas (see Table 3.12)

Where there are corresponding emission factors from the USEPA and EMEP/EEA, the factor providing the greatest release rate is employed. Table 3.17 summarises the pollutant release rates assumed for each phase of the project where incineration is scheduled. The release is based on the operational characteristics of the most appropriate incinerator (see Table 3.15) scaled proportionately according to the average natural gas disposal rate (see Table 3.13).

Table 3.17 Incinerator pollutant release rates and conditions assumed for assessment

Phase		1b & 1e	3b & 4b	3c & 4c	5b & 6b	5c & 6c	7b & 8b	7c & 8c
Incinerator		1200	PW	4500	1200	PW	PW	1200
Natural gas disposal rate	Nm^3/s	0.33	0.33	1.00	0.75	0.33	0.25	0.25
Pollutant release rate (g/s)								
Nitrogen oxides		0.1265	0.1265	0.3768	0.2827	0.1265	0.0940	0.0940
Carbon monoxide		0.5765	0.5765	1.7180	1.2887	0.5765	0.4290	0.4290
Sulphur dioxide		0.0445	0.0442	0.1327	0.0442	0.0442	0.0330	0.0330
Benzene (non-methane volatile organic compounds)		0.1539	0.1539	0.4587	0.3441	0.1539	0.1150	0.1150
Release conditions								
Exhaust gas velocity	m/s	4.0	3.0	3.6	8.8	3.0	2.2	2.9
Temperature	^oC	1093	1000	1093	1093	1000	1000	1093

It may be noted that manufacturer's specifications (see Table H.1) indicate significantly lower releases of nitrogen oxides, carbon monoxide and hydrocarbons than determined from the standard emission factors in Table 3.17.

3.5.5 Gas engines

The generation system proposed is based on a maximum of four identical natural gas fired Jenbacher JMS624 GS.NL engines, each with a maximum electrical output of 4405 kW. Based on this engine specification, supplied by Rathlin[12], the exhaust gas conditions in Table 3.18 were determined for each engine. On average it is expected that, when operational an engine will run continuously at a load equivalent to 70% of the engine's maximum continuous rating (MCR). Table 3.18 presents exhaust gas conditions at both full load and the expected average loading of 70%.

Table 3.18 Flue gas conditions (for each engine)

Load		100% MCR	70% MCR
Electrical output[a]	kWe	4405	3084
Fuel consumption[a,b]	kW	9695	6787
	GJ/s	0.0097	0.0068
	Nm^3/s	0.259	0.181
Stoichiometric exhaust gas flow rate[c]	Nm^3/s	2.86	2.00
Exhaust gas flow rate[d]	Nm^3/s, wet	5.41	3.79
	Nm^3/s,dry	4.88	3.42
Oxygen content of flue gas[d]	%,dry	10.9	10.9
Water vapour content[d]	%	9.7	9.7
Carbon dioxide release	kg/s	0.55	0.39
Flue gas temperature[a]	°C	348	348
Flue gas volume rate (actual)	m^3/s	12.30	8.61
Flue diameter (internal)[a]	m	0.8	0.8
Flue gas velocity	m/s	25.4	17.1
Flue gas volume rate at reference conditions	Nm^3/s	3.07	2.15

a. Operating parameters from the Jenbacher JMS624 GS.NL technical specification[12].
b. Based on a natural gas net calorific value of 37.5 MJ/Nm^3 and the gas composition in Table 3.14.
c. Calculated based on the fuel composition in b.
d. Calculated based on the stoichiometric air requirement and flue gas flow rate and the specified combustion air requirement[12].
e. Reference conditions are a dry gas containing 5% oxygen at standard temperature and pressure (STP, 273 K temperature and 1013 mb pressure).

The above parameters have been employed in the initial modelling for the engines operating at an average loading of 70% of the maximum continuous rating.

The pollutant release rates have been determined based on experience and published literature.

Rathlin[12] have confirmed that each engine will operate at a nitrogen oxides emission concentration of less than 250 mg/m^3 (at reference conditions) and as such this is taken as the basis for determination of the plant's nitrogen oxides releases in this assessment.

A study of natural gas-fired engines in Denmark[20] found that a small proportion of the release of nitrogen oxides will be in the form of nitrous oxide (N_2O). The study indicates an emission factor equivalent to around 4 mgN_2O/m^3 in the exhaust gas. For this assessment the corresponding European Environment Agency[19] emission factor (0.5 g/GJ thermal input) has been employed which equates approximately to 2 mgN_2O/m^3.

Emission factors for carbon monoxide from the Danish study[20], the US EPA[13] and the European Environment Agency[19] indicate a concentration of between 100 and 500 mg/m^3 at reference conditions for natural gas-fired engines. In this assessment the applicable European Environment Agency[19] emission factor (56gCO/GJ thermal input) has been employed which equates to approximately 200 mg/m^3.

While emission factors[13,19,20] for volatile organic compounds indicate exhaust gas concentrations of up to 1600 mg/m^3 at reference conditions, it is likely that a significant proportion of the emission will be methane and lower hydrocarbons. Experience indicates that the concentration of higher hydrocarbons (C_7 and above) present in the flue gas will be less than 10 mg/m^3 and is generally representative of the proportion of higher hydrocarbons in the natural gas fuel[20]. In this case an emission concentration of 5 mg/m^3 (at reference conditions) is assumed. A concentration of 1600 mg/m^3 is assumed for methane releases.

The National Grid indicate that the total sulphur content of supplied natural gas is less than 50 mg/m^3 (www.nationalgrid.com/industry-information/gas-transmission-system-operation/gas-quality). For this assessment a sulphur content in natural gas of 214 mgS/m^3 has been assumed, based on the natural gas composition in Table 3.14. This equates to an exhaust gas concentration of sulphur dioxide, on complete oxidation, of around 36 mg/m^3 at reference conditions.

Based on the above assumptions the pollutant release rates in Table 3.19 have been determined and subsequently used in this assessment and are consistent with an average loading of 70% MCR..

Table 3.19 Pollutant discharge rates (for each engine operating at 70% MCR)

Property		Value
Emission factors		
Nitrogen oxides	mgNO_2/m^3	250
Carbon monoxide	gCO/GJ	56
Sulphur dioxide	mgS/m^3 of gas	214
Volatile organic compounds	mg/m^3	5
Methane	mgCH_4/m^3	1600
Nitrous oxide	gN_2O/GJ	0.5
Pollutant release rates		
Nitrogen oxides	gNO_2/s	0.5373
Carbon monoxide	gCO/s	0.4161
Sulphur dioxide	gSO_2/s	0.0775
Volatile organic compounds	gbenzene/s	0.0106
Methane	gCH_4/s	3.4388
Nitrous oxide	gN_2O/s	0.0037

3.5.6 Fugitive releases and odours

Site operations during wellsite production operations have the potential to result in leakages of produced natural gas. This largely results from leakages in pipework and connections and from the well itself, but can also include releases from incineration and processing including storage tank venting. It is expected that industry standard loss prevention and maintenance procedures will minimise any leakages. It would therefore be expected that unintentional releases of produced gas to atmosphere will be insignificant. The drilling phase of the project is expected to result in negligible fugitive releases. The overbalanced drilling technique employed ensures that oil and gas are retained within the reservoir during drilling and as such losses during drilling are not considered further.

It is difficult to assess the likely level of leakage from activities associated with well production operations. Emissions factors for the release of gases from oil system operations, based on surveys of operations throughout the world, have been derived, primarily to provide an indication of the impact with respect to greenhouse gases. The Intergovernmental Panel on Climate Change (IPCC)[21] provide emission factors for fugitive releases for, among other gases, methane from activities associated with on shore oil production. Total annual fugitive releases are based on the number of wells in production as summarised in Table 3.20.

Table 3.20 Emissions factors for fugitive releases from oil wells

Activity	Oil production On shore lower emitting technologies and practices t/active well in production per year
Methane	2.19
Carbon dioxide	33.83
Non-methane VOCs	0.94
Nitrous oxide	0.00051

It is assumed that the fugitive releases will occur uniformly within the production phase based on the number of wells in production and the duration of the activity. This, together with the factors assumed, is seen as a worse case precautionary approach and will in some cases include releases which might also be included elsewhere (e.g. gas disposal and venting). Table 3.21 summarises the fugitive releases from the wells based on the gas composition in Table 3.14 and an even distribution of the fugitive release over the relevant operational years.

In the assessment of fugitive releases with respect to odour, a worst case condition is assumed where all eight wells are in production. This provides for maximum releases of both methane and sulphur compounds. Within the main assessment, fugitive releases are based on the number of wells in production for the project years under assessment.

Table 3.21 Fugitive natural gas releases from oil production (per well in production)

Activity		Oil production
Total annual methane release per well	t	2.19
Methane content of produced gas per well	% mass	77.2
Produced natural gas release per well	m^3 [a]	3452
	kg	2835
Duration	days	365
Methane release rate	gCH_4/s	0.0694
Non methane VOC release rate	gC/s	0.0298
C_7+ organic compounds[d]	gC_6H_6/s	0.00173
Carbon dioxide release rate	gCO_2/s	1.073
Nitrous oxide release rate	gN_2O/s	0.0000162
Methyl mercaptan release rate[b]	gCH_4S/s	0.0000351
Hydrogen sulphide release rate[b]	gH^2S/s	0.0000249

a. Assumes a determined natural gas density of 0.821 kg/Nm^3.
b. In the assessment of mercaptans and hydrogen sulphide it is assumed that the total sulphur content of the natural gas is either in the form of methyl mercaptan or hydrogen sulphide as appropriate (see Table 3.14).
c. Pollutant release rates assume a continuous uniform release averaged over the 365 days.

d. C_7 and above organic compound release is expressed as benzene equivalent and is based on based on a C_7 and above content of the total non-methane organic compound release of 5.8%.

Fugitive releases are represented as a point source release with a velocity of 0.1 m/s and temperature of 50°C.

Odours are most likely to arise from the presence of sulphurous compounds contained in the produced natural gas. The most important sulphurous compound in terms of odour is hydrogen sulphide which has an odour threshold of 0.0005 ppm (0.76 µg/m^3)[22]. Other sulphur bearing compounds such as mercaptans have odour thresholds greater than hydrogen sulphide. For instance, methyl mercaptan has an odour threshold reported to be around 0.002 ppm (4.6 µg/m^3)[23]. In the absence of understanding the synergistic odour effects of a mixture of sulphurous compounds, the assumption in the assessment of odour is that all sulphur in the produced natural gas is present as either hydrogen sulphide or methyl mercaptan depending on which substance is being assessed. This is considered a precautionary approach.

The above release rates and gas conditions have been used to assess the likely health and amenity impact of fugitive releases.

3.5.7 Cold venting

During well lifting there is a possibility that there will be a short period of cold venting. During this procedure gases, which will be a mixture of natural gas and either nitrogen or carbon dioxide, will be disposed of by incineration within the PW system. If necessary, the calorific value of the gas will be enhanced with propane in order to enable combustion.

If the calorific value of the gas mixture is below 26% of the normal natural gas calorific value, then the gas will be cold vented rather than incinerated. Each duration of cold venting is likely to be of a period of 45 minutes and although the number of cold venting periods cannot be confirmed, the assessed impact is not sensitive to the number of lifts. Rathlin[12] indicate that the maximum gas disposal burden during this period will be around 2.5 MMscfd. The impact of cold venting on air quality will be a largely short term impact on ambient concentrations of methane and higher hydrocarbons. Table 3.22 summarises the estimate of releases due to cold venting based on a 45 minutes' cold venting per event.

Table 3.22 Releases during cold venting

Maximum produced natural gas release rate[a]	scf per event	20312
	Nm^3/s	0.151
	kg/s	0.125
Methane content	% mass	77.2
Non methane VOCs content	% mass	15.5
Higher hydrocarbons (C_7 and above) content	% mass	1.23
Carbon dioxide	% mass	3.35
Release rates		
Methane	gCH_4/s	95.7
Non methane VOCs	g/s	19.3
Higher hydrocarbons (C_7 and above)[b]	gbenzene/s	1.115
Methyl mercaptan release[c]	gCH_4S/s	0.0485
Hydrogen sulphide release[c]	gH_2S/s	0.0344
Carbon dioxide	gCO_2/s	4.2

a. Assumes that the produced natural gas content of the release is no more than 26% of the expected maximum disposal requirement (2.5MMscfd) at a determined natural gas density of 0.821 kg/Nm^3 over a period of 45 minutes. Release rates are based on a uniform release over a period of 60 minutes.
b. The higher hydrocarbon release is assessed as benzene equivalent and is assumed to consist of C_7 and above compounds which comprise 5.8% by mass of the total non-methane organic compound release.
c. In the assessment of mercaptans and hydrogen sulphide it is assumed that the total sulphur content of the natural gas is either in the form of methyl mercaptan or hydrogen sulphide as appropriate (see Table 3.14).

In the main assessment the disposal of natural gas during well lifting is assumed to be via the intended route of incineration within the PW system and is based on the releases determined in Table 3.17. For the alternative arrangement where the gas is cold vented rather than incinerated, a separate assessment has been undertaken to consider the likely short term impact of methane, higher hydrocarbons and odour releases. The above release rates have been used in this assessment and are considered to represent an overestimate of releases in practice, both in terms of mass release and duration. It is also likely that at least part of the cold venting release is included within the fugitive release emission factor discussed in 3.5.6.

3.5.8 Other releases

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

For nitrous oxide emission factors of 2.1gN_2O/GJ and 0.5 gN_20/GJ (heat input) for diesel and natural gas combustion respectively[20] have been employed.

3.6 Modelling scenarios

ADMS 5.2 has been employed to estimate process contributions to ambient pollutant concentrations based on the general conditions specified above. For the initial assessment the model has been run using meteorological data for each of five years (2016 to 2020).

Plant have been considered to operate as specified over the period of the project. The project programme is summarised in Table 3.23 and indicates the number of working days for each phase of the operation and the project timeline assuming continuous and consecutive operation of all phases within each Project Year.

Table 3.23 Project schedule

Year	Phase	Start	End	Days	Activity
1	1a	1	60	60	Appraisal Drilling WNA-1
	1b	61	90	30	Appraisal Workover WNA-1
	1c	91	120	30	Appraisal Testing WNA-1
	1d	121	180	60	Appraisal Drilling WNA-2
	1e	181	210	30	Appraisal Workover WNA-2
	1f	211	240	30	Appraisal Testing WNA-2
	2	241	338	98	Wellsite Construction
	9	241	365	125	Production (Engine 1)

Table 3.23 continued

Year	Phase	Start	End	Days	Activity
2	3a	1	105	105	Appraisal Drilling WNA-3
	4a	106	195	90	Appraisal Drilling WNA-4
	3b	196	225	30	Appraisal Well Treatment and Clean Up WNA-3
	4b	226	255	30	Appraisal Well Treatment and Clean Up WNA-4
	9	1	365	365	Production (Engine 1)
3	3c	1	60	60	Appraisal Testing WNA-3
	4c	61	120	60	Appraisal Testing WNA-4
	5a	121	200	80	Appraisal Drilling WNA-5
	6a	201	270	70	Appraisal Drilling WNA-6
	9	1	365	365	Production (Engine 1)
	9	121	365	245	Production (Engine 2)
4	5b	1	30	30	Appraisal Well Treatment and Clean Up WNA-5
	6b	31	60	30	Appraisal Well Treatment and Clean Up WNA-6
	5c	61	120	60	Appraisal Testing WNA-5
	6c	121	150	30	Appraisal Testing WNA-6
	9	1	365	365	Production (Engines 1 & 2)
	9	151	365	115	Production (Engine 3)
5	7a	1	60	60	Appraisal Drilling WNA-7
	8a	61	120	60	Appraisal Drilling WNA-8
	7b	121	150	30	Appraisal Well Treatment and Clean Up WNA-7
	8b	151	180	30	Appraisal Well Treatment and Clean Up WNA-8
	9	1	365	365	Production (Engines 1, 2 & 3)
6	7c	1	30	30	Appraisal Testing WNA-7
	8c	31	60	30	Appraisal Testing WNA-8
	9	1	365	365	Production (Engines 1,2 & 3)
	9	60	365	305	Production (Engine 4)
7 to 20	9	1	365	365	Production (Engines 1,2,3 & 4)
	10	1	80	80	Workover & Maintenance
21	11	1	168	168	Decommissioning
22	12	1	90	90	Restoration

Table H.2 provides more detail on expected equipment usage during each phase of the project on a day to day basis. This is summarised in Table 3.24.

Table H.3 summarises the expected HDV movements during each phase of the project.

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 once commenced the individual project phase will run continuously with no breaks and will be of the full duration assumed. These assumptions would be expected to ensure that the project 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 expected project schedule, both in terms of long term and short term air quality impact.

In practice, it would be expected that there will be breaks within the various phases of the project. Some phases may be shorter or longer than intended. Nevertheless, it is considered that the project schedule in Table 3.23 represents a realistic, but nevertheless conservative, operational scenario which will provide estimates of air quality impact which will tend to be greater than those in practice, particularly in the case of impacts assessed over the long term. Any departures in practice, from the project 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.

Table 3.24 summarises the equipment usage assumed for each year of the project based on the schedule in Table 3.23.

Table 3.24 Equipment operation within each project year

Equipment	Days of operation during the 12 month period considered								
	Project year								
	1	2	3	4	5	6	7 to 20	21	22
Lighting	1-241 (241-365)	1-365	1-365	1-365	1-365	1-60	1-80	1-168	1-90
Welfare unit	1-241 (241-365)	1-365	1-365	1-365	1-365	1-60	1-80	1-168	1-90
Camp generator	1-240						1-80	1-168	1-90
Rig engine 1	1-60 121-180	1-195	121-270		1-120				
Rig engine 2	1-60 121-180	1-195	121-270		1-120				
Rig engine 3	1-60 121-180	1-195	121-270		1-120				
Rig engine 4	1-60 121-180	1-195	121-270		1-120				
Oil heater 1	91-120 211-240	1-365	1-365	1-365	1-365	1-365	1-365		
Oil heater 2	91-120 211-240	1-365	1-365	1-365	1-365	1-365	1-365		
Surface conductor	241-338								
Workover rig	61-90 181-210	196-255		1-60	121-180		1-60	1-168	
Flare CEB 350									
Flare CEB 1200	91-120 211-240			61-150		1-60			
Flare CEB 4500			1-120						
Construction plant	241-338								
Restoration plant							1-80		1-90

Table 3.24 continued

Equipment	Days of operation during the 12 month period considered								
	Project year								
	1	2	3	4	5	6	7 to 20	21	22
Fugitive (production)	241-365 (2)	1-365 (2)	1-365 (4)	1-365 (6)	1-365 (6)	1-365 (8)	1-365 (8)		
Heavy duty vehicles	1-365	1-365	1-365	1-365	1-365	1-365	1-365	1-168	1-90
Gas engine 1	241-365	1-365	1-365	1-365	1-365	1-365	1-365		
Gas engine 2			121-365	1-365	1-365	1-365	1-365		
Gas engine 3				151-365	1-365	1-365	1-365		
Gas engine 4									
PW Flare		196-225		1-60	121-180				
Cold venting[c]		196-225		1-60	121-180				

a. See Tables H.1 and H.2 for equipment description and daily operational hours respectively.
b. Where a period is shaded it indicates that the plant is operational, but is powered by electricity generated from the combustion of natural gas in the gas engines rather than diesel fuelled.
c. Depending on gas quality the disposal of produced natural gas may be either by incineration or cold venting. The main assessment considers disposal by incineration, while disposal by cold venting is considered in a separate assessment.

It is Rathlin's intention to use electricity generated during the combustion of natural gas in the gas engines to displace the diesel fuel for site plant. Any surplus electricity will be exported to the grid. Where a period of operation above is shaded it indicates that the plant is operational over the period, but uses electricity generated on site, rather than diesel fuel. During the main production phase (Years 7 to 20) it is assumed that on average three gas engines will operate continuously at a loading of 70% MCR, equivalent to an average continuous generation rate of 9252 kW. It is possible, in practice, that that loadings and operational frequency will be different than assumed, although the modelled operational pattern is considered a realistic and somewhat conservative estimate. This is considered to provide a somewhat higher estimate of air quality impact for the main phase of the project than is likely in practice.

Initial modelling indicated that the years providing the highest pollutant release rates and subsequent air quality impact were years 1 and 3 e.g.

Year	Maximum average long term release rate	Maximum short term release rate
1	PM_{10}, $PM_{2.5}$	NO_2, PM_{10}, $PM_{2.5}$
3	CO, VOC, NO2, SO2	CO, VOC, SO2

In addition, Years 4 and 7 provided a relatively high combination of long term nitrogen dioxide and sulphur dioxide releases which had the potential for ecological impact in terms of acid deposition.

Years 1, 3, 4 and 7 have been subject to detailed modelling to determine worst case air quality impact for the intended project schedule. The project schedule during each of these years has been assessed over 5 meteorological years (2016 to 2020). The assessment of air quality impact is based on the worst case process contributions determined over these operating scenarios for the five meteorological years considered.

The assessment has also been repeated in full to determine the in combination impact of other existing and planned nearby sources of similar pollutant releases which might not be fully considered within the background concentrations adopted and which might have an influence on air quality at the selected local sensitive human and ecological receptors.

In addition to the main assessment described above, two further assessments have been made to determine the impact of fugitive emissions and cold venting as an alternative to incineration during well lifting episodes. Fugitive releases are also included, where appropriate, in the main assessment. The additional assessments consider:

Fugitive releases: the health impact of releases of methane, hydrogen sulphide and mercaptans (short term and long term basis) and the impact on amenity of odour releases resulting from the release of sulphurous compounds (hydrogen sulphide and mercaptans) in the produced natural gas.

Cold venting: the maximum short term health impact of methane, volatile organic compounds, hydrogen sulphide and mercaptans releases and the impact on amenity of odour releases resulting from the release of sulphurous compounds (hydrogen sulphide and mercaptans).

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 5.2 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 averaging bases respectively (see Table 2.1). Figures A.3 and A.4 provide the corresponding illustrations for 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 occurring close to the centre of the site where there is a concentration of high energy intensive equipment (drilling rig engines and gas engines). This pattern is typical of low level releases. The maximum off site process contribution occurs at the wellsite's northern boundary in the general direction of the prevailing wind.

Air quality standards with respect to human health are not considered to be applicable at the wellsite boundary and beyond in the areas most affected by site process contributions. It is not considered that frequent human exposure, over the periods of the standards is likely in these areas (see section 2.3.1) due to the absence of any residential locations or designated footpaths.

The air quality impacts of these pollutants 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 nature conservation sites where critical levels and loads are applicable.

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 West Newton A wellsite (Table G.1 and Figures 3.1 and 3.2) and along the footpaths to the east and north west of the wellsite boundary (see Figure 3.1 and Table G.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 the air quality standard averaging periods is likely.

In the following discussion the maximum process contribution over project years 1, 3, 4 and 7 is considered. For other project years the process contribution will be lower than the maximum. Tables G.3 and G.4 summarise process contributions at the footpaths and residential locations respectively over each of project years considered for comparison.

Table 4.1 summarises the maximum process contributions and predicted environmental concentrations at the nearest footpaths. 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 4.1 Maximum process contributions and predicted environmental concentrations at footpaths (short term impact)

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration		Project year[a]
		μg/m³	% standard	μg/m³	μg/m³	% standard	
Carbon monoxide	8 hours	153.22	1.5	1470	1623	16.2	1
	1 hour	189.80	0.6	2102	2292	7.6	1
Nitrogen dioxide	1 hour	96.08	48.0	17.98	114	57.0	1
Sulphur dioxide	15 min	12.23	4.6	3.64	15.9	6.0	7
	1 hour	11.28	3.2	2.72	14.0	4.0	7
	24 hours	7.26	5.8	1.60	8.9	7.1	7
PM_{10}	24 hours	2.11	4.2	19.00	21.1	42.2	1
Benzene	24 hours	11.93	39.8	0.42	12.4	41.2	1
Nitrogen monoxide	1 hour	194.58	4.4	3.66	198.2	4.5	1

a. Indicates the project year during which the maximum process contribution occurs (see Tables 3.23 and 3.24).

The maximum process contributions of the following pollutants are equivalent to less than 20% of the short term environmental standard less the background and are therefore considered insignificant:

Carbon monoxide
Sulphur dioxide
PM_{10}
Nitrogen monoxide

The maximum process contribution of nitrogen dioxide exceeds screening criteria, although the corresponding predicted environmental concentration is comfortably within the environmental standard. It may be noted that the maximum concentrations only relate to small sections of footpath which are close to the eastern site boundary (footpaths FP9 and FP18 in Figure 3.1). At all other sections of these footpaths and at all other footpaths process contributions are lower, and in most cases substantially lower, than the maximum process contributions in Table 4.1. In addition, as discussed later, the predicted process contribution of nitrogen dioxide is most likely to be a substantial overestimate of that in practice, particularly at the nearby footpath areas where conversion rates are expected to be significantly lower than assumed in this assessment (see Table G.1). Human exposure for the full duration of the short term standard averaging period (1 hour) along the short section of footpath affected is considered unlikely.

The maximum process contribution of volatile organic compounds (assessed as benzene) exceeds the screening criteria, although the predicted environmental concentration is less than half of the environmental standard. Similar to nitrogen dioxide, maximum process contributions are found on a short section of the footpath close to the eastern site boundary. In this assessment any release of hydrocarbons, where the composition cannot be clearly identified, is assumed to be present as benzene and the air quality standards for benzene applied to determine significance. This includes all hydrocarbon emissions from road and non-road stationary diesel engines, all non-methane releases from the incineration of produced gas. These are considered significant over estimates as it is likely that in all cases a substantial proportion of the hydrocarbon and non-methane organic compounds releases will comprise lower hydrocarbons which have much less stringent environmental standards compared to benzene. In practice, it would be expected that volatile organic compound releases would have a much lower significance than determined in this assessment. In addition, continuous exposure for the period of the standard (24 hours) along the affected section of footpath is considered unlikely.

All maximum short term predicted environmental concentrations are comfortably within the applicable short term environmental standards. It is concluded that process contributions from wellsite operation pose no meaningful threat to environmental standard compliance at the nearby public footpaths.

Table 4.2 summarises the maximum process contributions and predicted environmental concentrations at residential locations in the vicinity of the wellsite. 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 both the long and short term air quality standard averaging periods is likely.

Table 4.2 Maximum process contributions and predicted environmental concentrations – Residential locations

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration		Project year[a]
		μg/m^3	% standard	μg/m^3	μg/m^3	% standard	
Carbon monoxide	8 hours	42.85	0.4	1470	1513	15.1	1
	1 hour	61.84	0.2	2102	2164	7.2	1
Nitrogen dioxide	1 hour	32.82	16.4	17.98	51	25.4	1
	annual	2.91	7.3	8.99	12	29.8	1
Sulphur dioxide	15 min	3.44	1.3	3.64	7	2.7	7
	1 hour	2.60	0.7	2.72	5	1.5	7
	24 hours	1.52	1.2	1.6	3	2.5	4
PM_{10}	24 hours	0.38	0.8	19	19	38.8	1
	annual	0.12	0.3	16.1	16	40.6	1
$PM_{2.5}$	annual	0.12	0.6	8.81	9	44.7	1
Benzene	24 hours	3.17	10.6	0.42	4	12.0	1
	annual	0.39	7.7	0.36	1	14.9	1
Nitrogen monoxide	1 hour	82.94	1.9	3.66	87	2.0	1
	annual	2.72	0.9	1.83	5	1.5	1

a. Indicates the project year during which the maximum process contribution occurs (see Tables 3.23 and 3.24).

The maximum process contributions of the following pollutants are equivalent to less than 10% of their short term environmental standard and/or less than 1% of their long term environmental standard and are therefore considered insignificant:

Carbon monoxide
Sulphur dioxide
PM_{10}
$PM_{2.5}$
Nitrogen monoxide

The maximum short term process contributions of the following pollutants are less than 20% of the short term environmental standard less the corresponding background and/or the maximum predicted environmental concentration is less than 70% of the long term environmental standard and are therefore considered insignificant:

Volatile organic compounds (as benzene)
Nitrogen dioxide

For all project years maximum process contributions of all pollutants are within screening criteria and require no further consideration. In addition, for all project years the maximum predicted environmental concentration of all pollutants is less than, and in some cases substantially less than, half of the applicable standard. Bearing in mind the precautionary assumptions made in the assessment, it is considered unlikely that pollutant process contributions from the proposed West Newton A wellsite development will pose any risk to, or have any meaningful influence on, continued attainment of air quality standards at the nearest locations of human exposure.

Based on Environmental Protection UK (EP UK) and the Institute of Air Quality Management (IAQM) classification (section 2.5.4) the maximum impact significance of releases of nitrogen dioxide and volatile organic compounds at the most affected sensitive location (Caley Cottage) is considered 'slight'. For all other substances considered the impact significance is classed as 'negligible' at all residential locations. Table 4.3 summarises the assessment of significance.

Table 4.3 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	7.3	30	Slight
PM_{10}	0.3	41	Negligible
$PM_{2.5}$	0.6	45	Negligible
Benzene	7.7	15	Slight
Nitrogen monoxide	0.9	2	Negligible

a.Process contributions and predicted environmental concentrations are expressed as a percentage of the applicable long term environmental standard (see Tables 4.2 and G.2) for the most affected residential location.

4.3 Impact of process releases at sensitive nature conservation sites

Three sites with European and national ecological designations and five local wildlife sites requiring assessment, based on Environment Agency criteria (see section 2.5.3), were identified in the vicinity of the West Newton A wellsite as discussed in section 3.1.

The main pollutants 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 on the site boundaries 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 UK Air Pollution Information System (APIS) and are summarised in Table 4.4

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 4.5. 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.

Local wildlife sites are considered as a single area with a broadleaved, mixed and yew woodland habitat.

Table 4.4 Site relevant critical loads and levels

Site		135	136	137-159	160-184
		Hornsea Mere SPA	Greater Wash SPA	Lambwath Meadows SSSI	Local wildlife sites
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 deciduous woodland	Supra littoral sediment	Neutral grassland	Broadleaved, mixed and yew woodland
N deposition CL	kgN/ha/y	10-20	8-10	20-30	10-20
Critical loads for acid deposition					
Most sensitive habitat		Unmanaged broadleaved coniferous woodland	Supra littoral sediment	Neutral grassland	Broadleaved, mixed and yew woodland
Minimum CLminN	keq	0.142	0.223	0.438	0.357
Minimum CLmaxS	keq	2.257	0.470	1.570	2.317
Minimum CLmaxN	keq	2.614	0.693	2.008	2.674

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

Table 4.5 Site relevant background concentrations

Site		135	136	137-159	160-184
		Hornsea Mere SPA	Greater Wash SPA	Lambwath Meadows SSSI	Local wildlife sites
Nitrogen oxides annual mean	$\mu gNO_2/m^3$	9.16	20.32	10.28	12.34
Sulphur dioxide annual mean	$\mu gSO_2/m^3$	1.22	1.26	1.34	1.85
Nitrogen deposition	kgN/ha/y	13.8	19.1	21.0	37.1
Nitrogen acid deposition	keq/ha y	1.0	1.4	1.5	2.65
Sulphur acid deposition	keq/ha y	0.2	0.2	0.2	0.28

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

The maximum process contributions to concentrations of nitrogen oxides and sulphur dioxide at the conservation sites are summarised in Table 4.6.

Table 4.6 Maximum process contributions of nitrogen oxides and sulphur dioxide at conservation sites

Site		135	136	137-159	160-184
		Hornsea Mere SPA	Greater Wash SPA	Lambwath Meadows SSSI	Local wildlife sites
Nitrogen oxides[a]					
Maximum annual mean PC	$\mu gNO_2/m^3$	0.06	0.14	1.63	1.02
	% CL	0.2	0.5	5.4	3.4
Background concentration	$\mu gNO_2/m^3$	9.16	20.32	10.28	12.34
Maximum annual mean PEC	$\mu gNO_2/m^3$	9.22	20.46	11.91	13.36
	% CL	31	68	40	45
Maximum daily mean PC	$\mu gNO_2/m^3$	2.7	2.4	22.0	25.1
	% CL	1.4	1.2	11.0	12.6
Back ground concentration	$\mu gNO_2/m^3$	18.3	40.6	20.6	24.7
Maximum daily mean PEC	$\mu gNO_2/m^3$	21.0	43.0	42.6	49.8
	% CL	11	22	21	25
Sulphur dioxide					
Maximum annual mean PC	$\mu gSO_2/m^3$	0.003	0.010	0.116	0.050
	% CL	0.03	0.10	1.16	0.50
Background concentration	$\mu gSO_2/m^3$	1.22	2.26	1.34	1.85
Maximum annual mean PEC	$\mu gSO_2/m^3$	1.22	2.27	1.46	1.90
	% CL	12	23	15	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% of the applicable critical levels for the Hornsea Mere and Greater Wash SPAs and less than 100% of the critical levels at the local wildlife sites. At the Lambwath Meadows SSSI the long term predicted environmental concentrations of nitrogen oxides and sulphur dioxide are below 70% of the critical level. The daily process contribution of nitrogen oxides is just above the screening criteria, although the predicted environmental concentration only around 20% of the critical level. All process contributions at the SPAs and local wildlife sites are considered insignificant

The determination of nitrogen deposition at the nature conservation sites is summarised in Table 4.7. 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 deposition at conservation sites

Site		135	136	137-159	160-184
		Hornsea Mere SPA	Greater Wash SPA	Lambwath Meadows SSSI	Local wildlife sites
Maximum process N deposition	$\mu gNO_2/m^2/s^a$	0.00012	0.00029	0.00171	0.00214
	kgN/ha/y	0.01187	0.02814	0.16438	0.20509
	% CL[b]	0.1	0.4	0.8	2.1
Background concentration	kN/ha y	13.80	19.10	21.00	37.10
Maximum annual mean PEC	kN/ha y	13.81	19.13	21.16	37.31
	% CL[b]	138	239	106	373

a. Determination of deposition is based on the deposition velocity for forest terrain for all sites except Lambwath Meadows which is considered to be grassland terrain[25].
b. The critical load selected is the minimum of the range specified for the most sensitive habitat over the entire site.

Process contributions to nutrient nitrogen deposition are below 1% of the applicable critical loads at the Hornsea Mere and Greater Wash SPAs and Lambwath Meadow SSSI and less than 100% of the critical loads at the local wildlife sites, and as such are not considered significant. While there is exceedance of the critical load at all sites, this is due to existing large background depositions and it is not considered that the process contributions have any significant influence on critical load compliance at these sites.

The determination of the process contribution to acid deposition at these sites is summarised in Table 4.8.

Table 4.8 Acid deposition at conservation sites

Site		135	136	137-159	160-184
		Hornsea Mere SPA	Greater Wash SPA	Lambwath Meadows SSSI	Local wildlife sites
Nitrogen acid deposition	$\mu gNO_2/m^2/s^a$	0.00012	0.00029	0.00171	0.00214
	kgN/ha/y	0.0119	0.0281	0.1644	0.2051
	keq/ha y	0.0008	0.0020	0.0117	0.0146
Sulphur acid deposition	$\mu gSO_2/m^2/s^a$	0.0001	0.0002	0.0014	0.0012
	kgS/ha/y	0.0126	0.0372	0.2198	0.1900
	keq/ha y	0.0008	0.0023	0.0137	0.0119
Total process acid deposition	keq/ha/y	0.0012	0.0035	0.0205	0.0177
	% CL[b,c]	0.05	0.5	1.0	0.7
Total background acid deposition	keq/ha/y	1.20	1.60	1.70	2.93
Maximum annual mean PEC	keq/ha y	1.20	1.60	1.72	2.95
	% CL[b,c]	46	231	86	110

a. Determination of deposition is based on the deposition velocity for forest terrain for all sites except Lambwath Meadows which is considered to be grassland 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.

Process contributions to acid deposition are below 1% of the applicable critical loads at the Hornsea Mere and Greater Wash SPAs and Lambwath Meadows SSSI and below 100% of the critical load at the local wildlife sites, and as such are not considered significant. While there is exceedance of the critical load at most sites, this is due to existing large background depositions and it is not considered that the process contributions have any significant influence on critical load compliance at these sites.

At the nearest sites sensitive to nitrogen and acid deposition, maximum process contributions are considered largely insignificant and unlikely to pose any threat to, or have any substantial influence on, the attainment of critical levels. The Ecological Impact Assessment[30] has concluded that the potential effects of these process contributions upon these sites are not significant.

4.4 Cold venting

Cold venting of produced natural gas is expected to be a short duration (45 minutes or less) and infrequent event resulting from the lifting of the well prior to the routing of gases to the flare and as such has been considered in terms of its short term air quality impact only.

Releases of natural gas by cold venting have implications for human health and amenity due to odour as summarised in Table 4.9.

Table 4.9 Short term process contributions from cold venting at residential locations

Human health - Averaging basis		Hourly mean
Maximum process contribution of benzene (24 hour mean)[d]	μg/m^3	5.3
	% standard	2.7
Maximum process contribution of methane	μg/m^3	10840
	% standard	5.1
Maximum process contribution of hydrogen sulphide	μg/m^3	3.9
	% standard	2.6
Maximum process contribution of methyl mercaptan	μg/m^3	5.5
	% standard	1.8
Odour - Averaging basis		98th percentile of hourly means
Maximum process contribution of hydrogen sulphide (98 percentile of hourly means)[c]	μg/m^3	1.2
	ou$_E$/m^3[a]	1.5
	% benchmark[b]	51
Maximum process contribution of methyl mercaptan (98 percentile of hourly means)[c]	μg/m^3	1.6
	ou$_E$/m^3[a]	0.4
	% benchmark[b]	13

a. Odour thresholds of 0.76 and 4.3 μg/m^3 are assumed for hydrogen sulphide and methyl mercaptans respectively.
b. The Environment Agency odour benchmark adopted for the assessment is 3.0 ou$_E$/m^3 (98th percentile of hourly means) consistent with a 'moderately offensive odour'.
c. In the assessment of hydrogen sulphide and mercaptans it is assumed that the total sulphur content of the gas is present as either hydrogen sulphide or methyl mercaptan depending on the substance being assessed.
d. The 24 hour mean for volatile organic compounds assumes a maximum of one well lifting operation requiring cold venting per 24 hour period.

The maximum short term process contributions of methane, volatile organic compounds, methyl mercaptan and hydrogen sulphide are within screening criteria (20% of the environmental standard less the background concentration) and may be considered insignificant. It should be considered that this is an infrequent event and that the maximum process contributions are based on a conservative estimate of duration and release rate and the worst case meteorological conditions. It might be expected that maximum process contributions in practice would be somewhat lower.

In terms of odour, the assumed benchmark of 3.0 ou$_E$/m^3 is expressed on the basis of a 98th percentile of hourly means (i.e. 176th highest hourly mean). In this case cold venting is short and infrequent and not expected to approach the benchmark. In the event that additional periods of cold venting are required, the impact is not sensitive to the number of lifts, provided venting is limited to a period of 45 minutes per hour. For the purposes of comparison, the odour release is assessed as a continuous year round release. On this basis the maximum odour contribution at local residential locations is well within the benchmark. In practice, while a noticeable odour might be experienced during cold venting, this would be a short term and infrequent event which would not compromise the odour benchmark.

4.5 Fugitive releases

Fugitive releases of natural gas may have implications for both human health and amenity with respect to odours. Fugitive releases of methane and odour were assessed separately to the other releases from the wellsite, although the main assessment does include consideration of fugitive releases of volatile organic compounds.

Table 4.10 summarises the air quality impact at local residential locations in terms of human health and the risk to amenity for odours. The maximum annual fugitive releases are assessed which are considered to occur when all eight wells are in production during project years 7 to 20. Fugitive releases during other project years are lower.

Table 4.10 Maximum process contributions resulting from fugitive releases

Human health - Averaging basis		Annual mean	Hourly mean
Maximum process contribution of methane	µg/m^3	5.8	241.1
	% standard	0.1	0.1
Maximum process contribution of hydrogen sulphide	µg/m^3	0.0021	0.086
	% standard	0.0015	0.06
Maximum process contribution of methyl mercaptan	µg/m^3	0.0029	0.122
	% standard	0.03	0.04
Odour - Averaging basis		98th percentile of hourly means	
Maximum process contribution of hydrogen sulphide (98 percentile of hourly means)[c]	µg/m^3	0.042	
	ou_E/m^3[a]	0.055	
	% benchmark[b]	1.8	
Maximum process contribution of methyl mercaptan (98 percentile of hourly means)[c]	µg/m^3	0.059	
	ou_E/m^3[a]	0.014	
	% benchmark[b]	0.5	

a. Odour thresholds of 0.76 and 4.3 µg/m^3 are assumed for hydrogen sulphide and methyl mercaptans respectively.
b. The Environment Agency odour benchmark adopted for the assessment is 3.0 ou_E/m^3 (98th percentile of hourly means) consistent with a 'moderately offensive odour'.
c. In the assessment of hydrogen sulphide and mercaptans it is assumed that the total sulphur content of the gas is present as either hydrogen sulphide or methyl mercaptan depending on the substance being assessed.

Maximum long term and short term process contributions of methane, hydrogen sulphide and methyl mercaptans are less than 1% and 10% of the long term and short term environmental standards respectively. Process contributions are therefore considered insignificant and unlikely to have any substantial influence on environmental standard attainment at the nearest residential locations.

The maximum process contribution to odour at residential locations from releases of hydrogen sulphide and mercaptans are estimated to be equivalent to 1.8% and 0.5% respectively of the Environment Agency's benchmark for moderately offensive odours. It is therefore considered that fugitive releases from operations at the West Newton A wellsite pose a negligible risk to loss of amenity due to odour.

4.6 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.

4.6.1 Meteorological conditions

Table 4.11 summarises the influence of meteorological conditions on maximum process contributions for the discrete receptor groups describing the neighbouring residential locations, the local footpaths and ecological conservation sites (see Annex G).

Table 4.11 Influence of meteorological conditions on maximum process contribution

Substance	Averaging basis	Residential	Footpath	Conservation sites
	Maximum process contribution (ratio of maximum to minimum year)			
Carbon monoxide	8 hours	1.8	1.6	1.8
	1 hour	1.4	1.2	1.3
Nitrogen dioxide	1 hour	1.7	1.5	1.7
	annual	1.4	1.3	2.1
Sulphur dioxide	15 min	1.4	1.3	2.3
	1 hour	1.9	1.9	2.9
	24 hours	2.1	1.7	2.1
PM_{10}	24 hours	1.7	1.5	1.8
	annual	1.7	1.5	1.8
$PM_{2.5}$	annual	1.7	1.4	1.6
Benzene	24 hours	1.5	1.2	1.5
	annual	2.0	1.9	2.3
Nitrogen monoxide	1 hour	1.4	1.3	1.2
	annual	1.7	1.5	1.7

Annual variations in meteorological conditions on average show up to a twofold difference between maximum and minimum process contributions, although in some individual cases differences can be somewhat higher. 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.

4.6.2 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 to ambient concentrations of nitrogen dioxide over the important averaging bases at 2016 meteorological conditions for Project Year 1. Table 4.12 illustrates the comparison between the ADMS and AERMOD model predictions averaged over receptor groups describing the neighbouring residential locations, the local footpaths and ecological conservation sites (see Annex G).

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 slightly lower predicted process contribution across most residential receptors for most averaging bases. 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.

Table 4.12 Maximum process contributions (variation with model)

Substance	Averaging basis	Maximum process contribution (ratio of ADMS to AERMOD - 2016)		
		Residential	Footpaths	Conservation sites
Nitrogen dioxide	annual	0.9	1.0	0.9
	1 hour	0.9	0.9	0.8
	24 hour	1.0	1.0	0.9

4.7 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 project is modelled based on operation of all major plant at 70% of full load on a continuous 24 hour per day basis for the entire duration of the project phase except where specifically limited by working hours or Rathlin's project schedule. This provides what is considered to be a comfortable 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. It is expected that the duration, frequency and intensity of equipment operation will be 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 to be quite conservative estimates. Conversion rates over the relatively short distances considered in this assessment are likely to be substantially lower than those assumed with estimates based on the Janssen relationship[24] indicating a likely overestimate of the significance of process releases (see Annex C and Table G.1) of nitrogen dioxide and associated nitrogen and acid deposition at the nature conservation sites.

- The produced natural gas content of sulphur dioxide assumed for this assessment is based on the highest content found from multiple samples. This is likely to be an overestimate in general, which will influence sulphur dioxide emissions and most likely provide a higher predicted contribution to acid deposition, particularly at the Lambwath Meadows SSSI, than in practice.

- 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 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 project. This assessment is based on a realistic, but conservative, case where the project schedule for each year runs continuously without breaks from the beginning of the year. 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 lower predicted process contributions at sensitive residential 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.

4.8 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[6], 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 project is assessed in Table 4.13 based on operating conditions in section 3.5. It is assumed, as intended by Rathlin, that electricity generated by the combustion of produced natural gas on site will be used to power stationary site engines and hence displace diesel fuel use.

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 project of 10577 tonnes.

Table 4.13 Calculation of POCP related releases

Substance	Release over project (t)				POCP	
	NO_2	CO	SO_2	Benzene		
POCP factor	2.8	2.7	4.8	21.8	tonnes	% of total
Project year						
1	62.42	26.37	0.96	3.77	332.9	3.1
2	94.68	31.26	2.70	6.56	505.6	4.8
3	119.35	73.44	9.62	15.75	922.0	8.7
4	51.41	42.07	6.72	8.23	469.2	4.4
5	68.70	46.86	7.53	6.51	497.0	4.7
6	54.32	42.58	7.52	9.29	505.8	4.8
7	56.67	46.70	7.36	9.05	517.3	4.9
8	56.67	46.70	7.36	9.05	517.3	4.9
9	56.67	46.70	7.36	9.05	517.3	4.9
10	56.67	46.70	7.36	9.05	517.3	4.9
11	56.67	46.70	7.36	9.05	517.3	4.9
12	56.67	46.70	7.36	9.05	517.3	4.9
13	56.67	46.70	7.36	9.05	517.3	4.9
14	56.67	46.70	7.36	9.05	517.3	4.9
15	56.67	46.70	7.36	9.05	517.3	4.9
16	56.67	46.70	7.36	9.05	517.3	4.9
17	56.67	46.70	7.36	9.05	517.3	4.9
18	56.67	46.70	7.36	9.05	517.3	4.9
19	56.67	46.70	7.36	9.05	517.3	4.9
20	56.67	46.70	7.36	9.05	517.3	4.9
21	10.63	7.67	0.01	0.88	69.8	0.7
22	3.40	5.44	0.01	0.37	32.2	0.3
Total	1258.24	929.53	138.06	178.04	10577	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 any credit for electricity generated and subsequently exported from site. Environment Agency guidance[26], 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[27]. 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, it is considered that releases of carbon dioxide, methane and nitrous oxide have implications for climate change. The annual release of each of these is assessed in Table 4.14 based on operating conditions in section 3.5 and represents the total release for the project. It is assumed, as intended by Rathlin, that electricity generated by the combustion of produced natural gas on site will be used to power stationary site engines and hence displace diesel fuel use.

Table 4.14 Calculation of greenhouse gas releases

Substance	Release over project (t)			Impact	
	CO_2	CH_4	N_2O	t CO_2 equivalent	% of total
Global warming potential (relative to CO_2, 100 years)	1	28	265		
Project year					
1	14546	41.3	0.32	15790	1.6
2	26571	165.6	0.71	31397	3.2
3	58691	389.8	0.76	69806	7.2
4	36512	296.5	0.40	44921	4.6
5	42114	336.5	0.49	51665	5.3
6	40242	344.0	0.43	49989	5.2
7	40486	343.4	0.46	50222	5.2
8	40486	343.4	0.46	50222	5.2
9	40486	343.4	0.46	50222	5.2
10	40486	343.4	0.46	50222	5.2
11	40486	343.4	0.46	50222	5.2
12	40486	343.4	0.46	50222	5.2
13	40486	343.4	0.46	50222	5.2
14	40486	343.4	0.46	50222	5.2
15	40486	343.4	0.46	50222	5.2
16	40486	343.4	0.46	50222	5.2
17	40486	343.4	0.46	50222	5.2
18	40486	343.4	0.46	50222	5.2
19	40486	343.4	0.46	50222	5.2
20	40486	343.4	0.46	50222	5.2
21	1431	0.9	0.04	1466	0.2
22	838	0.4	0.02	855	0.1
Total	787755	6382	10	968994	100

The assumptions made in relation to releases are considered to represent a precautionary case for the proposed operations. The determination indicates an equivalent carbon dioxide release for the project of 968994 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 E in accordance with the methodology described in the IAQM's guidance[28]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 F using methodology provided by the Highways Agency[29] and the IAQM[11].

Increases in road traffic brought about by the construction activities and subsequent well site operations are assessed to have a neutral impact on air quality based on Highway's Agency 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.

4.12 Cumulative impacts

This assessment has quantified the likely air quality impact of the development of the West Newton A wellsite in relation to releases to atmosphere and determined significance and compliance with environmental benchmarks based on the process contribution from the wellsite and the existing background pollutant concentrations. As discussed in section 2.4, the assessment has tended towards a precautionary approach using maximum values of background concentrations for the general area and nature conservation sites, which provides some margin of comfort. Future background concentrations will also be enhanced by pollutant contributions from other developments in the area of influence. It is therefore important to understand whether there are any significant current or planned developments in this area. Details of current and planned developments may be obtained from the local planning register and the Environment Agency's permitting database.

For the purposes of this assessment, a circular area of radius 10 km with centre the West Newton A wellsite was considered. The postcodes within this area are HU7, 11 and 17. These were used as the search criteria within the East Riding of Yorkshire Council's e planning portal and the Environment Agency's register of permits issued and applications made. All planned and current developments from 2016 onwards in these postcodes were considered and initially screened for contribution of affected pollutants and distance from the West Newton A wellsite. All developments beyond the 10 km search area were omitted, as it considered unlikely that releases would have any significant impact around the West Newton area. The remaining developments falling within the search area were assessed for their likely additional contribution to pollutant background concentrations around the wellsite. The search identified one development, which was likely to have some influence as summarised in Table 4.16.

Table 4.16 Cumulative impact development search

Site	Permit	Date	Location	Impact
East Riding of Yorkshire Council e planning				
None				
Environment Agency Notice of applications made				
None				
Environment Agency Notice of permits issued				
Tansterne Biomass Power Plant	WP3738DE	3.11.17	HU11 4RE	Biomass power plant with a combined thermal input of 76MW burning 257120 t/year of waste wood.

The activity identified in Table 4.16 is likely to have some impact on background concentrations of the pollutants of interest in this assessment. A simplified model of the Tansterne Biomass power plant was prepared in order to estimate the contribution to background concentrations around the sensitive receptors considered in this assessment. The primary modelling parameters for the power plant are summarised in Table 4.17.

Table 4.17 Modelling parameters for assessment of the Tansterne Biomass Power Plant

Activity		Tansterne Biomass Power Plant[a]
Location	m	522500 437400
Release height	m	55
Release velocity	m/s	15.0
Temperature	°C	150
Carbon monoxide	gCO/s	3.44
Nitrogen dioxide	gNO_2/s	13.76
PM_{10}	g/s	0.69
Sulphur dioxide	gSO_2/s	3.44
Volatile organic compounds	gC_6H_6/s	0.69

a. Release based on full load operation at permit emission limit values.

Tables 4.18 and 4.19 summarise the maximum in combination process contributions from the proposed project at West Newton A and the Tansterne plant considered at the residential locations and footpaths and nature conservation sites respectively. These tables are directly comparable with Tables 4.1 and 4.2 and Tables 4.6 to 4.8 respectively.

Table 4.18 Maximum process contributions from cumulative activities at residential locations and footpaths

Substance	Averaging basis	Maximum process contribution			
		Residential locations		Footpaths	
		μg/m³	% standard	μg/m³	% standard
Carbon monoxide	8 hours	42.85	0.4	153.22	1.5
	1 hour	61.84	0.2	189.80	0.6
Nitrogen dioxide	1 hour	32.82	16.4	96.08	48.0
	annual	2.91	7.3	17.06	42.7
Sulphur dioxide	15 min	3.44	1.3	12.23	4.6
	1 hour	2.60	0.7	11.28	3.2
	24 hours	1.52	1.2	7.26	5.8
PM_{10}	24 hours	0.38	0.8	2.11	4.2
	annual	0.12	0.3	0.74	1.8
$PM_{2.5}$	annual	0.12	0.6	0.74	3.7
Benzene	24 hours	3.17	10.6	11.93	39.8
	annual	0.39	7.7	6.58	132
Nitrogen monoxide	1 hour	82.94	1.9	194.58	4.4
	annual	2.72	0.9	15.93	5.1

The additional process contributions of the Tansterne plant on a long term and short term basis at residential locations and on a short term basis at local footpaths are insignificant based on Environment Agency assessment criteria. When considered in combination with the process contributions from the proposed operations at the West Newton A wellsite the main assessment conclusions remain unchanged.

Table 4.19 Maximum process contributions from cumulative activities at conservation sites

Site		135 Hornsea Mere SPA	136 Greater Wash SPA	137-159 Lambwath Meadows SSSI	160-184 Local wildlife sites
Nitrogen oxides					
Maximum annual mean PC	$\mu gNO_2/m^3$	0.10	0.40	1.71	1.13
	% CL	0.3	1.3	5.7	3.8
Maximum daily mean PC	$\mu gNO_2/m^3$	2.7	3.0	22.0	25.1
	% CL	1.4	1.5	11.0	12.6
Sulphur dioxide					
Maximum annual mean PC	$\mu gSO_2/m^3$	0.014	0.077	0.136	0.079
	% CL	0.1	0.8	1.4	0.8
Nitrogen deposition					
Maximum process nitrogen deposition	kgN/ha/y	0.020	0.081	0.172	0.228
	% CL	0.2	1.0	0.9	2.3
Acid deposition					
Maximum process acid deposition	keq/ha y	0.004	0.023	0.023	0.029
	% CL	0.2	3.3	1.2	1.1

At the nature conservation sites considered, in combination process contributions have some impact on the conclusions of the assessment for the West Newton A operations alone. At the Greater Wash SPA the in combination acid deposition exceeds screening criteria. The Tansterne Power Station is the predominant contributor of nitrogen and sulphur at the Greater Wash SPA accounting for around 80% of the total in combination acid deposition process contribution. In addition, in combination process contributions to acid deposition just exceed screening criteria at the Lambwath Meadows SSSI. The Ecological Impact Assessment[30] has assessed the potential effects of air quality changes based upon the data as outlined above upon the SPAs (Hornsea Mere and Greater Wash) and Lambwath Meadows SSSI and have concluded that these are not significant.

The Tasterne plant became fully operational in early 2018 and as such it might be expected that current background concentrations provided by DEFRA and APIS will include some consideration of releases from the plant. In addition, the modelling of the Tasterne plant is based on a worst case of full load continuous operation with releases consistent with the permit emission limit values. It is therefore expected that, in practice, additional process contributions from in-combination effects, over and above those accounted for in the existing background concentrations, would be largely limited to those from the proposed activities at West Newton A and as such the contributions from the Tasterne plant would be lower than those determined in Tables 4.18 and 4.19. In practice, it is expected that the conclusions of the modelling of the proposed West Newton A project alone would not materially change when in-combination effects are considered.

5 CONCLUSIONS

Rathlin Energy (UK) Limited propose to develop a wellsite, known as West Newton A, on land off Fosham Road near West Newton. The aim is to undertake an appraisal and potential further drilling of two existing wells and to drill and appraise a further six wells. Following successful appraisal, the wells would be brought into production. The current programme envisages well abandonment and site restoration following a production period of 20 years, with a total project duration of around 22 years.

As part of the planning and permitting process it is necessary to assess the dispersion of releases to atmosphere associated with the proposed operations to determine their impact on ambient concentrations of important pollutants around the local area. In particular, impact at locations of permanent human habitation and sensitive nature conservation sites in the context of attainment of applicable environmental standards requires assessment.

The main sources of pollutant releases during site operations will be from the use of diesel fuel in on-site stationary engines and construction and transport vehicles and from the combustion of produced natural gas by incineration and in gas engines for electricity generation. Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, sulphur dioxide and particulate matter were considered. The assessment was undertaken using the UK ADMS 5.2 modelling system with operating scenarios considered to provide realistic, but conservative, conditions for pollutant releases and air quality impact across the Project. This operating schedule also assumes that electricity produced on site would, where possible, be used to power stationary engines and displace the use of diesel fuel. Any surplus electricity would be exported.

Maximum pollutant process contributions from the 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.

At neighbouring locations of residential occupation, where long term human exposure might be expected, it is considered that pollutant process contributions over the duration of the project are insignificant and pose no meaningful threat to continued attainment of environmental standards.

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

At the nearest conservation sites requiring assessment, which are sensitive to nitrogen and acid deposition, maximum process contributions are considered are largely insignificant and unlikely to pose any threat to, or have any substantial influence on, the attainment of critical levels and critical loads. The Ecological Impact Assessment has concluded that the potential effects of nitrogen oxides, nitrogen deposition and acid deposition upon the Hornsea Mere and Greater Wash SPAs and Lambwath Meadows SSSI are not significant.

In combination effects, taking into account other recent or future proposed developments, largely have no impact on the conclusions of the assessment of the West Newton A development alone for human health or ecology. While in combination process contributions of nitrogen oxides and sulphur dioxide result in increases in acid deposition at the Greater Wash SPA and Lambwath Meadows SSSI leading to exceedance of screening criteria, it is considered that, in practice the conclusions of the modelling of the proposed West Newton A project alone would not materially change when in-combination effects are considered. The Ecological Impact Assessment has concluded that the potential effects of air quality changes upon the Greater Wash SPA and Lambwath Meadows SSSI are not significant.

Necessary assumptions made to undertake the modelling are considered to have the effect of 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 project 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 Highway's Agency guidance.

Operations on site will give rise to releases of greenhouse gases. Based on a realistic, but precautionary, assessment of operation it is considered that Project lifetime greenhouse gas releases are largely insignificant in relation to the UK's current inventory and future budgets.

6 REFERENCES

1. Environment Agency and Department for Environment Food and Rural Affairs, Risk assessment for specific activities, environmental permits, Environmental Management guidance: Air emissions risk assessment for your environmental permit, 3 September 2021 (www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air).

2. Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

3. Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.

4. SI 2010:1001, Environmental Protection, The Air Quality Standards Regulations 2010.

5. Institute for Occupational Safety and Health, International Chemical Safety Card 0291, 22 July 2015 (https://www1.agric.gov.ab.ca).

6. Environment Agency, "Horizontal guidance note H1 – Annex (f) Air Emissions", version 2.2, December 2011 (withdrawn 1 February 2016).

7. Health and Safety Executive, EH40/2005 Workplace exposure limits, January 2020.

8. British Geological Survey, Air quality and greenhouse gas monitoring in the Vale of Pickering, 2018 (http://www.bgs.ac.uk).

9. Environment Agency, UK Air Pollutants – Key Factors and monitoring data, Report SC 030174, April 2006.

10. East Riding of Yorkshire Council, 2020 air quality annual status report, June 2020.

11. EP UK & IAQM, Land use planning development and control: planning for air quality, January 2017.

12. Private communication, email E Walker (Zetland Group) to N Ford (SOCOTEC), dated 16 November 2021.

13. 'Compilation of Air Pollutant Emission Factors', Volume 1, 5th Edition, January 1995, United States Environmental Protection Agency.

14. Rahman SM, Impact of idling on fuel consumption and exhaust emissions and available idle-reduction technologies for diesel vehicles – A review, Energy Conversion and Management 74 (2013) 171–182.

15. DIESELNET, Technology guide 2017.04

16. H Christopher Frey, Real world energy use and emission rates for idling long haul trucks and selected idle reduction technologies, Journal of the Air and Waste Management Association. Vol 59, July 2009.

17. Khan S et al, Idle emissions from medium heavy duty diesel and gasoline trucks, Journal of the Air and Waste Management Association. Vol 59, March 2009.

18. Freedom of information request to Greater London Authority, May 2016.

19. EMEP/EEA, Emissions inventory guidebook 2019, September 2019.

20. National Environmental Research Institute, Emissions from Decentralised CHP plants 2007, Project 5 report – Emission factors and emission inventory for decentralised CHP production, NERI Technical report 786, 2010.

21. Intergovernmental Panel on Climate Change, 2019 refinement to the 2006 guidelines for National greenhouse gas inventories, Volume 2, Chapter 4.

22. Scottish Environmental Protection Agency, Odour guidance 2010.

23. Committee on Acute Exposure Guideline Levels, Acute exposure guidelines for selected airborne chemicals, September 2013.

24. Janssen LHJM, Van Wakeren JHA, Van Duuren H and Elshout A J, 1988, A classification of NO oxidation rates in power plant plumes based on atmospheric conditions, Atmospheric Environment, 22, 43-53.

25. AQTAG 06, Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air, Environment Agency Air Quality Monitoring and Assessment Unit, 20th April 2010.

26. Environment Agency and Department of Environment, Risk assessment for specific activities, environmental permits, Environmental Management guidance: Assess the impact of air emissions on global warming, 1 February 2016 (www.gov.uk/guidance/assess-the-impact-of-air-emissions-on-global-warming).

27. Intergovernmental Panel on Climate Change, 5th Assessment Report, AR5 Synthesis Report Climate Change: 2014.

28. Institute of Air Quality Management, Guidance on the assessment of dust from demolition and construction, February 2014.

29. Highways Agency, Design Manual for Roads and Bridges, HA207/07, May 2007.

30. AECOM, West Newton A Exploration Appraisal and Production Development – Ecological Impact Assessment, 60630268, Revision 2, May 2021.

31. Private communication, S Smart (Zetland) to N Ford (SOCOTEC), email dated 10 November 2021.

Annex A Dispersion modelling contour plots

The results of the modelling of the impact of pollutant releases from the project 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 the project year operations and meteorological conditions which provide the maximum process contributions across the assessment area in each case. All results are presented as the maximum contribution of the process (excluding existing background concentrations), expressed as a percentage of the applicable air quality standard limit.

The plots are considered over an area of 2km x 2km, which includes the assessment area, immediate area around the wellsite and the nearest residential neighbours.

For short term and long term averaging periods the contour plots are limited to minimum values of 1% and 10% of the long and short term environmental standards respectively. Values below these levels are generally considered to be insignificant in terms of air quality impact. The plots also show the area beyond which process contributions could be screened out based on Environment Agency assessment criteria.

The following figures are presented:

Figure 1 Predicted maximum process contributions of nitrogen dioxide for Project Year 1 (AQS limit 99.8 percentile of 1 hour means – 2019)

Figure 2 Predicted maximum process contributions of nitrogen dioxide for Project Year 1 (AQS limit annual mean - 2017)

Figure 3 Predicted maximum process contributions of volatile organic compounds for Project Year 7 (EAL for benzene 24 hour means – 2019)

Figure 4 Predicted maximum process contributions of volatile organic compounds for Project Year 7 (AQS limit for benzene annual mean - 2016)

Figure A.1 Predicted maximum process contributions of nitrogen dioxide for Project Year 1 (AQS limit 99.8 percentile of 1 hour means – 2019)

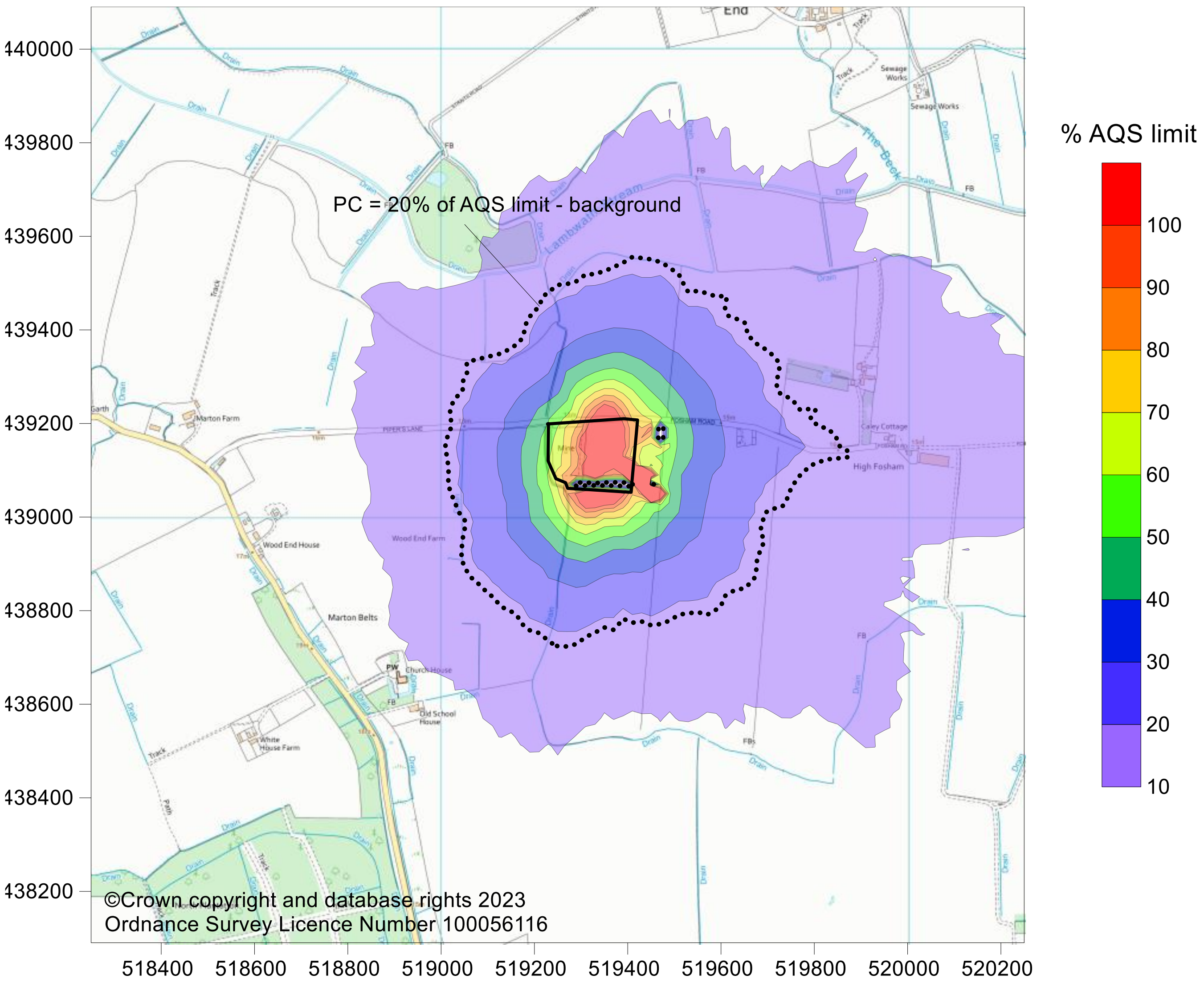


Figure A.2 Predicted maximum process contributions of nitrogen dioxide for Project Year 1 (AQS limit annual mean - 2017)

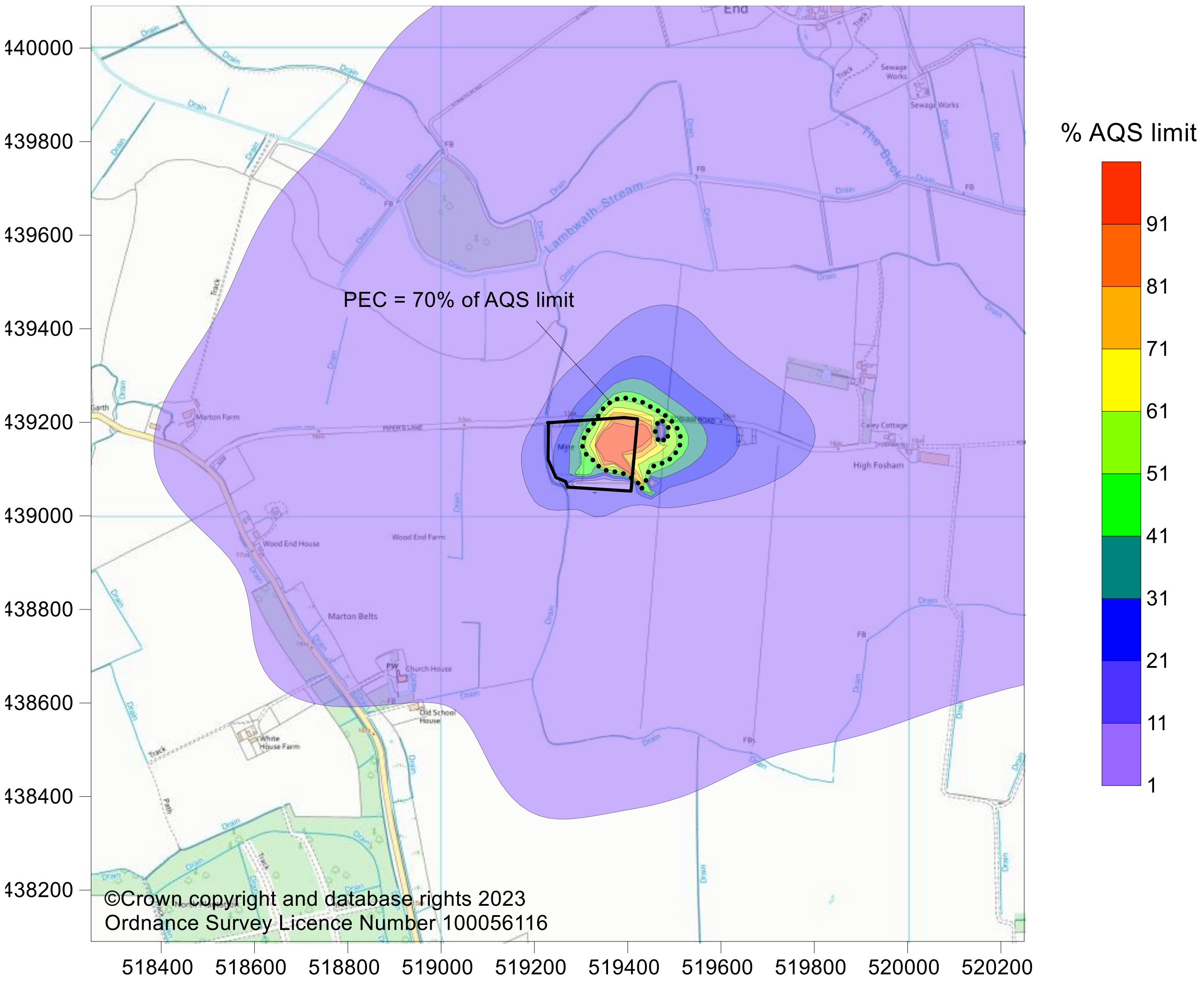


Figure A.3 Predicted maximum process contributions of volatile organic compounds for Project Year 7 (EAL for benzene 24 hour means – 2019)

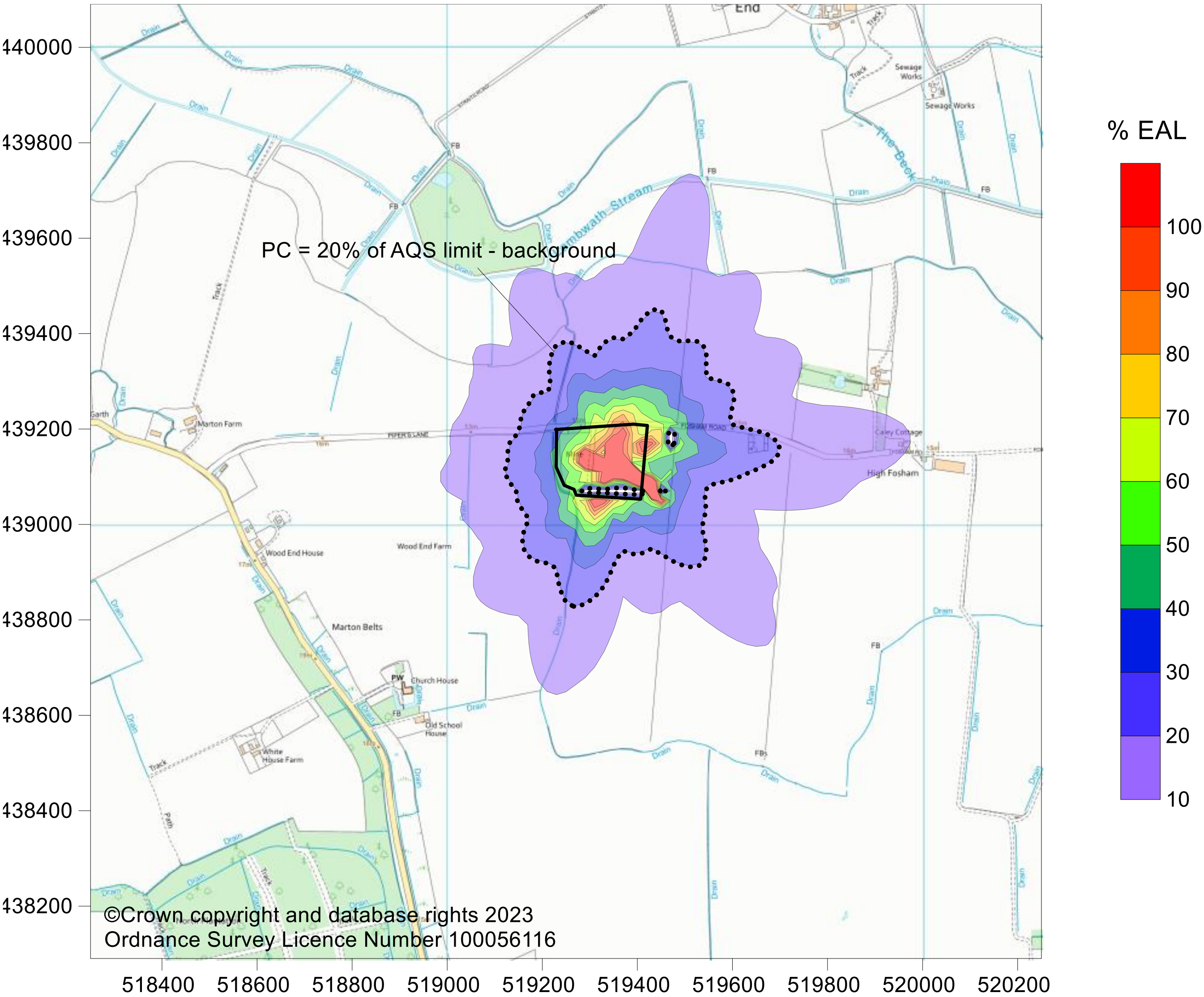
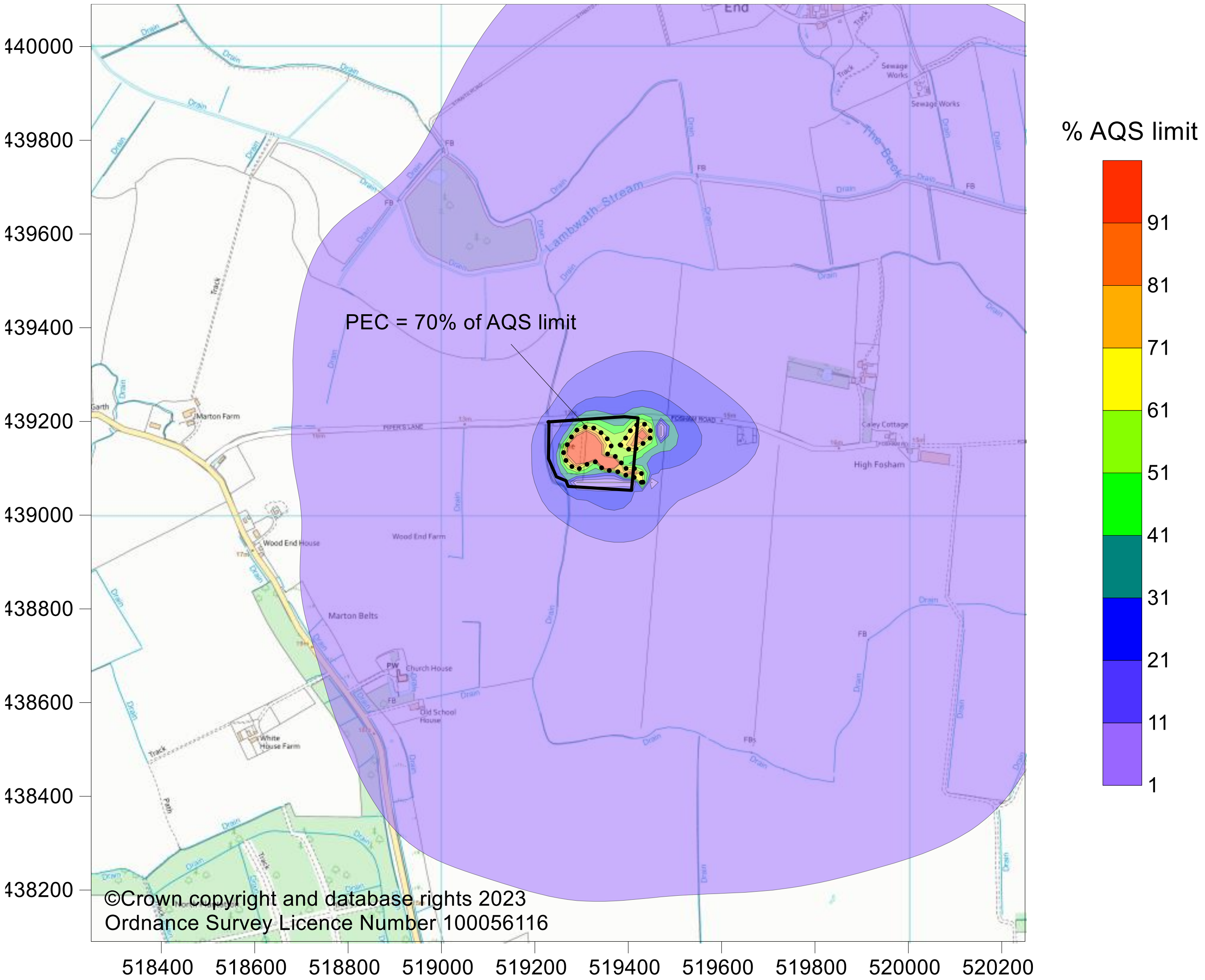


Figure A.4 Predicted maximum process contributions of volatile organic compounds for Project Year 7 (AQS limit for benzene annual mean - 2016)



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	2000 m x 2000m area with centre 519250 439090
Cartesian receptor grid	101 x 101 receptor grid (total 10201) with receptors spaced at 20m intervals
Discrete receptors	184 receptors - see Table G.1 for description
Meteorological data	Hourly sequential data supplied by the UK Meteorological Office from the Leconfield station for the 5 year period 2016 to 2020
Topography	Elevated terrain Ordnance Survey Land-form Panorama DTM (TA02, 04, 22 & 24)
Surface roughness	0.2m
Minimum Moni Obukhov length	1m
Surface albedo	0.23
Priestley Taylor parameter	1.0

The release characteristics of the main sources considered in this assessment are detailed in Tables 3.3 to 3.22.

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	Year 1	WNA Y1 S5 2020.APL
Nitrogen dioxide	1 hour mean	Year 1	WNA Y1 S5 2019.APL
	annual mean	Year 1	WNA Y1 S5 2017.APL
Sulphur dioxide	15 minute mean	Year 7	WNA Y7 S5 2016.APL
	1 hour mean	Year 7	WNA Y7 S5 2018.APL
	24 hour mean	Year 7	WNA Y7 S5 2016.APL
PM_{10}	24 hour mean	Year 1	WNA Y1 S5 2017.APL
	annual mean	Year 1	WNA Y1 S5 2017.APL
$PM_{2.5}$	annual mean	Year 1	WNA Y1 S5 2017.APL
Benzene	annual mean	Year 7	WNA Y7 S5 2016.APL
Carbon monoxide	hourly mean	Year 1	WNA Y1 S5 2019.APL
Benzene	24 hour mean	Year 7	WNA Y7 S5 2019.APL
Nitrogen monoxide	hourly mean	Year 1	WNA Y1 S5 2019.APL
	annual mean	Year 1	WNA Y1 S5 2017.APL

B.3 Models used

ADMS	Cambridge Environmental Research Consultants Limited ADMS 5.2: version 5.2.2.0 License: A01-1347-C-AD520-UK (10.10.23)
AERMOD	Lakes Environmental Software AERMOD View: version 10.2.0 (AERMOD version 21112) License: AER0005883 (21.11.23)

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[24] 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)

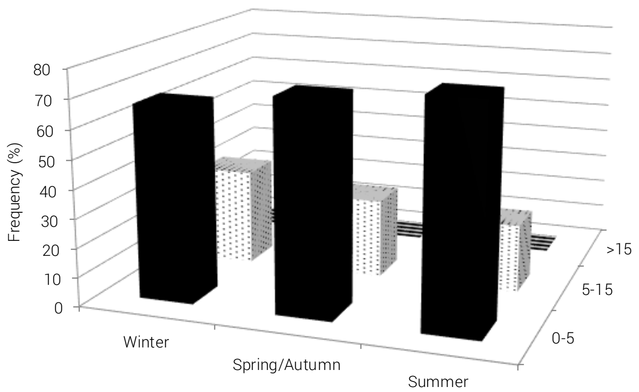
Background ozone concentration (ppb)	Wind speed at plume height (m/s)					
	0-5		5-15		>15	
	A	α	A	α	A	α
20-30	0.67	0.10	0.67	0.10	0.67	0.10
30-40	0.74	0.10	0.74	0.15	0.74	0.25
40-60	0.81	0.15	0.81	0.25	0.81	0.35
60-120	0.88	0.20	0.88	0.35	0.88	0.45
120-200	0.93	0.40	0.93	0.65	0.93	0.80

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 Leconfield station over the period employed in this assessment (2016 to 2020) 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	66.8	33.2	<0.1	4.2
Spring/Autumn	72.7	27.3	<0.1	3.8
Summer	76.6	23.4	<0.1	3.5

Seasonal wind speed

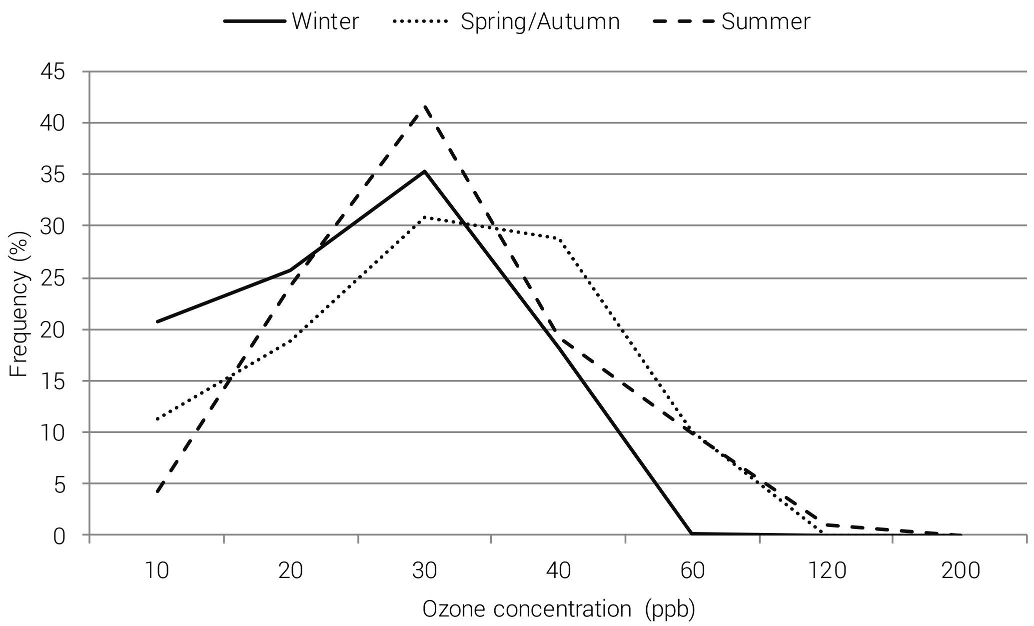


The wind speed is almost exclusively below the 15 m/s category for all seasons, with an overall average of 3.8 m/s.

The nearest automatic station monitoring station which includes measurement of ozone is Hull Freetown (UKA00450) which is located around 13km south west of West Newton (509482 429322). An analysis of hourly average data for 2020 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	20.7	25.7	35.4	18.2	0.1	<0.1	<0.1	20.0
Spring/Autumn	11.3	18.8	30.9	28.8	10.2	<0.1	<0.1	25.7
Summer	4.2	24.2	41.6	19.1	9.8	1.1	<0.1	26.2

Seasonal ozone concentration

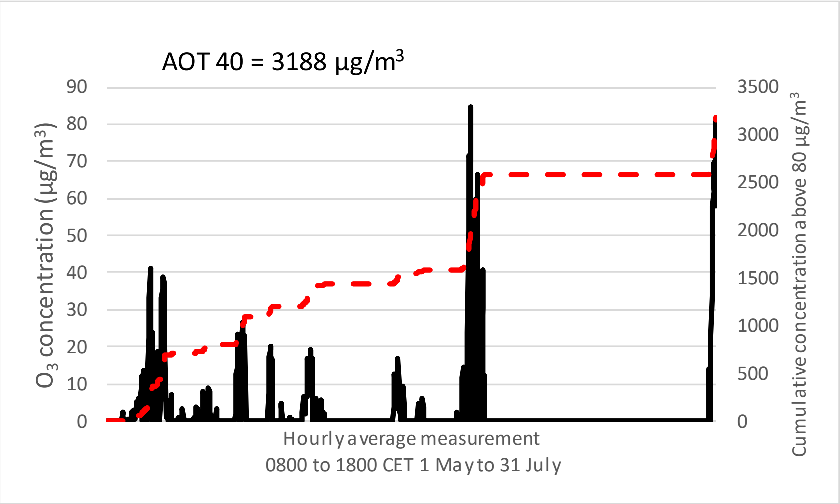


Based the values of wind speed and ozone concentration and Janssen's empirical relationship, it is considered that the following seasonal values for the parameters A and α are appropriate:

Season	Wind speed (m/s)	Ozone concentration (ppb)	A	α
Winter	5-15	20-30	0.83	0.07
Spring/Autumn	5-15	20-30	0.74	0.10
Summer	5-15	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 3188μg/m^3 as summarised below.

Ozone AOT 40 assessment (1May to 31 July 2020)



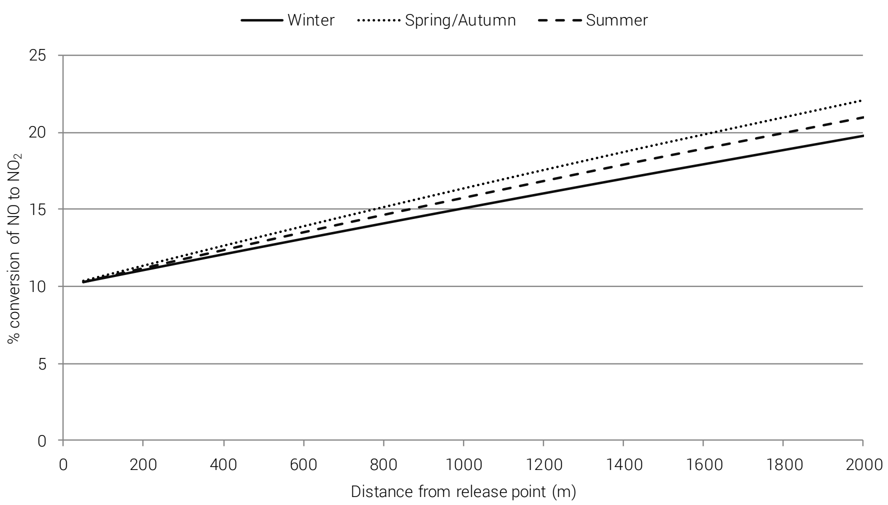
It is likely that a small amount of the nitrogen oxides emitted will be in the form of nitrogen dioxide. For the purposes of this assessment it is assumed that 10% of nitrogen oxides comprise nitrogen dioxide and as such Janssen's relationship for this situation is described by:

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

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. 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.

Estimated seasonal NO to NO_2 conversion rates



ANNEX D Meteorological data

For this modelling assessment hourly sequential meteorological data provided by the UK Met Office from the Leconfield station was employed and covered the 5 year period 2016 to 2020. 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 2016 to 2020 is presented. The windroses for each individual year of data used are illustrated below.

Figure D.1 Leconfield 2016

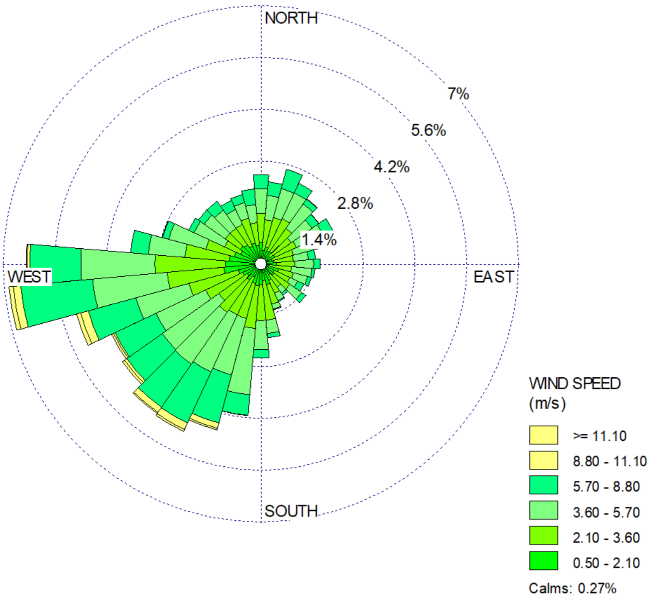


Figure D.2 Leconfield 2017

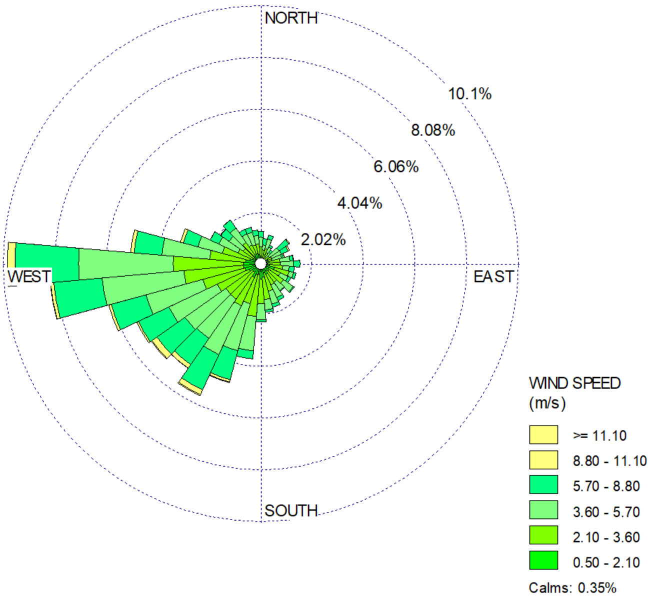


Figure D.3 Leconfield 2018

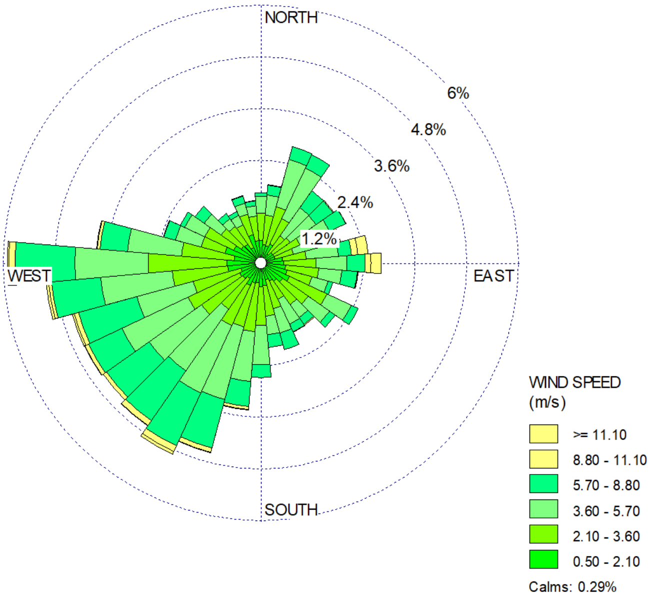


Figure D.4 Leconfield 2019

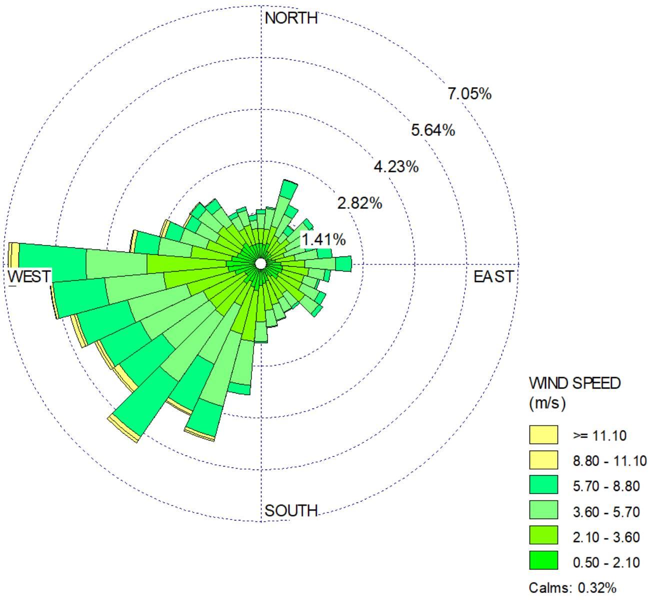
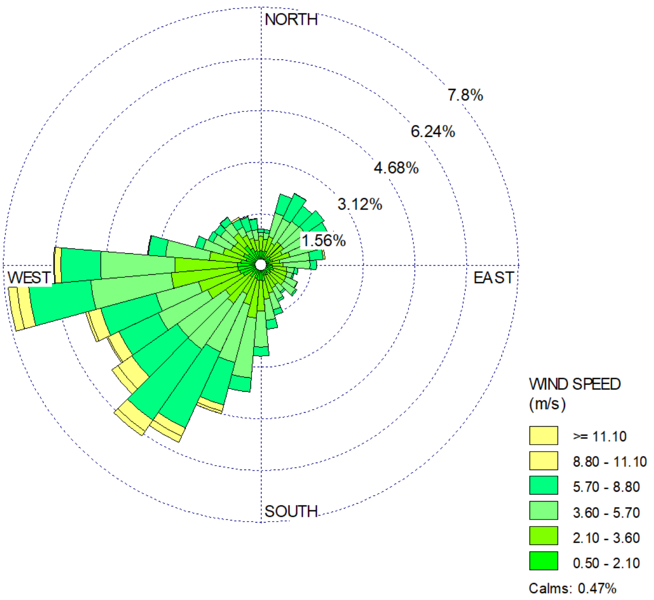


Figure D.5 Leconfield 2020



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 2016 to 2020.

Table D.1 Wind speed and direction (2016 to 2020) for Leconfield

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	2.4	2.7	2.3	1.3	<0.1	<0.1	8.6
NE	1.3	2.0	2.7	1.5	<0.1	<0.1	7.5
E	2.2	2.6	2.6	1.1	0.1	0.1	8.7
SE	1.8	2.3	1.7	0.4	<0.1	<0.1	6.3
SE	2.7	4.8	5.1	2.2	0.2	<0.1	15.0
SW	2.0	4.4	7.1	5.9	0.7	0.3	20.5
W	3.7	7.2	8.1	5.7	0.6	0.2	25.5
NW	2.3	2.2	2.1	0.9	<0.1	<0.1	7.5
Calm							0.3

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

Table D.2 Rainfall and wind direction (2016 to 2020) for Leconfield

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	7.3	0.5	0.4	0.1	0.1	0.1	0.2
NE	6.5	0.4	0.2	0.1	0.1	<0.1	0.2
E	7.7	0.3	0.2	0.1	0.1	0.1	0.2
SE	5.3	0.3	0.2	0.1	0.1	<0.1	0.2
SE	13.0	0.6	0.6	0.1	0.3	0.1	0.2
SW	19.0	0.7	0.4	0.1	0.1	<0.1	0.2
W	24.2	0.5	0.3	0.1	0.1	0.1	0.1
NW	6.7	0.4	0.2	0.1	0.1	<0.1	0.1
Calm	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total	90.2	3.7	2.7	0.7	1.0	0.4	1.3

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 (2016 to 2020) for Leconfield

No. days data	1827		
No. hours data	43848		
No. calm hours (<0.3 m/s)	150	0.34	%
No. dry hours (<0.1 mm/h)	39541	90.23	%
Mean wind speed (m/s)	3.8		
No. missing records	25	0.06	%
Available records	43823	99.94	%

ANNEX E Construction dust risk assessment

E.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 (IAQM)[28]. 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 West Newton A wellsite (phase 2) will take place in in Year 1 and will last around 98 days. During the subsequent well drilling, testing and production phases of the project there will be no appreciable construction work likely to give rise to dust emissions. The restoration phase of the project (phase 9) is of 70 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.

E.2 Screening assessment

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

• a 'human receptor' within 350 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 500 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 500 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 statutory ecological designation is a local wildlife site to the south west at a distance of 920m from the wellsite and 1.5 km from the site entrance off Fosham Road. Ecological receptors are therefore not considered within this assessment.

The nearest human receptors are around 490m to the east of the nearest wellsite boundary at Caley Cottage. Blackbush and High Fosham Cottage are around 500m from the nearest wellsite boundary. All other residential locations are beyond 500m of the wellsite boundary.

In terms of the route taken by vehicles leaving the wellsite entrance there are no residential locations within 500m of the specified route. Caley Cottage is the nearest residential location to the site entrance at a distance of 550m.

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.

E.3 Risk of dust impact

E3.1 Potential dust emission magnitude

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

Table E.1 Dust emission magnitude for earthworks activities

Criteria	Effect	Classification
Site area	The area of the entire wellsite is around 27,000 m^2 and is the only area where construction activities will take place. The area of the intended extension is around 18,000m^2.	Large
Soil type	Moderately dusty soil	Medium
Earth moving vehicles operating	Greater than 10 vehicles operating at any one time (see Table H.2)	Large
Material moved	Expected that around 25000 tonnes of top soil will be removed during construction and around 17000 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 construction phase of the project will last for 98 days and restoration is expected to last for 70 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 project is considered to be ‘Medium’.

Table E.2 Dust emission magnitude for construction activities

Criteria	Effect	Classification
Building volume	Total building volume is less than 25000 m^3.	Small
Dust potential of construction materials	Largely concrete for drilling pad and MOT type 1 aggregate for site surface (c. 17,000 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 well site will involve the construction of the drill pad. In addition, there will be the construction of the wellsite hard standing which will involve the laying of geotextile membranes and granular aggregate (c. 17, 000 tonnes). These activities will be conducted over a relatively short duration estimated at 98 days. While the dust magnitude is classified as 'Medium' this is considered a precautionary assessment.

Table E.3 Dust emission magnitude for track out

Criteria	Effect	Classification
Number of HDV vehicle movements	Less than 50 HDV outward movements expected in any one day (see Table H.3) during the construction and restoration phases.	Medium
Surface material	Moderately dusty.	Medium
Length of unpaved road	The site entrance is a junction on to the Fosham Road. There is minimal unpaved surface.	Small
Overall rating	Conservative estimate of effects.	Medium

There is direct access from the wellsite onto the Fosham Road and 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 E.4 Summary of dust emission magnitude

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

E3.2 Sensitivity of the area

IAQM guidance recommends the assessment of the sensitivity of the area takes 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 project (i.e. Caley Cottage, Blackbush and High Fosham Cottage). All other high sensitivity receptors are beyond 500m from any construction activity associated with the project.

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 junction on to the Fosham Road. The nearest residential location to the main route for HDVs is Caley Cottage which is some 550m from the site entrance. All other residential locations are beyond 600m of the site entrance.

There are no areas of woodland between the wellsite and the nearest residential properties which might provide a significant natural barrier to wind blown dust emissions.

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

Table E.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)	490	490	550
	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)	490	490	550
	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 E.4) and the sensitivity of the receiving area (Table E.5) as summarised in Table E.6.

Table E.6 Assessment of risk of impact

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

E.4 Conclusions and mitigation measures

The impact on human health is considered 'low' based on the distance between the wellsite and access track 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 site and the nearest nature conservation areas 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 F Air quality impact of construction and operations traffic

F.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 the Highways Agency[29] has been used to determine significance and impact of additional off-site traffic movements during the main phases of the project. The impact of on-site vehicle movements is considered within the main air quality assessment.

F.2 Expected traffic flows

The wellsite is to be accessed from the A165 via Langthorpe Road and Pipers Lane. In addition to this a southern access route is proposed via Burton Constable Road and Pipers Lane.

Table F.1 summarises the expected maximum heavy duty vehicle (HDV) movements for the duration of the project.

Table F.1 HDV movements over project

Year	HDVs arriving at site	Total HDV movements (in and out)	AADT
1	5092	10184	27.9
2	5970	11940	32.7
3	9210	18420	50.5
4	8480	16960	46.5
5	10770	21540	59.0
6	10660	21320	58.4
7 to 20	10285	20570	56.4
21	1320	2640	7.2
22	1560	3120	8.5

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 21540 equivalent to an annual average daily traffic (AADT) count of 59. This occurs during Year 5 of the project.

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 project.

F.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 F.2.

Table F.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 F.1
Heavy duty vehicle flows will change by 200 AADT or more	No – see Table F.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 West Newton A 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[11] 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 F.3.

Table F.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 project fall well below the IAQM criteria for an air quality assessment with AADT for HDVs of 59.

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.

F.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 Highway's Agency 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.

ANNEX G 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 G.1, together with the predicted nitrogen monoxide to nitrogen dioxide conversion rate (see Annex C). All receptors were at an elevation of 1.5 m with the exception of the conservation site receptors which were considered at an elevation of 0m.

The receptors fall into the following groups:

1 to 25 Residential locations (see Figure 3.1)
26 to 79 Footpaths (see Figure 3.1)
80 to 134 Site boundary (see Figure 3.1)
135 to 184 Conservation sites (see Figure 3.1 and Table 3.1)

Table G.1 Receptor locations

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
1	Caley Cottage	620 m E	519947	439168	14.0
2	High Fosham Cottage	664 m E	519991	439142	14.3
3	Black Bush	587 m E	519892	439301	13.8
4	Marton Farm	849 m W	518481	439216	15.4
5	Wood End House	720 m W	518625	438977	14.6
6	Church House	622 m SW	518916	438673	14.0
7	Old School House	665 m SW	518948	438593	14.3
8	White House Farm	933 m SW	518618	438534	15.9
9	Straits Farm	1014 m N	519571	440124	16.4
10	Piper Garth	1117 m W	518214	439235	17.0
11	Heywood Farm	1238 m W	518095	439261	17.8
12	Treasure Cottage	1379 m W	517952	439248	18.6
13	Wood House	1217 m S	519077	437949	17.6
14	The Cottage	1218 m S	519367	437922	17.6
15	The Crescent	1186 m S	519501	437967	17.4
16	Model Farm	1460 m SE	519912	437803	19.0
17	Mount Pleasant	1541 m SE	520163	437846	19.5
18	Old Farm Cottage	1664 m SE	520352	437829	20.2
19	Low Fosham	1591 m E	520878	438786	19.8
20	Manor House	1046 m NE	519804	440071	16.6
21	East Lambwath Road	1118 m N	519433	440253	17.0
22	West Lambwath Road	1369 m N	519292	440508	18.5
23	Longdykes Farm	1909 m NW	518325	440764	21.6
24	Whitedale Farm	2321 m NW	517744	440838	23.8
25	Westlands	2184 m NW	518070	440926	23.1
26	FP1	619 m W	518714	439225	14.0

Table G.1 continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
27	FP1	613 m W	518731	439284	14.0
28	FP1	619 m W	518743	439345	14.0
29	FP1	627 m NW	518760	439410	14.1
30	FP1	647 m NW	518775	439477	14.2
31	FP1	659 m NW	518804	439541	14.2
32	FP1	660 m NW	518845	439591	14.3
33	FP1	657 m NW	518895	439635	14.2
34	FP1	673 m NW	518936	439688	14.3
35	FP1	692 m NW	518989	439743	14.5
36	FP1	719 m NW	519021	439790	14.6
37	FP1	729 m NW	519021	439802	14.7
38	FP1	780 m NW	518995	439846	15.0
39	FP1	799 m N	519050	439890	15.1
40	FP1	817 m N	519100	439925	15.2
41	FP1	838 m N	519168	439963	15.4
42	FP1	866 m N	519238	440001	15.5
43	FP1	909 m N	519299	440048	15.8
44	FP1	947 m N	519355	440086	16.0
45	FP1	995 m N	519422	440130	16.3
46	FP1	1029 m N	519469	440159	16.5
47	FP9	971 m N	519484	440098	16.2
48	FP9	905 m N	519504	440028	15.8
49	FP9	856 m N	519516	439975	15.5
50	FP9	810 m N	519537	439922	15.2
51	FP9	741 m N	519543	439849	14.8
52	FP9	678 m N	519554	439779	14.4
53	FP9	621 m N	519557	439717	14.0
54	FP9	568 m NE	519578	439650	13.7
55	FP9	514 m NE	519589	439582	13.3
56	FP9	476 m NE	519601	439530	13.1
57	FP9	435 m NE	519575	439497	12.8
58	FP9	392 m NE	519516	439483	12.6
59	FP9	335 m NE	519513	439418	12.2
60	FP9	276 m NE	519502	439354	11.8
61	FP9	228 m NE	519499	439289	11.5
62	FP9	188 m NE	519487	439240	11.2
63	FP18	306 m E	519633	439140	12.0
64	FP18	303 m E	519625	439084	12.0
65	FP18	315 m SE	519610	439002	12.1
66	FP18	352 m SE	519604	438923	12.3
67	FP18	397 m SE	519595	438847	12.6
68	FP18	451 m SE	519586	438771	12.9

Table G.1 continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
69	FP18	502 m SE	519581	438707	13.3
70	FP18	561 m SE	519581	438639	13.6
71	FP18	630 m S	519566	438557	14.1
72	FP18	660 m S	519543	438516	14.3
73	FP18	822 m S	519516	438340	15.3
74	FP18	955 m S	519525	438206	16.1
75	FP18	888 m S	519519	438273	15.7
76	FP18	732 m S	519522	438434	14.7
77	FP18	1024 m S	519525	438135	16.5
78	FP18	1103 m S	519516	438053	17.0
79	FP18	1205 m S	519519	437951	17.6
80	Site boundary	121 m NE	519429	439205	10.8
81	Site boundary	109 m NE	519412	439207	10.7
82	Site boundary	96 m NE	519395	439207	10.6
83	Site boundary	86 m NE	519379	439208	10.6
84	Site boundary	76 m NE	519362	439208	10.5
85	Site boundary	69 m N	519346	439207	10.5
86	Site boundary	66 m N	519330	439206	10.4
87	Site boundary	66 m N	519316	439205	10.4
88	Site boundary	70 m NW	519298	439204	10.5
89	Site boundary	77 m NW	519284	439204	10.5
90	Site boundary	86 m NW	519269	439204	10.6
91	Site boundary	97 m NW	519254	439204	10.6
92	Site boundary	105 m NW	519242	439202	10.7
93	Site boundary	114 m NW	519232	439203	10.8
94	Site boundary	113 m NW	519231	439199	10.7
95	Site boundary	109 m NW	519231	439191	10.7
96	Site boundary	102 m NW	519234	439180	10.7
97	Site boundary	98 m W	519234	439170	10.6
98	Site boundary	96 m W	519234	439163	10.6
99	Site boundary	94 m W	519234	439153	10.6
100	Site boundary	92 m W	519236	439143	10.6
101	Site boundary	93 m W	519235	439134	10.6
102	Site boundary	94 m W	519235	439124	10.6
103	Site boundary	94 m W	519236	439116	10.6
104	Site boundary	96 m W	519238	439105	10.6
105	Site boundary	97 m SW	519243	439093	10.6
106	Site boundary	99 m SW	519247	439081	10.7
107	Site boundary	96 m SW	519255	439076	10.6
108	Site boundary	91 m SW	519266	439073	10.6
109	Site boundary	93 m SW	519274	439064	10.6

Table G.1 continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
110	Site boundary	91 m SW	519286	439059	10.6
111	Site boundary	86 m S	519303	439058	10.6
112	Site boundary	84 m S	519317	439057	10.6
113	Site boundary	86 m S	519330	439054	10.6
114	Site boundary	89 m S	519349	439054	10.6
115	Site boundary	97 m SE	519369	439053	10.6
116	Site boundary	106 m SE	519385	439052	10.7
117	Site boundary	114 m SE	519398	439051	10.8
118	Site boundary	122 m SE	519409	439050	10.8
119	Site boundary	117 m SE	519409	439057	10.8
120	Site boundary	112 m SE	519410	439064	10.7
121	Site boundary	107 m SE	519412	439076	10.7
122	Site boundary	102 m SE	519412	439084	10.7
123	Site boundary	98 m SE	519413	439093	10.7
124	Site boundary	95 m SE	519413	439101	10.6
125	Site boundary	92 m E	519413	439108	10.6
126	Site boundary	90 m E	519415	439123	10.6
127	Site boundary	89 m E	519416	439131	10.6
128	Site boundary	90 m E	519417	439142	10.6
129	Site boundary	91 m E	519417	439152	10.6
130	Site boundary	94 m E	519419	439162	10.6
131	Site boundary	99 m E	519420	439174	10.7
132	Site boundary	103 m NE	519420	439184	10.7
133	Site boundary	106 m NE	519421	439191	10.7
134	Site boundary	112 m NE	519421	439201	10.7
135	Hornsea Mere SPA	7083 m N	517874	446072	43.8
136	Greater Wash SPA	5508 m NE	524149	441802	38.2
137	Lambwath Meadows SSSI	1062 m NE	520044	439923	16.7
138	Lambwath Meadows SSSI	1037 m NE	520057	439877	16.6
139	Lambwath Meadows SSSI	1005 m NE	520070	439818	16.4
140	Lambwath Meadows SSSI	972 m NE	520080	439755	16.2
141	Lambwath Meadows SSSI	941 m NE	520093	439687	16.0
142	Lambwath Meadows SSSI	990 m NE	520160	439675	16.3
143	Lambwath Meadows SSSI	1035 m NE	520225	439654	16.5
144	Lambwath Meadows SSSI	1105 m NE	520309	439645	17.0
145	Lambwath Meadows SSSI	1180 m NE	520391	439650	17.4
146	Lambwath Meadows SSSI	1632 m NE	520774	439895	20.0
147	Lambwath Meadows SSSI	1610 m NE	520780	439832	19.9
148	Lambwath Meadows SSSI	1589 m NE	520780	439782	19.8
149	Lambwath Meadows SSSI	1563 m E	520784	439704	19.6
150	Lambwath Meadows SSSI	1540 m E	520782	439643	19.5
151	Lambwath Meadows SSSI	1614 m E	520858	439652	19.9

Table G.1 continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
152	Lambwath Meadows SSSI	1743 m E	520982	439685	20.7
153	Lambwath Meadows SSSI	1711 m E	520972	439612	20.5
154	Lambwath Meadows SSSI	1686 m E	520965	439538	20.3
155	Lambwath Meadows SSSI	1692 m E	520982	439494	20.4
156	Lambwath Meadows SSSI	1757 m E	521054	439464	20.7
157	Lambwath Meadows SSSI	1820 m E	521123	439433	21.1
158	Lambwath Meadows SSSI	1890 m E	521199	439406	21.5
159	Lambwath Meadows SSSI	1936 m E	521245	439401	21.7
160	Local wildlife sites	1860 m SW	517724	438197	21.3
161	Local wildlife sites	1756 m SW	517825	438230	20.7
162	Local wildlife sites	1654 m SW	517935	438247	20.2
163	Local wildlife sites	1522 m SW	518095	438247	19.4
164	Local wildlife sites	1401 m SW	518255	438239	18.7
165	Local wildlife sites	1312 m SW	518390	438222	18.2
166	Local wildlife sites	1211 m SW	518466	438289	17.6
167	Local wildlife sites	1121 m SW	518550	438332	17.1
168	Local wildlife sites	1034 m SW	518643	438365	16.5
169	Local wildlife sites	980 m SW	518761	438340	16.2
170	Local wildlife sites	924 m SW	518879	438332	15.9
171	Local wildlife sites	1004 m SW	518921	438222	16.4
172	Local wildlife sites	1096 m S	518946	438112	16.9
173	Local wildlife sites	1186 m S	518963	438011	17.4
174	Local wildlife sites	1288 m S	519005	437893	18.0
175	Local wildlife sites	1365 m S	519064	437800	18.5
176	Local wildlife sites	1428 m S	519140	437725	18.9
177	Local wildlife sites	1564 m S	519123	437590	19.6
178	Local wildlife sites	1683 m S	519106	437472	20.3
179	Local wildlife sites	1789 m S	519132	437362	20.9
180	Local wildlife sites	1780 m S	519250	437362	20.9
181	Local wildlife sites	1762 m S	519376	437379	20.8
182	Local wildlife sites	1868 m S	519469	437278	21.3
183	Local wildlife sites	1934 m S	519545	437219	21.7
184	Local wildlife sites	1952 m S	519671	437219	21.8

a. Position of receptor relative to the **centre** of the West Newton A wellsite.

Table G.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 of the substances considered, are provided for each discrete receptor expressed as a proportion of the applicable air quality standard for the Project Year and meteorological year providing the highest process contribution at residential locations.

Table G.2 Maximum process contributions at discrete receptors

Receptor		Maximum process contribution (% standard)			
		Nitrogen dioxide		Volatile organic compounds	
		1 hour	annual	24 hours	annual
1	Caley Cottage	16.4	7.3	10.6	7.7
2	High Fosham Cottage	14.9	6.4	9.3	6.8
3	Black Bush	13.8	7.3	10.3	7.2
4	Marton Farm	7.2	1.4	4.9	1.4
5	Wood End House	8.0	1.7	4.8	1.6
6	Church House	11.6	2.5	5.3	2.2
7	Old School House	11.2	2.6	5.9	2.2
8	White House Farm	7.0	1.2	3.3	1.1
9	Straits Farm	7.7	1.9	5.4	1.9
10	Piper Garth	5.4	0.9	3.4	0.9
11	Heywood Farm	5.2	0.8	3.0	0.8
12	Treasure Cottage	4.3	0.7	2.5	0.7
13	Wood House	5.6	1.1	2.9	1.0
14	The Cottage	6.1	1.0	2.0	1.0
15	The Crescent	5.2	0.9	2.1	1.0
16	Model Farm	3.8	0.6	2.0	0.7
17	Mount Pleasant	3.5	0.6	1.6	0.6
18	Old Farm Cottage	3.7	0.6	1.9	0.6
19	Low Fosham	5.2	1.0	2.3	1.1
20	Manor House	7.1	2.1	3.6	2.1
21	East Lambwath Road	6.0	1.4	3.9	1.3
22	West Lambwath Road	4.6	0.9	2.8	0.9
23	Longdykes Farm	2.5	0.4	1.4	0.4
24	Whitedale Farm	2.1	0.3	1.0	0.3
25	Westlands	2.2	0.3	1.2	0.3
26	FP1	10.2	2.1	7.2	2.1
27	FP1	9.6	2.0	6.9	2.1
28	FP1	10.4	2.0	8.5	2.1
29	FP1	10.2	2.0	9.2	2.1
30	FP1	10.2	1.9	7.9	2.0
31	FP1	8.8	1.7	7.1	1.9
32	FP1	8.7	1.6	5.5	1.7
33	FP1	8.3	1.5	6.1	1.6
34	FP1	8.1	1.5	6.6	1.5
35	FP1	8.1	1.5	5.7	1.5

Table G.2 continued

Receptor		Maximum process contribution (% standard)			
		Nitrogen dioxide		Volatile organic compounds	
		1 hour	annual	24 hours	annual
36	FP1	7.3	1.5	4.9	1.5
37	FP1	7.0	1.5	4.8	1.5
38	FP1	6.6	1.4	4.4	1.3
39	FP1	6.7	1.4	4.6	1.4
40	FP1	6.8	1.4	4.7	1.4
41	FP1	7.1	1.4	5.0	1.4
42	FP1	7.7	1.4	4.4	1.5
43	FP1	7.5	1.5	4.4	1.5
44	FP1	7.6	1.6	4.6	1.6
45	FP1	7.0	1.6	4.5	1.6
46	FP1	7.4	1.6	4.1	1.6
47	FP9	7.9	1.8	4.6	1.8
48	FP9	9.1	2.1	5.5	2.1
49	FP9	9.0	2.4	6.3	2.3
50	FP9	10.0	2.7	7.2	2.6
51	FP9	10.1	3.2	8.2	3.1
52	FP9	11.2	3.8	9.2	3.7
53	FP9	12.0	4.5	9.8	4.3
54	FP9	13.6	5.5	9.0	5.1
55	FP9	15.0	6.8	9.2	6.1
56	FP9	16.6	8.1	10.5	7.1
57	FP9	18.1	9.3	12.1	8.2
58	FP9	19.4	10.3	13.4	9.0
59	FP9	23.8	14.0	18.2	12.3
60	FP9	30.3	20.0	23.9	17.8
61	FP9	38.1	28.9	29.0	26.8
62	FP9	48.0	42.5	39.8	41.6
63	FP18	27.7	21.1	24.2	22.7
64	FP18	26.7	16.2	18.8	17.8
65	FP18	25.1	8.0	19.1	8.6
66	FP18	22.9	6.2	13.7	6.3
67	FP18	19.3	4.7	14.2	4.8
68	FP18	17.1	3.4	10.1	3.8
69	FP18	14.1	2.6	7.8	3.2
70	FP18	12.3	2.3	7.3	2.7
71	FP18	10.3	2.0	6.4	2.3
72	FP18	9.5	1.9	5.6	2.1
73	FP18	7.3	1.5	3.6	1.6
74	FP18	5.9	1.2	2.8	1.3
75	FP18	6.4	1.3	3.2	1.4

Table G.2 continued

Receptor		Maximum process contribution (% standard)			
		Nitrogen dioxide		Volatile organic compounds	
		1 hour	annual	24 hours	annual
76	FP18	8.3	1.7	4.3	1.8
77	FP18	5.3	1.1	2.6	1.2
78	FP18	5.1	1.0	2.3	1.0
79	FP18	5.0	0.9	2.1	0.9
80	Site boundary	55.0	18.5	42.8	19.2
81	Site boundary	60.9	20.1	46.0	21.0
82	Site boundary	67.1	21.6	49.2	22.7
83	Site boundary	77.8	23.8	53.0	25.6
84	Site boundary	86.3	25.9	68.3	29.3
85	Site boundary	98.7	30.9	85.7	33.1
86	Site boundary	116.4	38.8	96.3	40.5
87	Site boundary	123.8	44.7	100.3	44.5
88	Site boundary	145.8	61.6	103.8	51.6
89	Site boundary	125.7	100.2	106.0	81.6
90	Site boundary	107.5	105.7	87.5	86.4
91	Site boundary	92.6	99.0	73.5	85.7
92	Site boundary	79.2	97.2	61.6	92.5
93	Site boundary	77.0	94.7	65.2	97.7
94	Site boundary	95.1	82.9	64.5	85.8
95	Site boundary	67.9	71.3	61.7	73.8
96	Site boundary	59.1	62.9	55.5	65.9
97	Site boundary	63.6	64.9	55.9	69.8
98	Site boundary	81.0	68.4	60.0	79.3
99	Site boundary	78.5	70.7	61.6	84.4
100	Site boundary	75.7	66.8	62.8	76.0
101	Site boundary	73.4	62.5	58.2	67.9
102	Site boundary	64.2	56.6	52.4	57.6
103	Site boundary	65.9	50.1	50.8	48.7
104	Site boundary	67.6	45.1	46.5	43.0
105	Site boundary	58.5	35.6	62.8	36.4
106	Site boundary	68.8	29.8	82.9	35.9
107	Site boundary	290.3	37.2	117.8	35.2
108	Site boundary	98.6	22.5	65.6	21.1
109	Site boundary	414.1	36.3	149.7	33.6
110	Site boundary	669.5	58.2	153.1	54.9
111	Site boundary	72.0	23.9	47.8	25.0
112	Site boundary	86.5	24.7	53.9	26.8
113	Site boundary	116.4	27.1	63.5	30.0
114	Site boundary	126.4	28.0	64.4	30.0
115	Site boundary	153.2	35.0	113.9	34.0

Table G.2 continued

Receptor	Maximum process contribution (% standard)			
	Nitrogen dioxide		Volatile organic compounds	
	1 hour	annual	24 hours	annual
116 Site boundary	207.8	47.8	163.7	40.8
117 Site boundary	240.0	61.2	186.4	45.0
118 Site boundary	156.7	56.7	117.1	43.9
119 Site boundary	122.6	50.3	91.7	40.9
120 Site boundary	108.4	38.4	88.3	33.5
121 Site boundary	98.6	35.7	74.0	30.5
122 Site boundary	146.6	35.2	65.2	29.9
123 Site boundary	79.7	28.3	53.4	24.9
124 Site boundary	73.7	27.8	49.5	25.0
125 Site boundary	67.7	27.6	49.9	25.7
126 Site boundary	63.4	27.0	49.5	25.5
127 Site boundary	60.6	26.9	51.0	25.7
128 Site boundary	59.7	26.8	51.9	25.9
129 Site boundary	59.1	26.9	52.5	26.7
130 Site boundary	58.5	26.3	52.0	26.6
131 Site boundary	56.6	25.0	49.8	25.5
132 Site boundary	57.1	23.8	49.3	24.3
133 Site boundary	57.1	21.6	46.9	22.2
134 Site boundary	56.8	20.2	45.4	21.0
135 Hornsea Mere SPA	1.0	0.1	0.5	0.1
136 Greater Wash SPA	1.3	0.2	0.5	0.2
137 Lambwath Meadows SSSI	7.7	2.4	3.2	2.1
138 Lambwath Meadows SSSI	7.8	2.5	3.1	2.2
139 Lambwath Meadows SSSI	8.3	2.6	2.9	2.4
140 Lambwath Meadows SSSI	8.7	2.7	3.5	2.5
141 Lambwath Meadows SSSI	9.4	2.9	4.0	2.7
142 Lambwath Meadows SSSI	9.1	2.6	3.7	2.5
143 Lambwath Meadows SSSI	8.2	2.5	3.7	2.4
144 Lambwath Meadows SSSI	7.7	2.3	3.4	2.2
145 Lambwath Meadows SSSI	7.0	2.1	3.0	2.0
146 Lambwath Meadows SSSI	4.9	1.3	2.0	1.2
147 Lambwath Meadows SSSI	4.9	1.3	2.0	1.2
148 Lambwath Meadows SSSI	4.7	1.4	1.9	1.3
149 Lambwath Meadows SSSI	4.8	1.5	2.3	1.4
150 Lambwath Meadows SSSI	5.3	1.5	2.6	1.5
151 Lambwath Meadows SSSI	5.1	1.5	2.6	1.4
152 Lambwath Meadows SSSI	4.7	1.3	2.3	1.2
153 Lambwath Meadows SSSI	4.7	1.4	2.6	1.4
154 Lambwath Meadows SSSI	5.1	1.5	2.9	1.5
155 Lambwath Meadows SSSI	5.2	1.5	2.9	1.5

Table G.2 continued

Receptor	Maximum process contribution (% standard)			
	Nitrogen dioxide		Volatile organic compounds	
	1 hour	annual	24 hours	annual
156 Lambwath Meadows SSSI	4.8	1.4	2.8	1.5
157 Lambwath Meadows SSSI	4.9	1.4	2.6	1.4
158 Lambwath Meadows SSSI	5.0	1.3	2.5	1.4
159 Lambwath Meadows SSSI	4.7	1.3	2.4	1.3
160 Local wildlife sites	3.3	0.4	2.4	0.4
161 Local wildlife sites	3.6	0.5	2.5	0.4
162 Local wildlife sites	3.5	0.5	2.6	0.5
163 Local wildlife sites	3.7	0.6	2.5	0.5
164 Local wildlife sites	4.7	0.7	2.1	0.6
165 Local wildlife sites	5.4	0.8	2.1	0.7
166 Local wildlife sites	6.1	0.9	2.3	0.8
167 Local wildlife sites	6.5	1.1	2.6	0.9
168 Local wildlife sites	6.9	1.2	2.8	1.1
169 Local wildlife sites	8.0	1.5	3.4	1.3
170 Local wildlife sites	9.1	1.8	4.2	1.5
171 Local wildlife sites	8.2	1.7	4.4	1.4
172 Local wildlife sites	6.9	1.5	3.7	1.3
173 Local wildlife sites	6.5	1.3	3.0	1.1
174 Local wildlife sites	5.8	1.1	2.4	1.0
175 Local wildlife sites	5.0	0.9	2.6	0.9
176 Local wildlife sites	5.1	0.9	2.4	0.8
177 Local wildlife sites	4.7	0.8	2.1	0.7
178 Local wildlife sites	4.3	0.7	1.9	0.6
179 Local wildlife sites	4.1	0.6	1.6	0.6
180 Local wildlife sites	3.9	0.6	1.4	0.6
181 Local wildlife sites	3.7	0.6	1.3	0.6
182 Local wildlife sites	3.2	0.5	1.1	0.5
183 Local wildlife sites	2.6	0.5	1.1	0.5
184 Local wildlife sites	2.3	0.4	1.1	0.5

Tables G.3 and G.4 provide the maximum process contributions for all substances over each of years 1,3,4 and 7 for the footpaths and residential location. These tables may be directly compared with Tables 4.1 and 4.2 respectively, which consider the maximum process contributions over all years.

Table G.3 Maximum process contributions during worst case project years at footpaths

Substance	Averaging basis	Process contribution % standard			
		Year 1	Year 3	Year 4	Year 7
Carbon monoxide	8 hours	1.5	0.6	0.6	0.6
	1 hour	0.6	0.2	0.2	0.2
Nitrogen dioxide	1 hour	48.0	10.9	15.1	15.2
Sulphur dioxide	15 min	1.6	3.1	4.5	4.6
	1 hour	1.1	2.2	3.2	3.2
	24 hours	1.9	3.8	5.5	5.8
PM_{10}	24 hours	4.2	0.6	0.6	0.6
$PM_{2.5}$	annual	3.7	0.6	0.6	0.6
Benzene	24 hours	39.8	33.0	22.2	23.2
Nitrogen monoxide	1 hour	4.4	1.1	1.4	1.4

Table G.4 Maximum process contributions during worst case project years at residential locations

Substance	Averaging basis	Process contribution % standard			
		Year 1	Year 3	Year 4	Year 7
Carbon monoxide	8 hours	0.4	0.1	0.2	0.1
	1 hour	0.2	0.1	0.1	0.1
Nitrogen dioxide	1 hour	16.4	2.7	3.3	3.5
	annual	7.3	3.3	4.6	4.9
Sulphur dioxide	15 min	0.4	0.9	1.2	1.3
	1 hour	0.3	0.5	0.7	0.7
	24 hours	0.4	0.8	1.2	1.2
PM_{10}	24 hours	0.8	0.1	0.1	0.1
	annual	0.3	<0.1	<0.1	<0.1
$PM_{2.5}$	annual	0.6	0.1	0.1	0.1
Benzene	24 hours	10.6	8.0	7.9	9.3
	annual	7.7	5.7	6.3	5.4
Nitrogen monoxide	1 hour	1.9	0.2	0.3	0.3
	annual	0.9	0.4	0.6	0.6

ANNEX H Site equipment specification

Details of the equipment specified for use and its operation during the project are provided in Tables H.1 and H2. Table H.3 provides details of the expected HDV movements during the project.

Table H.1 Site equipment specification

Equipment		Type	Description	Reference
a	Lighting	Site light 908	4 off Perkins 403D-11G engine, 8.8 kVA standby power, EU stage 3A	Bruno Generators, Site light 908P specification
b	Welfare unit	Liberty Guard	15 kVA generator, assumed to be EU Stage 3A compliant	MHM UK, MG15000 SSK-MV specification
c	14 t excavator	Hitachi ZX130-6	Isuzu AR-4JJX DOC and SCR, 78.5 kW, claimed EU Stage 4 compliant.	Hitachi, ZAXIS utility class excavators (17/08), 2019.
d	14 t excavator	Caterpillar 323	Caterpillar 7.1 engine, 122 kW, claimed EU Stage 4 compliant	Caterpillar 323 product specification, Cat.com
e	14 t excavator	Volvo EC140EL	Volvo D4J engine, 90 kW, claimed EU Stage 4 compliant	Volvo, Brochure for crawler excavator EC140E, 20045714-C, 2017.07.
f	Dozer	Liebherr PR726	Liebherr 934 A7, 120 kW, claimed EU Stage 4 compliant	Liebherr, PR 726 Litronic, LWT/VM 12227193-0, 5.05.19.
g	6t dumper	Thwaites MACH 2062	Deutz TD 3.6 L4 engine, 55.4 kW, claimed EU Stage 3B compliant	Thwaites Limited, MACH 2062 6t power swivel, 08/2017
h	9t dumper (2)	Thwaites MACH 2098	Deutz TD 3.6 L4 engine, 55.4 kW, claimed EU Stage 3B compliant	Thwaites Limited, MACH 2098 9t power swivel, 08/2017
i	13t sheeps foot roller (2)	Hamm 13i	Deutz TCD 4.1 L4, 115 kW, claimed EU Stage 5	Hamm AG, Hamm3i, 12.19, 2737730
j	Roller (2)	Bomag BW120	Kubota D1803, engine, 24.6 kW, claimed EU Stage 5 compliant	Bomag, Technical data, tandem rollers, BW 120 AD-5, 130220 sa04.
k	12t dumper	Hydrema 912F	Cummins QSB 4.5L, 108 kW, claimed EU Stage 4 compliant	Hydrema, 912F series articulated dump trucks, 0855426/02/2018
l	Concrete pump	Schwing-Stetter	Motor OM470, R6, 10.7 l, 240 kW (326 PS), 1,700 Nm	http://www.schwing-stetter.co.uk/Downloads/S20.pdf?t=637436076063436607
m	Surface conductor rig	Junttan PM 20LC	Cummins QSB6.7 engine, 179 kW, EU stage 3A compliant	Junttan, PM20LC Pile Driving Rig Data sheet, M120LC003, 2 March 2009

Table H.1 continued

Equipment		Type	Description	Reference
n	Camp generator	Perkins 2206A-E143TAG3	Gross power 350 kW, assume EU Stage 3A compliant	Perkins, PM1880A/12/14. 2206A-E13TAG3 engine specification
o	Drilling rig KCA Deutag T208	Rig Engine (4)	Caterpillar 3512B, 1200 kW, manufacturer's emission data	https://www.cat.com/en_GB/products/new/power-systems/electric-power/diesel-generator-sets/18330406.html
p	Flare CEB350	AEREON CEB300	Enclosed combustion systems, each 0.27 MMscfd (+ 10%).	Bekaert, CEB 300, 17/3/2008
q	Flare CEB1200	AEREON CEB1200	Enclosed combustion systems, each 0.9 MMscfd (+ 10%).	Bekaert, CEB 1200, 17/3/2008
r	Flare CEB4500	AEREON CEB4500	Enclosed combustion systems, each 3.5 MMscfd (+ 10%).	Bekaert, CEB 4500, 17/3/2008
s	Gas engine generator (4)	Jenbacher JMS 624 GS.NL	Electrical power 4405 kW at full load (9695 kW thermal input), manufacturer's emission data.	Jenbacher, Technical description, Cogeneration Unit JMS 624 GS.NL, 20.11.2020/A (AED2).
t	Workover rig	Moor 475	Detroit Series 60 engine, 354 kW, fuel consumption 85 l/h, US Tier 2 compliant	Detroit Diesel Corp, Detroit engine series 50 and 60 for petroleum applications, 6SA587 304, 2003
u	Oil heater (2)	RBC 1850	RBC 600 oil burner, fuel consumption 40 l/h (scaled to 410 kW) at AP42, 1.3 emission rates	Fulton, Technical information, Sheet 109, Issue 6.
v	Flare PW	PW Well Testing	Shrouded ground flare, 2.5 MMscfd	PW Well Testing, ground flare technical document, R1, 270616

Table H.2 Equipment usage during project phases

Phase of Development		Hours of Operation	Equipment	Hours
1	Appraisal Testing and Workover of Existing Wells			
1a	Appraisal drilling WNA-1 (1 to 60 – 60 days) Year 1	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
1b	Appraisal workover WNA-1 (61 to 90 – 30 days) Year 1	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day

Table H.2 continued

Phase of Development		Hours of Operation	Equipment	Hours
1c	Appraisal Testing WNA-1 (91-120 – 30 days) Year 1	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Oil heater	u (2)	24 hours per day
		CEB incinerator	p, q, r	24 hours per day
1d	Appraisal drilling WNA-2 (121-180 – 60 days)	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
1e	Appraisal workover WNA-2 (181-210 – 30 days) Year 1	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
1f	Appraisal Testing WNA-2 (211-240 – 30 days) Year 1	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Oil heater	u (2)	24 hours per day
		CEB incinerator	p, q, r	24 hours per day
2	Wellsite construction			
2	Wellsite construction (241-338 - 98 days) Year 1	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Surface conductor	m	12 hours per day Monday to Saturday
		Construction plant	c,d,e,f,g, h(2), i(2), j(2), k,,l	12 hours per day Monday to Saturday

Table H.2 continued

Phase of Development		Hours of Operation	Equipment	Hours
3	Wells WNA-3 development			
3a	Drilling WNA-3 (1-105 – 105 days) Year 2	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
3b	Appraisal well treatment and clean up WNA-3 (196-225 – 30 days) Year 2	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
		PW Flare	v	24 hours per day
3c	Appraisal testing WNA-3 (1-60 – 60 days) Year 3	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		CEB incinerator	p, q, r	24 hours per day
4	Well WNA-4 development			
4a	Drilling WNA-4 (106-195 – 90 days) Year 2	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
4b	Appraisal well treatment and clean up WNA-4 (226-255 – 30 days) Year 2	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
		PW Flare	v	24 hours per day
4c	Appraisal testing WNA-4 (61-120 – 60 days) Year 3	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		CEB incinerator	p, q, r	24 hours per day

Table H.2 continued

Phase of Development		Hours of Operation	Equipment	Hours
5	Well WNA-5 development			
5a	Drilling WNA-5 (121-200 – 80 days) Year 3	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
5b	Appraisal well treatment and clean up WNA-5 (1-30 – 30 days) Year 4	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
		PW Flare	v	24 hours per day
5c	Appraisal testing WNA-5 (61-120 – 60 days) Year 4	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		CEB incinerator	p, q, r	24 hours per day
6	Well WNA-6 development			
6a	Drilling WNA-6 (201-270 – 70 days) Year 3	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
6b	Appraisal well treatment and clean up WNA-6 (31-60 – 30 days) Year 4	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
		PW Flare	v	24 hours per day
6c	Appraisal testing WNA-6 (121-150 – 30 days) Year 4	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		CEB incinerator	p, q, r	24 hours per day

Table H.2 continued

Phase of Development		Hours of Operation	Equipment	Hours
7	Well WNA-7 development			
7a	Drilling WNA-7 (1-60 – 60 days) Year 5	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
7b	Appraisal well treatment and clean up WNA-7 (121-150 – 30 days) Year 5	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
		PW Flare	v	24 hours per day
7c	Appraisal testing WNA-7 (1-30 – 30 days) Year 6	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		CEB incinerator	p, q, r	24 hours per day
8	Well WNA-8 development			
8a	Drilling WNA-7 (61-120 – 60 days) Year 5	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Drilling rig	o	24 hours per day
8b	Appraisal well treatment and clean up WNA-7 (151-180 – 30 days) Year 5	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
		PW Flare	v	24 hours per day
8c	Appraisal testing WNA-7 (31-60 – 30 days) Year 6	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		CEB incinerator	p, q, r	24 hours per day

Table H.2 continued

Phase of Development		Hours of Operation	Equipment	Hours
9	Production			
9a	Production from WNA-1 & 2 (241 Year 1 to 365 Year 20 – 7060 days	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Oil heater	u(2)	24 hours per day
		Gas engine generator	s (1)	24 hours per day
9b	Production from WNA-3 & 4 (121 Year 3 to 365 Year 20 – 6450 days	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Oil heater	u(2)	24 hours per day
		Gas engine generator	s (1)	24 hours per day
9c	Production from WNA-5 & 6 (151 Year 4 to 365 Year 20 – 5955 days	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Oil heater	u(2)	24 hours per day
		Gas engine generator	s (1)	24 hours per day
9d	Production from WNA-7 & 8 (61 Year 6 to 365 Year 20 – 5415 days	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Oil heater	u(2)	24 hours per day
10	Well Workovers and maintenance			
7	Well workover and maintenance WNA-1 to 8 (1-80 Years 7 to 20 – 1120 days)	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day
11	Well Decommissioning			
11	Decommissioning (1-168 - 168 days) Year 21	Lighting and welfare	a(4),b	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Camp generator	n	24 hours per day
		Workover rig	t	24 hours per day

Table H.2 continued

Phase of Development		Hours of Operation	Equipment	Hours
12	Restoration and Aftercare			
12	Restoration (1-90 – 90 days) Year 22	Lighting and welfare	a(4),b	24 hours per day
		Camp generator	n	24 hours per day
		HDV	-	12 hours per day Monday to Saturday
		Restoration plant	c,d,e,f,g,h(2), k	12 hours per day Monday to Saturday

Table H.3 HDV movements during project phases

Year	HDVs arriving at site	Total HDV movements (in and out)	AADT
1	5092	10184	27.9
2	5970	11940	32.7
3	9210	18420	50.5
4	8480	16960	46.5
5	10770	21540	59.0
6	10660	21320	58.4
7 to 20	10285	20570	56.4
21	1320	2640	7.2
22	1560	3120	8.5

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 21540 equivalent to an annual average daily traffic (AADT) count of 59. This occurs during Year 5 of the project.

END OF REPORT

Contact:

Dr Nick Ford
SOCOTEC UK Limited
Unit D
Bankside Trade Park
Cirencester
Gloucestershire
GL7 1YT
T: 07768 257628
E: nick.ford@socotec.com